GHANA INFRASTRUCTURE PLAN

(2018 – 2047)

FINAL REPORT

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INFRASTRUCTURE AND SPATIAL PLANNING

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National Development Planning Commission

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LIST OF ACRONYMS AND ABBREVIATIONS

ADF	African Development Fund
AfDB	African Development Bank
AFOLU	Agriculture, Forestry and Other Land Uses
AGI	Association of Ghana Industries
BECE	Basic Education Certificate Examination
BOT	Build Operate Transfer
BPO	Business Processing Outsourcing
BRRI	Building and Road Research Institute
CHO	Community Health Officer
CHPS	Community Based Health Planning Services
CICs	Community Information Centres
CIF	Chinese Infrastructural Fund
COP	Conference of Parties
CPR	Contraceptive Prevalence Rates
CSIR	Council for Scientific and Industrial Research
CSM	Cerebral Spinal Meningitis
CWSA	Community Water and Sanitation Agency
EAIF	Emerging Africa Infrastructure Fund
EEE	Electrical and Electronic Equipment
EFA	Education for All
EIA	Environmental Impact Assessment
EPC	Engineering Procurement and Construction
EPA	Environmental Protection Agency
ESP	Education Strategic Plan
ESPA	Environmental Services Providers Association
EU-AITF	EU-Africa Infrastructure Trust Fund
FSRU	Floating Storage and Regasification Unit
FSTPs	Faecal Sludge and Septage Treatment Plants
GAEC	Ghana Atomic Energy Commission
GAMA	Greater Accra Metropolitan Area
GDP	Gross Domestic Product
GER	Gross Enrolment Rate
GERD	Gross Expenditure on Research and Development
GHACEM	Ghana Cement Manufacturing Company
GHG	Green House Gases
GIDI	Ghana Industrial Development Initiative
GIFEC	Ghana Investment Fund for Electronic Communications
GIIF	Ghana Infrastructure Investment Fund
GIN	Green Infrastructure Network
GIP	Ghana Infrastructure Plan
GIPC	Ghana Investment Promotion Centre
GKMA	Greater Kumasi Metropolitan Area
GLSS	Ghana Living Standards Survey
GMIC	Ghana Multimedia Incubation Centre
GNI	Gross National Income
GPHA	Ghana Ports and Harbours Authority
GPI	Gender Parity Index

GPRSII	Growth and Poverty Reduction Strategy (II)
GRIDCo	Ghana Grid Company
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
GWh	Gigawatt hours
GWCL	Ghana Water Company Limited
HDI	Human Development Index
HICs	High Income Countries
HR	Human Resource
IAEA	International Atomic Energy Agency
ICT	Information and Communications Technology
ICT4AD	ICT Policy for Accelerated Development
IEA	International Energy Agency
IFI	International Financial Institutions
IGFs	Internally Generated Funds
ILGS	Institute of Local Government Studies
INDC	Intended Nationally Determined Contributions
IoT	Internet of Things
IPPU	Industrial Process and Product Use
IRWR	Internal Renewable Water Resources
ISSER	Institute of Statistical Social and Economic Research
ITU	International Telecommunication Union
IWRM	Integrated Water Resources Management
JHS	Junior High School
JMP	Joint Monitoring Programme
JSS	Junior Secondary School
KMA	Kumasi Metropolitan Area
KNUST	Kwame Nkrumah University of Science and Technology
KPIs	Key Performance Indicators
KVIP	Kumasi Ventilated Improved Pit
LFG	Land Fill Gas
LI	Legislative Instrument
LICs	Lower Income Countries
LMICs	Lower Middle Income Countries
LMS	Limited Mechanised System
LPG	Liquefied Petroleum Gas
LTNDP	Long Term National Development Plan
M&E	Monitoring and Evaluation
MDAs	Ministries, Departments and Agencies
MESTI	Ministry of Environment, Science, Technology and Innovation
MICs	Middle Income Countries
MICS	Multiple Indicator Cluster Surveys
MLGRD	Ministry of Local Government and Rural Development
MMA	Metropolitan and Municipal Assemblies
MMDAs	Metropolitan, Municipal and District Assemblies
MMSFD	Million Cubic Feet of Gas A Day
MOE	Ministry of Energy
MOF	Ministry of Finance
MOFA	Ministry of Food and Agriculture
MOH	Ministry of Health

MRV	Measuring, Reporting and Verification
MSLC	Middle School Leaving Certificate
MW	Megawatt
MWRS	Ministry of Water Resources and Sanitation
NADMO	National Disaster Management Organisation
NCA	National Communications Agency
NCCAS	National Climate Change Adaptation Strategy
NCCP	National Climate Change Policy
NCCSC	National Climate Change Steering Committee
NDPC	National Development Planning Commission
NEDCo	Northern Electricity Distribution Company
NEPAD	New Partnership for Africa's Development
NER	Net Enrolment Rate
NERIC	National Education Reform
NESP	National Environmental Sanitation Policy
NESSAP	National Environmental Sanitation Strategy and Action Plan
NGOs	Non-Governmental Organisations
NIC	Newly Industrialised Countries
NITS	National Interconnected Transmissions System
NRW	Non-Revenue Water
NSDF	National Spatial Development Framework
NTSC	National Technical Steering Committee
NVTI	National Vocational Training Institute
NWP	National Water Policy
ODA	Official Development Assistance
ODF	Official Development Fund
OECD	Organisation for Economic Cooperation and Development
PE	Private Equity
PHC	Population and Housing Census
PL	Physical Losses
PPIAF	Public Private Infrastructure Advancement Fund
PPP	Public-Private Partnership
PPPs	Policies Plans and Programmes
PSS	Point Source System
PSWSS	Point-Source Water Supply System
PURC	Public Utilities Regulation Commission
PUWSS	Peri-Urban Water Supply System
RBBs	River Basin Boards
RCC	Regional Coordinating Council
RE	Renewable Energy
Rfi	Resource-for-infrastructure
RFID	Radio Frequency Identification
SADA	Savannah Accelerated Development Authority
SAIDI	System Average Interruption Duration Index
SDF	Spatial Development Framework
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SESIP	Strategic Environmental Sanitation Investment Plan
SHS	Senior High School
SMEs	Small and Medium-sized Enterprises

SOE	State Owned Enterprise
SPV	Special Purpose Vehicle
SSA	Sub-Saharan Africa
SSS	Senior Secondary School
SSSCE	Senior Secondary School Certificate Examination
STEM	Science Technology, Engineering and Mathematics
STI	Science, Technology and Innovation
STMA	Sekondi Takoradi Metropolitan Area
STWSS	Small Town Water Supply System
TARWR	Total Actual Renewable Freshwater Resources
TCF	Trillion Cubic Feet
TCPD	Town and Country Planning Department
TOR	Tema Oil Refinery
TVET	Technical and Vocational Training
TWR	Total Water Requirement
UASB	Upflow Anaerobic Sludge Blanket
UAW	Unaccounted for Water
UK	United Kingdom
UMIC	Upper Middle Income Countries
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollars
USF	Universal Service Fund
UWSS	Urban Water Supply System
VIP	Ventilated Improved Pit
VRA	Volta River Authority
WARM	Water Resources Management
WASSCE	West African Secondary School Certificate Examination
WC	Water Closet
WDI	World Development Indicators
WEEE	Waste Electrical and Electronic Equipment
WQI	Water Quality Index
WRC	Water Resources Commission
WRI	Water Research Institute
WSSDP	Water Sector Strategic Development Plan

EXECUTIVE SUMMARY

ENERGY INFRASTRUCTURE PLAN

A reliable and robust national energy infrastructure stimulates economic growth, poverty alleviation and general wellbeing. It is imperative therefore, that if the country is to achieve economic growth and attain the goals of the Long-term National Development Plan (LTNDP), then huge amounts of reliable and affordable electricity would have to be available to industry, social services and households. The key outputs, issues and investments towards the attainment of the objectives of the 40-year LTNDP are summarised in the figure below.

Indicative activities and cost of financing the Energy Infrastructure, 2018-2047

POWER

- Total investments (excluding fuel) for coal, oil, gas, renewable, nuclear power and transmission and distribution will exceed $168 billion.
- Total power generation increased to 50,168 MW.
- Clean coal technology (ultra-supercritical) 12,200MW (24%) developed.
- Transmission and distribution losses reduced to 2.5% and 6% by 2057.

PETROLEUM

- Sustainable exploration, development and production of oil & gas mainly by Ghanaian firms
- Extension oil and gas pipelines across the country
- New gas discoveries made to support declining stock
- LPG for cooking - household penetration increased from 23% to 100%.

RENEWABLE ENERGY

- Increased share of renewable energy (solar, wind, wave & biofuel) to 18% of national energy mix, from 88MW to 9,000MW by 2047
- Improvement in the efficiency of production and use of woodfuels
- Renewable Energy to be mainstremed into GIP
- Renewable energy Authority established to implement master plan.

NUCLEAR

- Ghana roadmap for nuclear development addresses 19 nuclear infrastructure issues across 3 Phases.
- First nuclear power plant to be in operation by 2029
- 12,800 MW (26%) of nuclear power developed, serving as prime baseload energy to scale-up industrialisation and manufacturing

CROSS-CUTTING ISSUES

Environmental Impact – climate change

Contribution towards energy diversity and security

Contribution towards equity in energy access

Improvement of technical and management capacity of Energy Institutions

Electric Power – Generation Expansion Plan

The generation mix will be expanded with the addition of hydroelectric plants, coal, gas-fired and nuclear plants.

The plan also includes other renewable sources like solar, wind, wave and biogas which are in line with Government's policy to promote renewable sources to mitigate greenhouse gas emissions, reduce air pollution and contribute to energy security. It is expected that the full potential of wind, approx. 1,500 MW capacity, will be developed. The capacity of solar plants will rise to more than 6,300 MW by 2047. The total installed capacity of renewable energy sources by 2047, including mini hydro is projected at 9,000 MW, constituting 18 percent of total installed generation capacity. Renewable Energy will be mainstreamed into infrastructure delivery to leverage funding opportunities under the GIP.

Boosting the Generation Mix

Every modern economy needs a well-diversified energy mix to function well. To support Ghana's plans to industrialise and create a more mature economy, there is a need to diversify energy sources, while ensuring that power is cheap and sustainable to drive economic activity, and the kind of structural change that advanced countries have experienced in their economies. Considering the aforementioned, and recognising that coal will generally continue to play a substantial power generation role, the International Energy Agency (IEA) in its 2012 Technology Roadmap, *Higher Efficiency, Low Emissions Coal Fired Generation Report* presented the coal technologies of the future.

Coal

Coal has over the centuries formed the backbone of the power sector of most developed countries. It has over the years provided low cost power to underpin their industrialisation. With electricity growth stagnant in these developed countries, and structural shifts in their economies to less energy intensive service sectors, as well as lower gas prices and increased commitment to mitigate climate change, there is now an increasing shift from coal to renewables and natural gas. However, given Ghana's limited reserves of gas, and with low cost hydro sites already developed, coal would have to play a role in the country's effort at ensuring adequate, reliable, competitively electric power for economic development.

Technology

Significant advances in coal technology over the past few decades have resulted in increasing efficiency and lower environmental impact. Currently, the main technologies being built are Supercritical and Ultra-supercritical, with efficiencies in excess of 40% net low heat value (LHV) compared to subcritical units, which make up more than 50% of the existing coal fleet that have efficiencies of about 30%. Generally, higher efficiencies mean a smaller quantity of coal is used to generate a unit amount of electricity, and therefore lower emissions per unit. Additionally, improvements in pollution abatement technology have considerably reduced other emissions such as SOx, NOx, particulates and dust, thereby reducing the impact of coal generation on the environment.

Regardless of the improvements in coal plant efficiencies, coal is noted to produce the highest carbon emission per unit of generation, and increased use of coal will result in an increase in pollution levels. Nonetheless, with the available emission control technologies and a well-balanced energy generation mix, it should be possible to still meet the country's greenhouse gas targets, while still ensuring reliable cost-effective and stable electricity prices.

Every modern economy needs a well-diversified energy mix to function well. To support Ghana's plans to industrialise and create a more robust economy, there is a need to diversify energy sources, while ensuring that power is cheap and sustainable to drive economic activity, and the kind of structural change that advanced countries have experienced in their economies.

Electricity Transmission Plan

A reliable power system is critical to the socio-economic improvement in the lives of the citizenry of every nation. A number of measures has been put in place to reduce transmission losses from the current 4.5% to 2.5% over the next 40 years. The recommendations include incorporating the transmission grid with a high capacity and reliable fibre optic network.

Electricity Distribution Plan

An efficient electricity distribution system that provides reliable delivery of power is expected to accomplish the following:

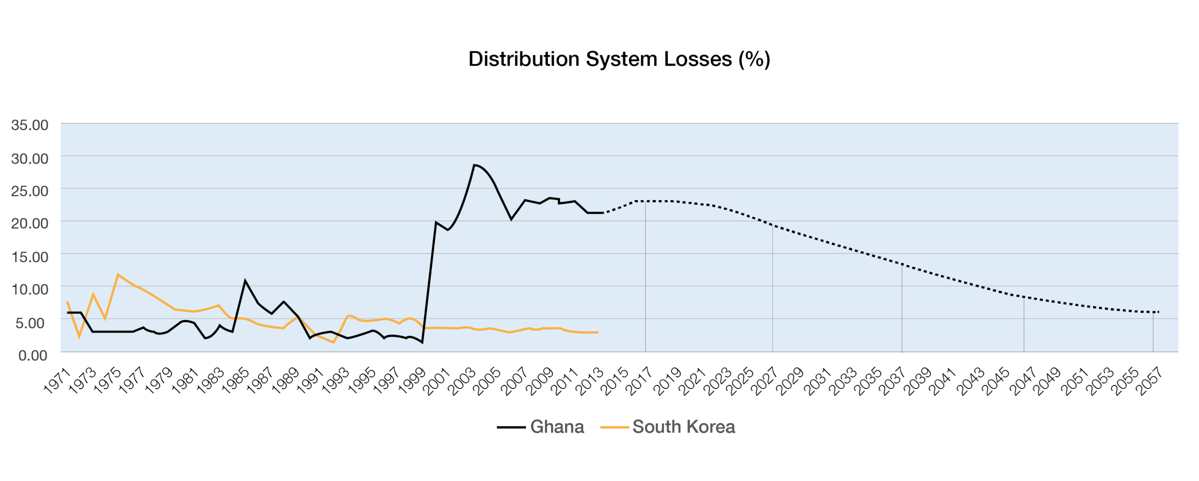
i) Robust and modernised power distribution infrastructure with very wide electricity coverage;

ii) Power distribution network having very low system losses and high reliability performances comparable with the best in the industry;

iii) Cost effective/affordable electricity tariff for consumers; and well-trained human resources to effectively and efficiently operate and manage the power distribution system.

Distribution system losses are a transparent measure of the overall efficiency of the power distribution business. The figure below depicts the historical distribution losses for both Ghana and South Korea. From the figure, it can be seen that Ghana was averagely doing well from 1971 through to 1999 than South Korea. However from year 2000 onwards, the distribution losses in Ghana started to increase while that in South Korea started to reduce. Under the GIP, distribution losses will be reduced to 6% over the next 40 years. It is expected that savings would be made for implementing loss reduction measures in the transmission and distribution systems.

Historical Transmission & Distribution Losses for Ghana and South Korea



Investment Requirements

The huge infrastructure expansion of the electricity network has an associated high investment cost. The required investment covers the entire generation mix as well as transmission and distribution networks. The cumulative investment requirement for the entire planning period is about 168 billion US dollars. The investments do not cover cost of coal, gas, oil and nuclear fuel supplied. It does not also cover operating and maintenance expenses.

RENEWABLE ENERGY

The vision of the Renewable Energy (RE) Masterplan is to develop the renewable energy sector with the capacity to sustainably utilise resources and transform Ghana into a renewable energy research, production, and services hub.

The RE strategy and targets are as follows:

i. Increase the supply of renewable energy[1] in the grid from 38 MW (1 % of total generation) in 2015 to 9,000 MW in 2047, representing 18% of total installed capacity;

ii. Reduce the dependence on biomass as main fuel for thermal energy applications (cooking and heating);

iii. Provide renewable energy-based decentralised electrification options in 1000 off-grid communities;

iv. Promote local content and participation in the renewable energy industry.

Indicative Strategies for Renewable Energy

In line with the Renewable Energy Act, 2011 (Act 832), the Ministry of Energy and the Renewable and Alternative Energy Directorate will adopt the following strategies in order to meet the stated objectives of the Act.

i. The utilities will play key roles, especially in relation to utility scale projects. The Volta River Authority, Bui Power Authority and the proposed Renewable

[1] Renewable energy as defined by the Renewable Energy Act 2011 (Act 832). In the Act, hydropower capacity up to 100 MW is considered renewable.

Energy Authority will be encouraged to grow and expand the renewable energy electricity space through public and private sector led investments;

ii. GRIDCo will drive strategic investments and expansion of the National Interconnected Transmissions System (NITS) to accelerate the interconnection of utility renewable energy projects;

iii. The Renewable Energy Purchase Obligation (REPO) will be implemented to ensure that the distribution companies, ECG and NEDCo and all other bulk customers integrate electricity generated from renewable resources in their distribution and consumption mix;

iv. ECG and NEDCo are to ensure that net-metered systems have access to the distribution grid, in line with the 'Net-Metering Code';

v. Private sector investment is at the centre of the REMP. Private sector investments toward achieving the targets in the REMP, especially, utility scale projects, will be given the utmost priority. The REMP will continue to create opportunities through the RE-FiTs, competitive procurement of RE projects and purchase obligations to increase investment in the sector;

vi. The government will give financial incentives and procurement preferences to private sector actors engaged in the local assembly and manufacturing of renewable energy technologies and related services. Manufacturing and assembling of renewable energy technologies is pivotal to the overall success of the plan, and strategic links in the renewable energy value chain would be fully implemented;

vii. The Ghana Standards Authority will be strengthened to ensure that local production of renewable energy technologies meet international standards.

NUCLEAR POWER

The roadmap[2] for Ghana's nuclear power programme identifies actions for each of 19 infrastructure issues spanning the three phases of development. Appropriate agencies have been identified to be responsible for the various infrastructure actions in the roadmap. An overall time frame of 14 years has been proposed from programme initiation to plant commissioning. This is predicated on strong government commitment and dedicated funding for activities. Phases 1 and 2, which sum up the developmental phase is planned for eight years, whereas Phase 3, the construction phase, is scheduled for six years. It is expected that Ghana's first nuclear power plant will be in operation by 2029.

Industrial Involvement

Ghana is putting in place an industrial plan to off-take a large of the gas. Developing local or national industrial participation[3] for a nuclear power programme involves the arrangement or rearrangement of a number of industries in the country for services, materials supply, fabrication and construction, as part of the integrated supply chain that should be established for the programme. Though for the first nuclear power plant, the most common scheme is a turnkey engineering, procurement and construction (EPC) contract for both the nuclear island and the balance of plant of the EPC contractor will engage subcontractors and suppliers to engineer, design, construct and commission the nuclear power plant units which typically is a mix of local industrial organisations and

[2] The roadmap for Ghana nuclear power programme, NPID-120000-STG-001, January 2016
[3] IAEA NE series No. NG-T-3.4: Industrial involvement to support a national nuclear power programme, Vienna, 2016

international suppliers. Again, the owner/operator organisation will take on projects that are related to the turnkey project with the EPC contractor (e.g. grid upgrades, roads, training centres and administrative facilities) and will enter into contracts with local industrial organisations to support these projects. Therefore, there is the need to develop national institutions to support the programme.

National Position

The national position[4] is the outcome of a deliberative process and study that establishes the governmental strategy and commitment to develop, implement and maintain a safe, secure and sustainable nuclear power programme known as knowledgeable decision. It should be noted that an intention to develop a nuclear power programme is not a decision to embark on a nuclear power programme. According to the Ghana's roadmap for nuclear power development, a comprehensive report which will present an assessment of the 19 infrastructure issues including a complete prefeasibility for an implementation of a nuclear programme is expected by 2017.

Funding and Finance

The nuclear power programme so far has not been given the necessary funding support to develop the needed nuclear power infrastructure required for the introduction of nuclear energy into Ghana's energy mix. It must be noted that the development of the needed nuclear infrastructure is a national requirement that cannot be owned by any third-party. Thus, strong government commitment, ownership and dedicated funding for the program is critical. It is considered that strong funding support from government would also encourage stronger international developmental support for the country's nuclear power infrastructure development.

A first-run estimated cost of the fourteen-year roadmap for developing the required nuclear infrastructure is US$ 125 million. These estimates account for only the investments needed to develop the necessary infrastructure, and do not include the costs associated with the construction of the nuclear power plant itself.

Urgent Actions Requiring Government's Attention

The roadmap requires all these studies to be completed by the end of 2017 to enable the government make a knowledgeable commitment to the nuclear power programme. It is therefore imperative that government gives critical attention to ownership of the nuclear power programme by government, the establishment of owner/operator organisation, and setting aside dedicated funds for all other work tasks of the Ghana Nuclear Power Programme Organisation (GNPPO).

PETROLEUM

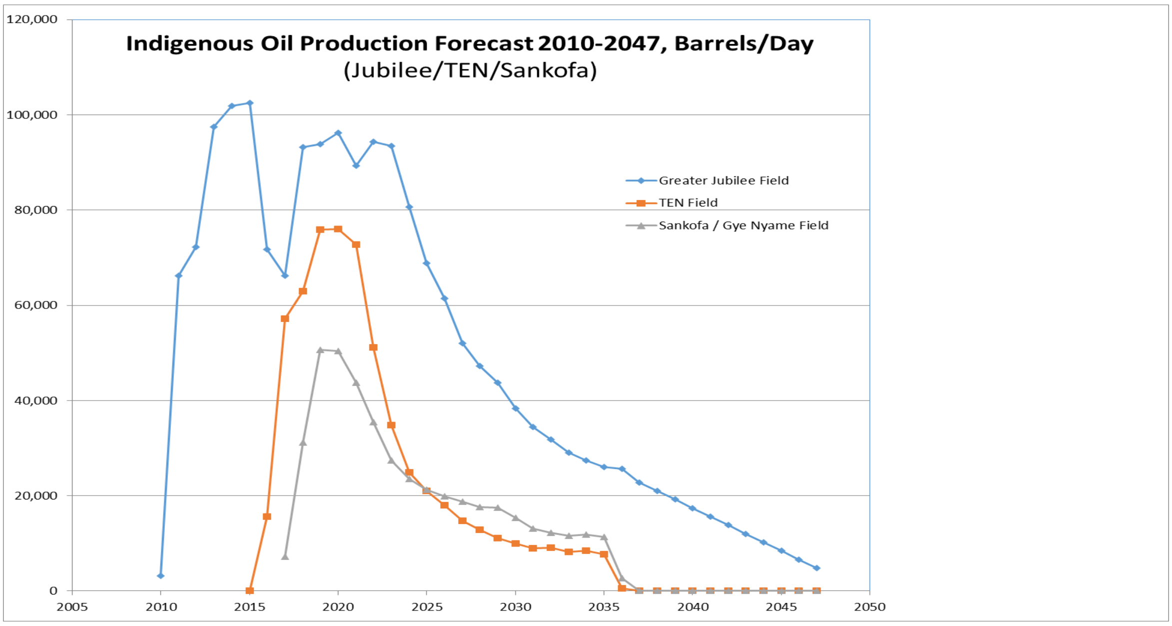
The goals of the petroleum sub-sector are to ensure the sustainable exploration, development and production of the country's oil and gas resources; foster the judicious management of the oil and gas revenue for the overall benefit and welfare of all Ghanaians, and promote the indigenisation of related knowledge, expertise and technology.

Oil Production Potential

[4] IAEA NE series No. NG-T-3.14: Building a national position for a new nuclear power programme, Vienna, 2016.

Ghana's oil production potential points to a gradual decline in all the oilfields from year 2020 as presented in the following figure (proven reserves). Unless new fields come on-stream, the country is expected to find alternative fuel support in the medium to long term.

Oil Production Forecast, 2010-2047, Barrels/Day



Oil Infrastructure Plan - Demand Forecast for Petroleum Products

Meanwhile, the demand profile for various petroleum products shows significant increase in premium and LPG by 2050 as a result of increased vehicular and household use. Therefore steps have been put in place to explore more oil and gas fields and increase power generation.

The Gas Infrastructure Plan

The West African Gas Pipeline (WAGP) supplies have been unreliable, subject to major interruptions and consistently below agreed supply volumes. The capacity of WAGP can however accommodate future growth in gas demand up to 474 MMscf/day maximum with compresssion additions. In case the gas volume increases to 474 MMscf/day, this would suffice for a 3,000 MW combined cycle power plant.

Gas Demand Forecast for Power and Non-Power Loads

Efforts shall be made to direct gas to non-power sectors including industrial heat, residential and commericial, CNG for transportation, fertilizer/urea, methanol, dimethyl ether, ammonia/ammonium nitrate, and petrochemicals.
Given the uncertainties over future gas supplies, the development of new power and gas infrastructure and the demand for power, three alternative scenarios for gas demand projections have been considered. The high case scenario indicates gas demand of 4,750 MMsfcd by 2047.

ROAD TRANSPORT

The vision of the road transport sector is to provide an integrated, efficient, cost-effective and sustainable transportation system responsive to the needs of society, supporting growth and poverty reduction and capable of establishing and maintaining Ghana as transportation hub of West Africa.

Existing Condition of Ghana's Road Network

As of 2015, only 23 percent of the road maintainable network was paved.

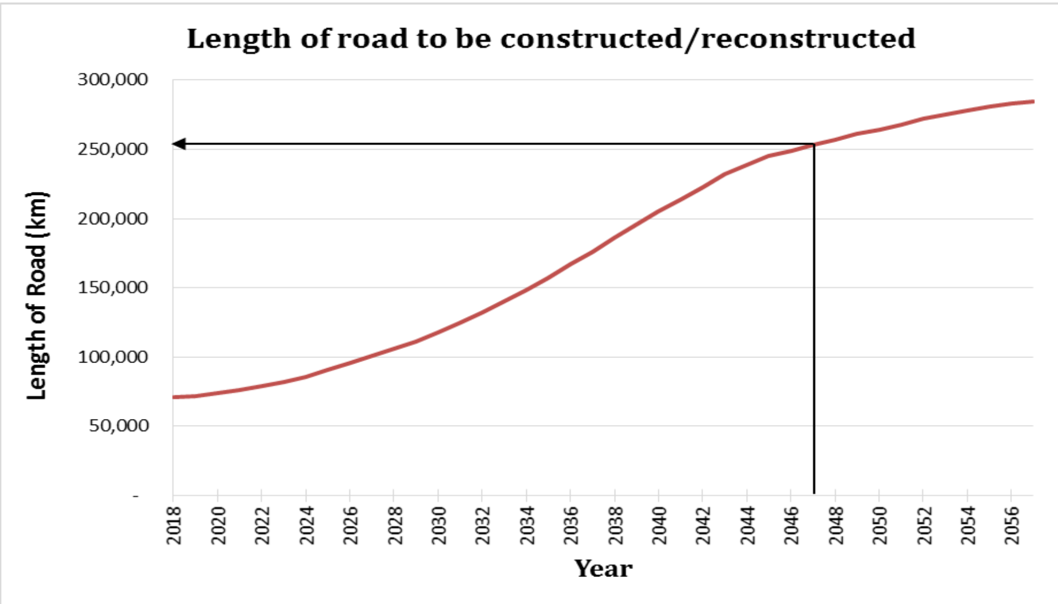
Road Network by Surface Type by Length, 2015 (km)

Road Agency	Rigid	Asphaltic Concrete	Surface Treated	Gravel	Earth	Total Paved	Total Unpaved
GHA	39	2,356	6,672	5807	-	9,066	5,807
DFR	-	-	1,928	27,231	12,886	1,928	40,117
DUR	3	956	5,044	5,226	4,232	6,004	9,458
Total	42	3312	13,644	38,264	17,118	16,998	55,382
% Percentage	0.06	5	19	53	23	23	77

Projected Road Network Size and projected investments

The length of the road network will increase from 72,000km in 2018 to 253,000km by 2047. Basically, about 177,000 km of new roads will be constructed or reconstructed during the development phase. All regional capitals will be linked by multi-lane carriageway. The total investments required to expand the current network length to 253,000 km is US$271.7 billion. This includes an amount of US$40 billion required for improvement and redevelopment of the existing road network.

Length of road to be constructed/reconstructed during the plan period



Vehicle Population per 1000 Persons

It is expected that Ghana's Vehicle Population per 1000 Persons (VP1000P) will increase from 70 to 250 by 2047, much lower than 600 vehicles, which is the current average for high-income countries. This is because efforts will be made to use more mass transport, largely buses and railway.

Developing the Road Grid System to accommodate Electric Vehicles

Ghana will develop the necessary infrastructure and create nationwide charger networks in the cities and the countryside. Electric Vehicles (EVs) will increase Ghana's electricity demand, which has already been addressed under the Power Sector Infrastructure Plan. For electric cars, there are wider community benefits. Increased adoption will result in little or no vehicular emissions.

Road Safety

The National Road Safety Commission (NRSC) is leading the implementation of the Third National Road Safety Strategy (NRSS III) that will aim at reducing the number of persons killed and seriously injured (KSI) in road traffic crashes by 50 percent by 2020.

Construction Sector

Ghana's construction industry will be developed to a high international standard, to undertake a major part of the expected construction boom. Hundreds of contractors will be meticulously trained and classified in roads and bridges, steel and building construction to achieve the targets.

AVIATION

The vision of the aviation sector is to position Ghana as the preferred aviation hub and leader in the airport business in West Africa.

Existing State of Ghana's Aviation Sector

Kotoka International Airport (KIA) is the most frequently used airport for both domestic and international travels. Tamale and Kumasi Airports have also been refurbished and upgraded to the status of international airports but full operations are yet to commence. Sunyani and Takoradi Airports handle domestic air travel. There are other facilities used for emergency, medical and tourism purposes including airstrips with short runways.

Air Traffic Forecast

It is expected that air traffic will increase within the planning period as a result of an increase in economic activity as well as tourism development. This projection is also consistent with recent trends and the high growth potential of the aviation industry.

Ghana's Airports Development

There will be enhanced interconnectivity between the country's airports. This will facilitate the movement of passenger and freight in an efficient and effective manner. The table below shows a summary of airports/aerodromes envisioned for the development of the country's aviation industry. Major projects include the redevelopment of a new Kumasi Airport at Ankaase on a 26,000 acre land. The government and the private sector will also develop a new world class aerotropolis at Prampram.

Summary of Airports Development

Airports	Region	Category of Airport		Future Status
		Current category	Future category	
Kotoka International Airport	Greater Accra	D	D	Hub Airport
Kumasi	Ashanti	C	C	International Airport
Tamale	Northern	C	C	International Airport
Sunyani	Brong Ahafo	B	B	Regional Airport
New Takoradi (Princess Town)	Western	-	B	Regional Airport
Ho	Volta	A	B	Regional Airport
Wa	Upper West	B	B	Regional Airport
Bolgatanga	Upper East	A	B	Regional Airport
Cape Coast	Central	-	B	Regional Airport
Koforidua	Eastern	-	B	Regional Airport
Prampram	Greater Accra	-	C	International Airport
New Kumasi (Ankaase)	Ashanti	-	C	International Airport
Mole	Northern	F	A	Regional Airstrip
Yendi	Northern	F	A	Regional Airstrip
Okwenya-Akuse	Eastern	F	A	Regional Airstrip

MARITIME

The vision of the maritime sector is to provide an efficient and reliable multimodal transport/ logistics and local connection transport system, and contribute to enhance regional economic development within a safe, affordable and sustainable environment.

Existing Situation of Ghana's Maritime Sector

Ghana's two main seaports are located at Tema and Takoradi. Adjoining these two seaports are the Tema and Sekondi Fishing Harbours respectively. With respect to inland water transportation, the Volta Lake is the main means for inland water transport in the country.

Development of the Ports

The infrastructure development of the Tema Port is phased to respond to the traffic demand forecast, with a planned total infrastructure investment estimated at about USD 2.0 billion. The Takoradi Port will be re-positioned through an extensive expansion and modernisation programme to better serve the needs of the oil and gas, mining and the trading sectors. The development strategy of GPHA is to invest in the basic port infrastructure of the breakwater and dredging, on behalf of the state, and cede the various terminal operations and services to private entities under strict terms and conditions. Total investment costs for the final extension of Takoradi Port is estimated at USD 990 million.

Boankra Inland Port

The Boankra Inland Port (BIP) Project will be an international business and distribution centre, offering similar services as a seaport without a waterfront. The BIP Project is to be sited on a 400-acre land at Boankra in the Ashanti Region.

Artisanal Fishing and Canoe Landing Facilities

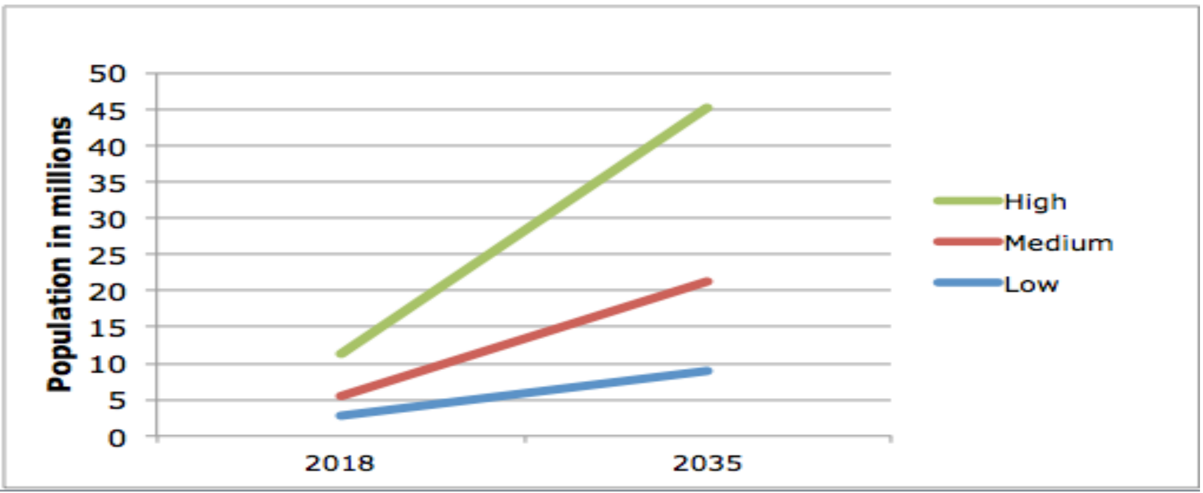
The following towns will be selected for improvement and development into Fish Landing Sites for artisanal vessels: Ada, Teshie, Jamestown, Tema in the Greater Accra Region; Axim and Dixcove in the Western Region; Elmina, Winneba, Mumford, Senya-Beraku, Gomoa-Fetteh and Moree in the Central Region; and Keta/Anloga in the Volta Region.

Inland Water Transport System

It is estimated that between 2018 and 2035, the average number of passengers crossing the Volta Lake could increase from 11.3 million passengers per year to 45.6 million passengers (2035). This implies that passenger traffic around the principal crossing sites is expected to grow from 500,000 in 2018 to 3 million passengers per annum by 2035.

Freight transport on the Volta Lake to the northern part of the country is expected to grow from 262,000 tonnes in 2018 to 1 million tonnes by 2035, while that of the Northern and Central Lake areas will grow from 80,000 tonnes in 2018 to 360,000 tonnes in 2035. Consequently, ferry, local and tramping services as well as infrastructure will be developed to support the growth in both freight and passengers.

Yearly Passenger Traffic Forecast (2018-2035)



RAILWAYS

Rail transport currently forms less than 1% share of Ghana's transportation modal mix for passenger transport and 3% for freight. Towards achieving high income country status therefore, and with the objective to make rail transportation attractive in Ghana, there is the need to ensure that the right investments are made in order to achieve greater efficiency within the sector.

Existing Situation of Ghana's Railway Sector

The current railway network in the country consists of a 947 km route with 1067 mm gauge tracks, located in the southern-most part of the country, forming a triangle, with the Western Line traversing Takoradi – Kumasi, the Eastern Line from Accra to Kumasi and a Central Line that runs parallel to the coast line linking the Western Line to the Eastern Line. Long spells of neglect since the railway was built in the colonial era have today resulted in only 13% of the existing tracks being somewhat operational. Majority of the rolling stock and additional infrastructure are in a dilapidated state and need urgent rehabilitation.

Future Railway Network

In the year 2013, a Railway Master Plan was designed by the GRDA to initiate a rail infrastructure intervention. The Master Plan defines 6 different phases for rehabilitating and extending the railway infrastructure in the country to suit a high-income country status and also serve the citizenry. By the end of the plan period, when rail passenger traffic is expected to grow from a projected 730,000 at 2015 to 1.38 million passengers per day, it will cover a distance of 4,007 km across the entire country.

The implementation of the master plan will require an investment of about US$26 billion covering consultancy, infrastructure and stations; rolling stock; and signal and telecommunications, over the next 30 years of planned standard gauge railway lines and additional lines for the sub-urban networks. The country will have sub-urban railway networks constructed in Accra, Kumasi, Tamale and Sekondi-Takoradi to be planned and developed as part of the overall redevelopment of the cities. Accra, for example, will have the country's first underground railway line constructed along the Liberation Road/Independence Avenue, between Accra and Adenta.

Future Railway Network

Even though the government will own the railway infrastructure, it is imperative that a new railway regulatory body will be established to ensure safety in the operations of the various companies that will participate in the country's new railway system, as well as be responsible for fixing fees to be levied on the train operating companies for using the infrastructure. A Railway Development Fund, Railway Training School and Research bodies will be established as part of the developed of the sector.

WATER RESOURCES MANAGEMENT

The overarching goal is to ensure sustained availability, development, and management of water resources for an industrialised, inclusive and resilient economy; and an equitable, healthy and disciplined society.

Current State of Water Resources

Total actual renewable freshwater resources (TARWR) in the country are estimated to be 53.2 billion cubic m^3/yr, of which 30.3 billion m^3/yr are generated internally. It is estimated that the remaining 22.9 billion m^3/yr originates from outside of the country's international borders. Thus, Ghana is to a large extent depending on collaboration with its riparian neighbours on sharing its water resources potential.

Freshwater ecosystems are in a quite unhealthy state. The activities of small-scale miners (galamsey) are almost entirely responsible for the deterioration in the quality of some water bodies such as the Tano, Pra, Birim, Offin and Ankobra Rivers.

Estimated Future Water Availability and Requirements

Currently, available national freshwater resources per capita are estimated at about 1,941 m^3/cap/year. A country is said to be rich in water when it has more than 1,700 m^3/cap/year. Based on the Long-term National Development Plan (LTNDP) high population growth and the TARWR of 53.2 billion m^3/year (excluding groundwater), it is anticipated that the annual water availability per capita would drop below the water rich benchmark figure of 1,700 m^3 by the year 2021. By the year 2047, the situation would be critical with annual water availability per capita at about 1,040 m^3/cap/year.
The country would be in a situation of water scarcity after year 2049 with annual freshwater resources per capita projected at 969m^3 by 2053. This analysis was made based solely on surface freshwater availability. However, there is a huge groundwater resources potential which would be investigated, assessed and evaluated to constitute an additional potential resource base.

The future total water requirement (TWR) is likely to rapidly exceed the available resources from 2027. The TWR is expected to double from 2027 especially for industrial uses (6.4 times) and irrigation (2.2 times) in view of the transition towards an Upper Middle Income Country (UMIC). In this case, 99% of the IRWR or 57% of the total actual renewable water resources (TARWR) would be committed. The country would therefore rely mostly on the external water inflows from 2029 to 2037. Therefore, it will be difficult to meet the projected requirements without damaging the environment, which calls for well-informed infrastructural interventions.

Estimated Water Requirements based on Income Level Ratios (2018-2047)

Year	Domestic WR (million m^3)	Industrial WR (million m^3)	Irrigation WR (million m^3)	Total WR (million m^3)	TWR as % of IRWR	TWR as % of TARWR
2018	782.80	234.84	4,114.42	5,132.07	17	10
2021	1,716.42	514.93	5,149.27	7,380.62	24	14
2025	3,125.94	937.78	9,377.83	13,441.55	44	25
2027	3,966.86	5,950.29	20,231.00	30,148.16	**99**	**57**
2029	4,270.82	6,406.22	21,781.16	32,458.20	107	61
2033	4,931.26	7,396.88	25,149.40	37,477.54	124	70
2037	5,568.72	8,353.07	28,400.45	42,322.23	**140**	**80**
2041	6,265.78	16,291.02	17,920.13	40,476.93	134	76
2045	7,006.97	18,218.12	20,039.93	45,265.01	149	85
2047	7,468.31	19,417.60	21,359.36	48,245.26	**159**	**91**

Implementation Targets, Timeframes and Activities

The indicative water resources infrastructure targets envisaged at the end of the planned period are the following:

i. Increase water use or withdrawal to 1,025 m^3 per/cap/year;
ii. Meet total water requirement of 48 billion m^3/year;
iii. Improve the water quality of all river basins to a Water Quality Index (WDI) of more than 80 (good quality water).

Financial Requirement

An estimated US$76.25 million constitutes the financial requirement for planned programmes up to 2025 and is indicative for the initial phase.

WATER SUPPLY

The overarching vision of this plan is to provide adequate, safe, affordable and sustainable water supply for all consumer categories by 2047.

Existing Water Supply Systems

A general overview of existing water supply systems in Ghana indicates that most of the systems are operational but mostly below the required capacity due to various physical and operational bottlenecks.

Overall Status of Existing Infrastructure

System Technology	Countrywide Developments
Point Source System (PSS)	28,718
Small Town Water Supply System (STSS)	391
Peri-urban Water Supply System (PUWSS)	17
Urban Water Supply System (UWSS)	71

Water Demand Projections

In order to meet the set goals, an appropriate estimation of the water demand of target supply areas is crucial to facilitate the development of the various systems. The table below indicates the regional water demand projections for the plan period.

Overall Status of Existing Infrastructure

Region	Baseline	Projected Demand (m^3/day)						
	2016	2018	2022	2026	2030	2034	2038	2047
Greater Accra	413,310	432,541	519,925	612,566	700,493	794,933	911,964	1,302,237
Ashanti	441,339	465,493	576,662	655,687	727,280	840,721	930,676	1,238,384
Brong Ahafo	156,483	163,709	201,242	239,948	287,111	339,206	418,910	644,755
Central	204,545	217,423	250,846	287,563	333,194	374,326	425,995	589,160
Eastern	171,685	178,971	204,437	232,924	273,203	304,848	335,331	460,272
Northern	200,514	212,313	242,644	274,917	311,444	362,420	405,483	546,874
Upper East	57,326	58,710	85,908	96,349	107,796	124,491	146,084	201,323
Upper West	42,330	43,954	49,105	53,045	58,800	65,915	74,146	99,474
Volta	125,959	132,335	151,085	175,572	197,556	217,155	246,242	334,654
Western	88,920	92,532	88,571	100,012	111,806	126,229	142,466	182,830
Total	**1,902,411**	**1,997,981**	**2,370,425**	**2,728,583**	**3,108,683**	**3,550,244**	**4,037,297**	**5,599,963**

Planned Infrastructure Development

Based on the water demand projections and gap analysis, the required infrastructure developments over the various horizons to meet the set goals have been carried out. These have been categorised into the following two modes of development:

i. Upgrading of existing systems to higher system technologies;
ii. Expansion of existing systems to meet projected demands.

Collated summary of existing systems to be upgraded to higher system technology

System Technology	2018 Horizon	2022 Horizon	2026 Horizon	2030 Horizon	2034 Horizon	2038 Horizon	2042 Horizon	2047 Horizon
PS	1448	1120	896	717	657	547	228	114
STWS	309	376	381	402	336	321	315	313
PUWS	12	43	17	39	3	3	21	66
UWS	1	2	2	1	1	2	3	2

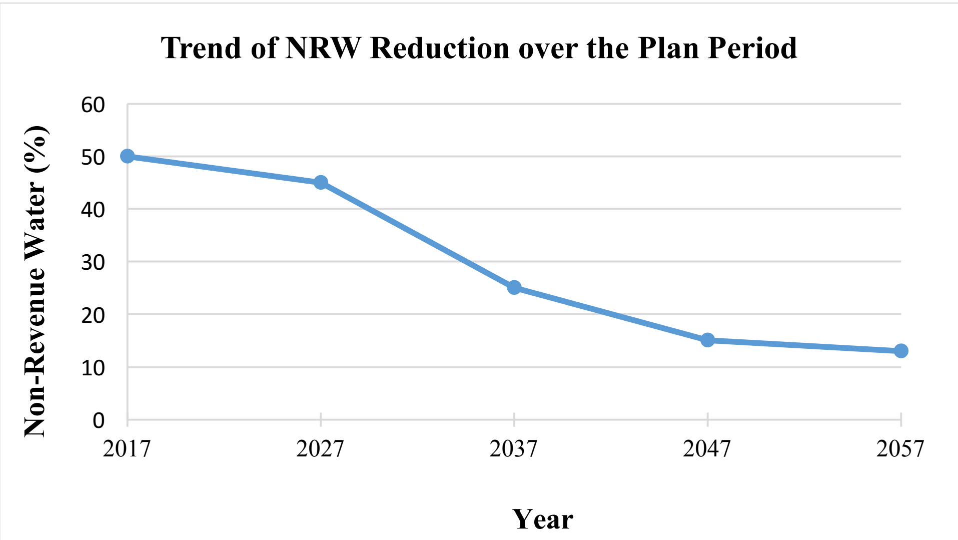
Collated summary of existing systems to be expanded to meet projected demand

System Technology	2018 Horizon	2022 Horizon	2026 Horizon	2030 Horizon	2034 Horizon	2038 Horizon	2042 Horizon	2047 Horizon
PS	724	560	448	358	328	274	114	57
STWS	313	37	457	482	468	476	495	517
PUWS	1	58	7	33	15	3	6	48
UWS	5	7	6	8	7	5	5	10

Non-Revenue Water

System management performance in terms of non-revenue water is indicated in the figure below. Non-revenue water losses will reduce from an urban average of 50 percent to less than 15 percent by 2047.

Non-Revenue Water Target



Financial Requirements

A total investment of $9 billion is required to carry out the required infrastructure developments over the plan period.

INTEGRATED WASTE MANAGEMENT

The vision is to provide an integrated and sustainable waste management and sanitation infrastructure and services that ensure a healthy living environment for all and supports agriculture and industrial development.

Current Situation

Only about 3.9 percent of the population of Ghana (3.6 percent urban, 0.3 percent rural) has access to sewerage systems and this generates about 61,500 m^3 of sewage a day. A little over 50% of the population has access to solid waste collection services. The remainder employ unacceptable disposal methods such as burning, dumping in open public spaces and burying on compounds.

Expected Sanitation Outcomes

i. Affordable and sustainable household and public sanitation facilities and appropriate technologies for 100% access provided;
ii. Adequate infrastructure for conveyance, treatment and disposal including reuse (sewage and septage) provided. One hundred percent (100%) coverage of improved sanitation (sewerage and on-site) by 2033 and 2041 for urban and rural communities, respectively.

Expected Targets for Sanitation

Year	Urban		Rural	
	Sewerage (%)	Improved On-site Technology (%)	Sewerage (%)	Improved On-site Technology (%)
2021	5	40	1	30
2025	10	45	2	35
2029	20	60	5	50
2033	30	70	10	60
2037	40	60	15	65
2041	50	50	20	80
2045	60	40	30	70
2047	70	30	30	70

Expected Solid Waste Management Outcomes

The framework expects the following outcomes to be achieved with respect to the management of solid waste:

i. Facilities and services for 95% source separation and minimisation of waste provided on individual, institutional, commercial, etc., premises.
ii. Infrastructure for 100% collection and transportation of municipal waste provided.
iii. Infrastructure for 100% effective management of Municipal Electrical and Electronic Waste (MEEW) provided.

Land Area Requirements

By 2047, it is projected that about 9 km^2 of land area per annum would be required for landfilling. Due to an increasing rate of urbanisation and the resulting scarcity of land for final waste disposal, it may be desirable to secure lands in outlying areas of urban clusters within metropolitan and municipal areas for future use.

Financial Requirements

A total investment of US$31.1 billion will be required to achieve the objectives and set targets for integrated waste management by 2047.

DRAINAGE, FLOOD CONTROL AND COASTAL PROTECTION

The vision is to improve drainage, and reduce the risks of flooding and coastal erosion on people, the economy, environment and society.

Existing State of Drainage, Flood Control and Coastal Protection Management

Some cities where floods have occurred in recent times are Accra, Cape Coast, Takoradi, Tamale, Kumasi, Koforidua, Bolgatanga and Ho. Flooding has led to the destruction of coastal infrastructure in urban areas and small fishing villages, threatened important cultural and historical resources, hindered coastal tourism development, and affected the socio-economic life of the local populations in many areas, especially around Keta, Ada, Accra, Nkontompo and Shama. It has also attracted national attention in recent times.

Strategies for Reduction of Flooding in Northern Savannah Zone

There is the need to develop civil and cultural systems for water resources management to ensure the proper planning, evaluation, monitoring and funding of water resources projects that are coming up in the SADA zones. Other strategies include the following among others:

i. Organise and reinforce consultations among countries sharing common water resources with the country, the riparian countries of the Volta Basin and all development partners interested in and concerned with the development of water resources of the basin;
ii. Harmonise the national policies relating to the management of the water resources of the Volta basin, through the adoption and enforcement of integrated water resources management throughout the basin;
iii. Replace vegetation by replanting trees to minimise the rate of soil erosion and subsequent sediment transport into the rivers.

Strategies for Reduction of Flooding in Urban Centres

There is the need to strengthen and enforce land use planning in urban centres. There is also the need to increase the provision of permanent underground storm sewers to replace the current open channels. This system will provide a unique measure for solid waste control. The following are proposals for flood reduction in urban centres among others:

i. Carry out an assessment of the current drainage capacities in urban settlements and delineate flood prone areas;
ii. Overlay flood prone areas with social and economic hotspots to guide the development of interventions;
iii. Prepare development plans for the urban communities as well as the hydraulic infrastructures and carry out cost-benefit analyses, and social and environmental impact assessments of each of the plans.

Strategies for Reduction of Coastal Floods and Erosion Degradation

The following strategies will be employed to reduce coastal floods and erosion degradation:

i. Barriers to coordinated action against coastal erosion and flooding will be removed;
ii. There is the need to set up an inter-agency group to focus on coastal management programmes in the country;
iii. There is the need to strengthen weak regulatory and planning frameworks;
iv. There is the need to adopt integrated approach to solving coastal flood shocks requiring coordination among key stakeholders, including traditional authorities and civil societies;
v. The focus will be on financing and investing in coastal protection and capacity-building programmes, including awareness and sensitisation and supporting the development of new coastal policies and regulatory frameworks;
vi. There is the need to educate communities on how to combat coastal erosion and adapt to climate change. Local governments and NGOs could play key roles in this direction.

Financial Requirements

A total investment of US$42.7 billion is required to carry out the implementation of drainage, flood control and coastal protection activities during the plan period.

IRRIGATION INFRASTRUCTURE

The vision is to harness the natural resources of water and land to produce enough food to achieve national food and nutrition security, as well as increase foreign exchange through exports by 2047.

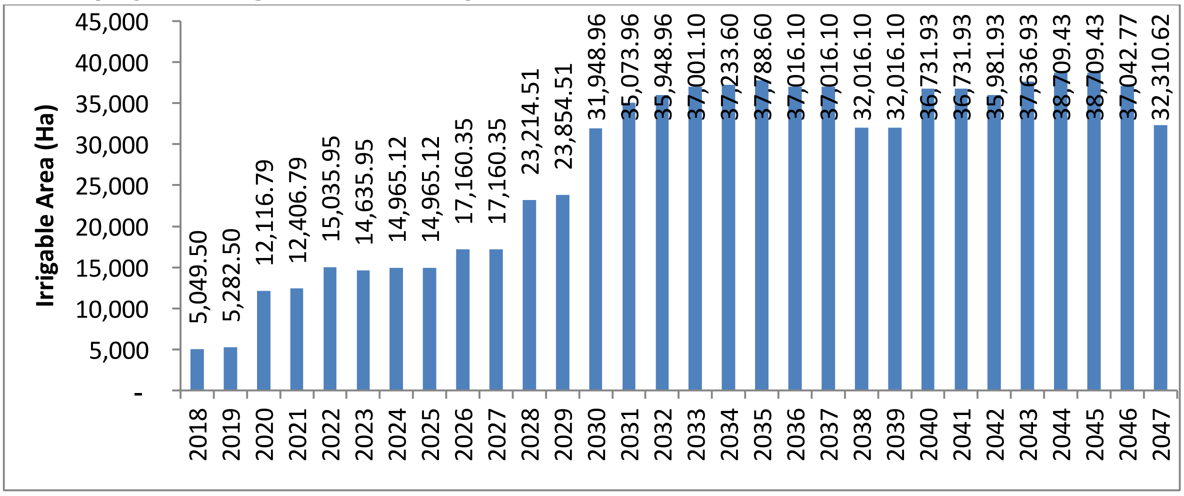
Current State of Irrigation

Ghana has a total land area of 23.8 million hectares of which the cultivable land area is estimated to be 13.6 million hectares. The irrigable potential is 1.9 million hectares but only 30,000 hectares (2%) has been developed by both formal public and private sectors, leaving over 98% of the potential untapped. It is said that about 200,000 hectares, 11% of potential of informal private sector is developed but this figure is yet to be verified. Ghana's irrigation infrastructure is categorised into formal, informal and commercial systems. Presently, only about 11,000 hectares of irrigable land is funded by the public or formal sector. Small scale informal irrigation accounts for 189,000 hectares while commercial irrigation accounts for 21,000 hectares. There are 56 public irrigation schemes distributed throughout the various regions of Ghana.

Projected Irrigable Area Development

It is estimated that about 822,762 hectares will be put under various irrigation systems in the country during the 30-year GIP period. In addition to the existing total current formal irrigation coverage of 30,000 hectares, the total irrigated area envisaged to be covered by the programme will be 852,762 hectares, forming about 45% of the estimated nationwide available irrigable land of 1.9 million hectares.

Annual projected irrigable area development



Capital Investment Requirements

A total amount of US$7.166 billion is required for irrigation infrastructure development is within the plan period.

HUMAN SETTLEMENTS, HOUSING, AND SOCIAL, CIVIC AND COMMERCIAL INFRASTRUCTURE

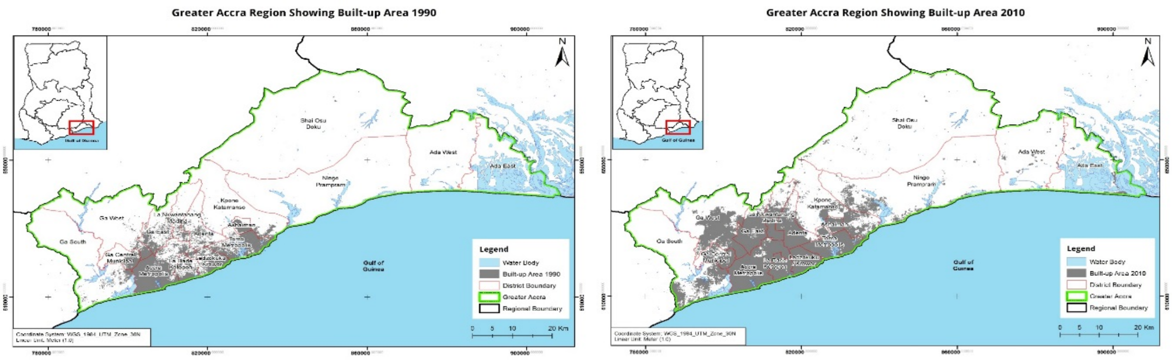
The country's vision for the human settlements, housing and civic infrastructure sector is to safeguard the quality of the living environment, while ensuring that settlements are accessible, safe and sustainable, with adequate housing supply and social infrastructure that are efficient and equitably distributed, all towards developing cities as engines of growth and development.

Generally, the spatial pattern of settlements in the southern parts of the country are more nucleated, with higher built-up population densities. The northern parts of the country, on the other hand, exhibit a rather sparse appearance, with lower population densities, making them less supportive of basic infrastructure and services than the former, which among other things, instigates an out migration phenomenon towards the southern parts of the country, particularly to Accra, the capital and the most populous city in the country, as well as Kumasi, the second most populous city in the country, causing settlements in these areas to expand rapidly and putting undue pressure on existing infrastructure, causing them to stretch beyond elastic limit.

Rapid population growth and increased urbanisation means shelter is a very critical commodity in Ghana. Over the years, the demand for housing in the country has far outpaced supply; resulting in the high cost of building and renting, majority of the citizenry are priced out of the housing market, thereby prompting a wide deficit. This has contributed to the spurring on of informal housing delivery systems and causing them to thrive. With resultant issues as overcrowding, decline in the quality of housing and its ancillary facilities, etc. The housing sector is thus presented with challenges arising in both quantitative and qualitative terms.

Again, the rapid growth has prompted massive urban sprawl and led to the formation of greater metropolitan/functional areas. This phenomenon arises when an existing Metropolitan Area extends beyond its administrative boundaries to merge with smaller surrounding towns, with which they share strong economic linkages. The Greater Accra Metropolitan Area (GAMA) and the Greater Kumasi Sub-Region have been formed as a result of this phenomenon. In the case of GAMA, the urban sprawl is currently spilling across the Central and Eastern regional boundaries with places like Kasoa and Aburi serving as dormitory towns for people who work in Accra, thus constituting a part of the daily commuting zone of the area.

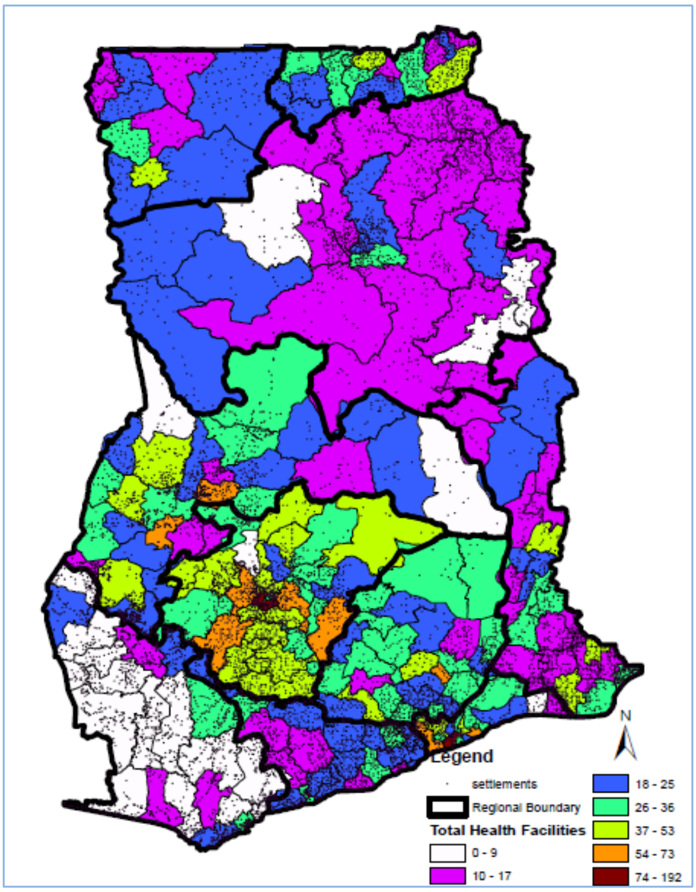
Built up foot print in Greater Accra between 1990 and 2010



A simple *"needs assessment"* conducted, based on the standards set in the Zoning Guidelines and Planning Standards[5]; reveals a significant deficit in the provision of social infrastructure. Facilities for Health and Education are markedly skewed towards the southern part of the country, although the western region has been quite neglected, especially where health facilities are concerned.

[5] This document was produced by the Ministry of Environment Science and Technology in collaboration with the Town and Country Planning Department, in November 2011, to serve as a guide and to describe the criteria acceptable for the use or development of a piece of land or an area, as well as to determine the scale, location and site requirements of various land uses and facilities.

Distribution of Health Facilities at MMDA Level, 2016



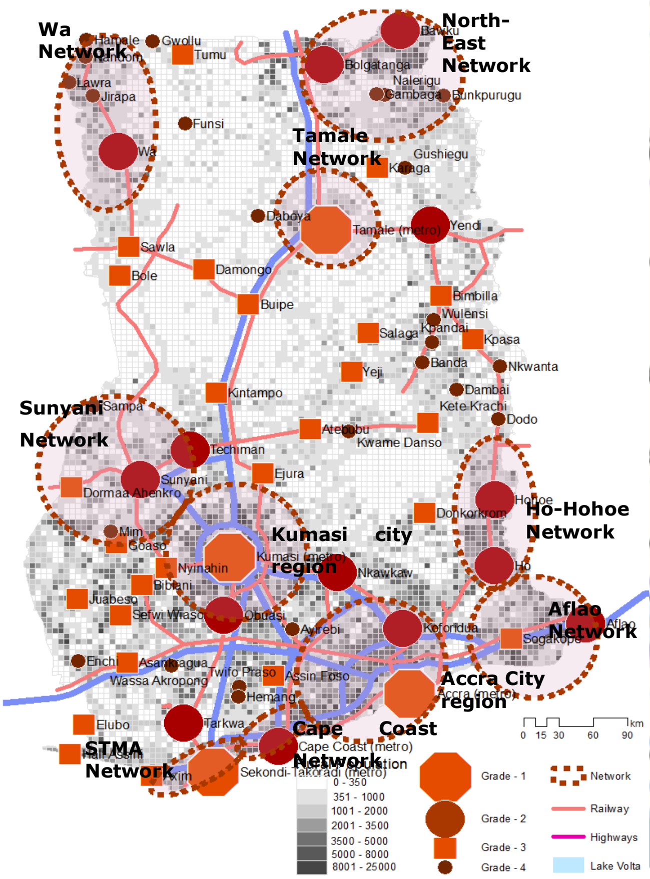
Systems to support the judiciary services in the execution of justice in the country are also considerably inadequate, with major correctional facilities in the country, significantly overcrowded and lacking the required ancillary facilities to foster reformation and rehabilitation in addition to the current form of punishment, which is just incarceration and denial of freedom.

Given the vision of the country to attain high-income status by the end of the plan period, human settlements, housing as well as social, civic and commercial infrastructure will be given critical attention, to ensure that the citizenry live in dignity, under habitable conditions, and have their infrastructure needs adequately met.

The NSDF proposes a network of human settlements based on a hierarchy, to ensure symbiotic synergies are developed between the highest levels of settlements, through the medium to the least in the hierarchy of settlements in the country. Strong transportation networks, and other social, civic and commercial infrastructure in the form of health, education, energy, ICT and waste management infrastructure, will to be incorporated to ensure the efficient delivery of services.

It is also important to protect the ecological assets of the country. Green spaces, parks and gardens etc., will be incorporated, not only as a way of preserving the environment, but to improve the health and the safety of the citizenry.

National Spatial Development Framework and growth nodes linked to resource endowments



Based on this, growth nodes have been identified, around which development growth should be planned. These nodes are endowed with resources that could be tapped into to promote industrialisation. They are thus expected to attract large proportions of the population. It is therefore proposed that future housing supply be planned around these.

The 2010 PHC established a housing deficit of about 2.7 million. In establishing the housing need for the plan period, the NDPC, together with the National Population Council defined three (3) population growth scenarios of high, medium and low variants as a basis for the housing needs assessment for the plan period. Based on the average population growth scenario, an extra 7.9 million houses need to be added to the housing stock of the country. Assuming the deficit from the year 2010 persists, a total of about 10.6 million housing units are required to accommodate the total Ghanaian populace by the year 2047.

Estimated housing needs per household, 2010 to 2047 based on average growth rate scenario

Year	Projected Population	HH Size	Population per HH size	Average HH per house	No. of HH = Population/HH size/Ave. HH per house	No. of houses/1,000	20% houses in good condition (with toilet, water, access road)	DEFICIT TO DATE = Extra Houses required ('000)
2010*	24,658,823	4.44	5,553,789	1.61	5,467,136	3,393	679	2,714
2015	29,491,279	4.38	6,733,169	1.55	6,733,169	4,344	679	3,665
2020	30,819,286	4.32	7,134,094	1.50	7,134,094	4,756	679	4,078
2025	34,329,697	4.24	8,096,627	1.45	8,096,627	5,584	679	4,905
2030	38,040,887	4.15	9,166,479	1.40	9,166,479	6,547	679	5,869

2035	41,925,917	4.05	10,352,078	1.35	10,352,078	7,668	679	6,990
2040	45,997,564	3.97	11,586,288	1.30	11,586,288	8,913	679	8,234
2045	50,168,787	3.88	12,930,100	1.25	12,930,100	10,344	679	9,666
2047	51,842,835	3.8	13,642,851	1.20	13,642,851	11,369	679	**10,690**

Source: NDPC and Authors' estimates (2016)

Again, the demand for housing in Ghana is influenced by the ability of the household to afford and to pay for it. However, given the current situation in the country, only about 50% of households are capable of renting a house for Gh¢300 or less per month and 35% requiring accommodation with rents of GHC10 or less. The government must adopt and follow sustainable housing processes to enable the citizens to acquire housing with secure tenure in an integrated society within a safe and healthy environment.

Housing affordability pyramid

Income Range	Income GHC/Month	Percentage of all Households	Maximum affordability HC:Y=3	Housing cost aimed at the thresholds*	Monthly maximum rent levels affordable at R:Y of 10%
Very High	>4,000	5%	180,000	476,000 & 204,000	500+
High	3,001-4,000	10%	144,000	163,200	400
Mid-high	2,001-3,000	50% of households can afford housing costing less than GH72,000	108,000	95,200	300
Middle	1,001-2,000		72,000	Up to 54,000	200
Moderate	501-1,000		36,000		100
Low Income	101-500		18,000		50
	51-100	35% of households can afford housing costing less than GHC12,000	12,000		10
No wage Income	0-50				

To ensure the successful implementation of the proposals made in the human settlement, housing and social, civic and commercial infrastructure sector plans, these must be linked directly to the provision of energy, water, transport, ICT, waste management, (etc.) sectors. Over the plan period, the human settlements sector is expected to achieve the following goals:

i. Sustainable city planning and urban development;
ii. Cities without slums and/or informal settlements;
iii. Efficiency in the use of urban land;
iv. Improved functionality, efficiency and resilience of both existing and new settlements;
v. Enhanced quality of life and environment of rural communities and small towns;
vi. Improved institutional capacities to effectively manage urban development and space; and
vii. Healthy, prosperous and equitable cities.

The housing sector is expected to achieve the following goals:

i. Provision of adequate new housing through stimulation of market efficiency and competition with public assistance for no and low-income households who cannot afford adequate housing;
ii. Sustainable management of existing housing stock through enhancement of market mechanisms and land redevelopment to ensure optimum housing choice;
iii. Developed and enhanced systems for sustainable housing supply and inventory management;

iv. Sustainable human settlement growth and development that encourages liveable neighbourhoods with compact mixed-use development guaranteed;
v. Improved institutional capacities to effectively manage urban development and space;
vi. Improved functionality, efficiencies and resilience of human settlements; and
vii. A mature, robust and functioning housing market to efficiently supply and allocate through the market system guaranteed.

In the Social and Civic Infrastructure Sector, the following goals are expected to be achieved:

i. A healthy and productive population that reproduces itself safely;
ii. Social and civic infrastructure facilities that are robust and responsive, and also support society's wellbeing and transition to a high income country;
iii. Informal commercial facilities and spaces regularised and modernised; and
iv. Environmental quality of urban life improved.

Various initiatives proposed for implementation within the period include the following:

i. National Urban Regeneration Programme;
ii. Commercialisation of Local Building Materials, Construction Technology and Skills Improvement;
iii. Public Institutional Housing Scheme (Redevelopment & Rehabilitation);
iv. Mass Housing Scheme (Ownership and Rental);
v. Revitalisation of distressed mining towns;
vi. Smart growth of rural communities and small towns etc.

The successful implementation of the sector plans will ensure efficient land and settlement management, adequate housing and civic infrastructure supply, to improve the delivery of services for an enhanced quality of life for the citizenry.

INFORMATION AND COMMUNICATIONS TECHNOLOGY

The main goal for the ICT sector plan by the end of the plan period, is to build a 21st century digital infrastructure to drive economic growth, improve governance, enhance competitiveness, and support social development, while positioning Ghana to play a leading role in the development and export of technology globally.

Within the plan period therefore, the following priority areas are proposed in order to ensure that ICT infrastructure and use attain optimal application to promote socio-economic development.

Telecommunication Infrastructure

Ghana currently has an internet penetration rate of 17.1% [6]. Improving telecommunications infrastructure (broadband, wireless, fibre optics) widely in the country, will not only offer more opportunities for increased economic growth, but will also enable Ghana to achieve an internet penetration rate comparable to OECD countries

[6] https://www.oecd.org/aidfortrade/casestories/casestories-2017/CS-03-A4AI-Affordable-Internet-in-Ghana.pdf

and that of global leading countries. Government therefore, must ensure that every citizen and each household has access to broadband services. Also, fibre optic cables must be extended to remote and underserved communities, schools and health facilities, public places and homes.

ICT Facilities

These include such facilities as innovation parks, incubators, community information centres (CICs) etc. that are important resources for socio-economic development in digital economies. Many city authorities in more advanced economies are tapping into the use of such facilities to plan, design and monitor development occurrences in a development concept termed as "smart cities".

It is envisioned that by the end of the plan period, each regional capital would have been developed into a smart city, using innovative digital technology to plan and monitor occurrences within their catchments, with each regional capital having an ICT park with an accompanying ICT incubator as a hub for nurturing young entrepreneurs, developing innovative ideas, generating revenue as well as creating employment in the country.

National Digital and E-Government infrastructure

The E-Transform Ghana project (which is sponsored by the World Bank[7]) has been going on since the year 2014, and is expected to provide the necessary ICT infrastructure for effective, efficient and transparent e-government and economic systems. There are different sub-areas to be covered including building a National Identification System, an E-government portal, an E-Immigration system etc. These sub-projects are in different stages of finalisation and will be completed by the end of the year 2019 to help stimulate an effective e-governance system in the country.

Geographic Information System (GIS) Database

Ghana's online location infrastructure remains very limited and unreliable. The country will capture its evolving spatial data in order to build an online GIS database, to store space and time based data, which will provide opportunities for trend and time series analysis. The captured data will be updated periodically to show changes in spatial patterns as they evolve, so as to inform policymaking and analyses. Government is therefore required to develop and implement an online GIS application system.

ICT infrastructure Financing

Financing ICT infrastructure requires huge investments. While government funding may exist, other alternatives including Public Private Partnerships (PPP) will be explored. To ensure maximum government ownership, partnership arrangements will incorporate such strategies like the Build Operate Transfer (BOT) for example, so that ownership can be transferred to the government after expiration of the agreement period. To implement an effective PPP, for example, government will develop a comprehensive PPP policy and guidelines specifically for ICT infrastructure financing.

[7] See: http://projects.worldbank.org/P144140/gh-etransform-ghana?lang=en&tab=overview

Areas for ICT Policy Updates

Ghana has developed a number of ICT policies over the years. These include the National Cyber Security Policy and Strategy as well as the Interconnect Clearing House Policy. These policies are more recent, and thus reflect current trends in ICT advancements. However, other policies like the ICT for Accelerated Development (ICT4AD) for example, are obsolete and will be reviewed. Again, while these policies exist, they have not been adequately implemented and thus will be given the requisite attention for implementation.

Areas for ICT Laws Updates

Although some laws have been passed to support the use of ICT in a more legitimate way, most of the laws are not up to date. Some ICT laws like the Copyright Law, the Electronic Transactions Act, the National Information Technology Act, the Electronic Communications Act and Data Protection Act will be reviewed, updated and extended to cover the full extent of ICT use in the country.

Chapter 1 Context of the Ghana Infrastructure Plan

1.1 Introduction

The National Development Planning Commission (NDPC – also called the Commission), acting in accordance with the 1992 Constitution embarked on a process in 2015 to develop a Long-term National Development Plan (LTNDP) to shape the scope and content of the medium term plans that the country has used for decades. The vision for the long-term development framework is based on the 1992 constitution and the aspirations of Ghanaians as expressed during nationwide consultations organised by the Commission between 2015 and 2016.

1.1.1 Path to High-Income Country Status

The LTNDP envisages that by 2057, when Ghana celebrates its 100th independence anniversary, the country's economy would be:

i. Ranked among high-income countries;
ii. Export-oriented, industrialised, diversified and resilient;
iii. Driven by Ghanaian entrepreneurship;
iv. Characterised by high-value services;
v. Dynamic, with a globally competitive manufacturing sector;
vi. Have an efficient agricultural sector capable of feeding the nation and exporting to global markets.

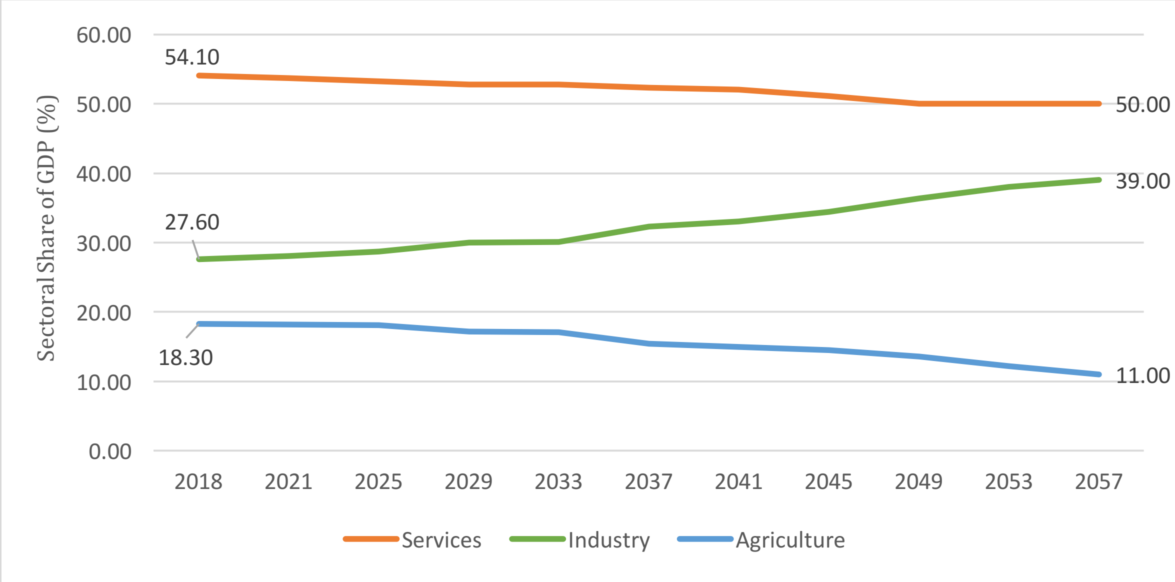
1.1.2 Ghana's Economy by 2057

The LTNDP is expected to facilitate Ghana's transition from a lower middle-income country to a high-income one by 2057. Under the Plan, the Commission expects Ghana's economic output, or Gross Domestic Product (GDP), to increase from an estimated US$45.5 billion in 2018 to about US$ 3.6 trillion in 2057, driven by an ambitious programme of industrialisation and export-led growth. Average national income (or per capita gross national income (GNI)) is expected to grow to just about US$60,000, about US$22,000 in today's prices.

Underlying this ambitious programme of economic transformation would be extensive policy and institutional reforms to attain and sustain macroeconomic stability over the period while pursuing sectoral policies to free the entrepreneurial energies of Ghanaian, raise household incomes, and reduce overall poverty to its barest minimum.

The structure of the economy for the next 40 years as projected by the NDPC is represented in Figure 1.1.

Figure 1.1: Economy structure Projection between 2018 and 2057



Source: NDPC, 2016

Infrastructure will play a key role, and the logistics sector will be developed to ensure maximum use of physical infrastructure. It is expected that by 2047 (10 years before the end of the full long-term plan), the infrastructure assets of Ghana would have been substantially developed to support the implementation of the Long-term Plan and the consolidation and maintenance of progress in the years to come.

1.1.3 Population and Urbanisation Rates

NDPC projects a population of 57 million by 2057, at an average per capita annual growth rate of 1.8%, as indicated in Table 1.1. The overall strategy of the LTNDP is to combine the lessons of Ghana's development record with the future needs of a growing and urbanising population. The country's urbanisation rate for 2057 is projected to be 73%.

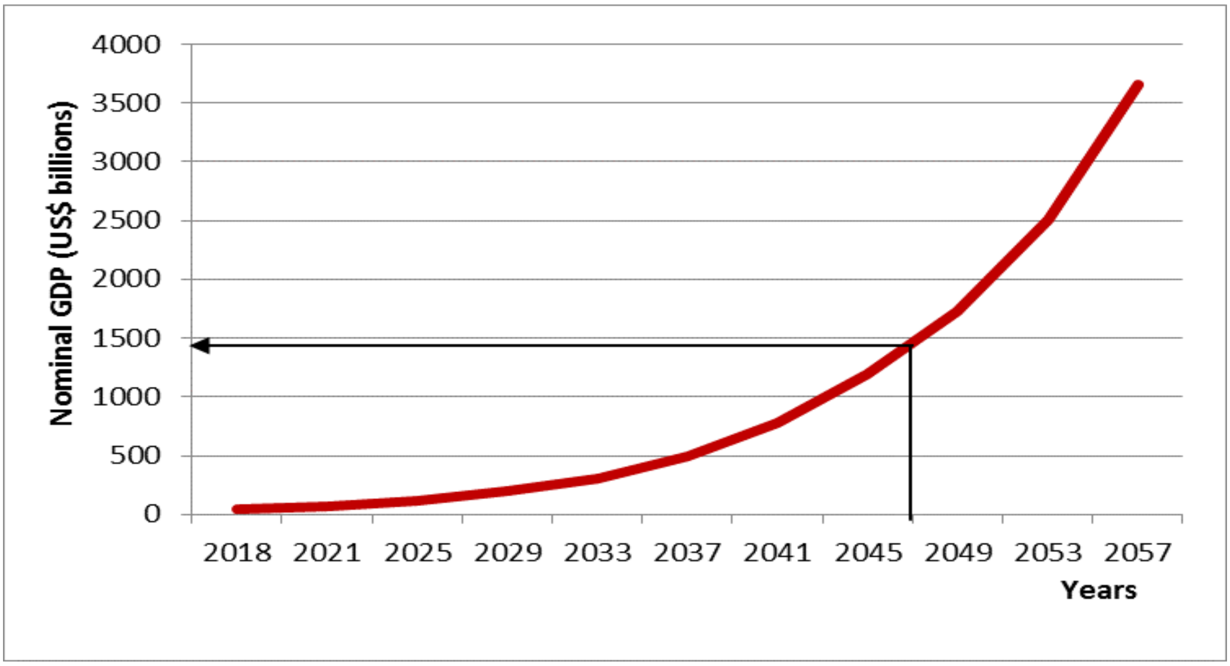
The projected nominal GDP, population and average income per capita, as shown in Table 1.1, are graphically represented in Figures 1.2, 1.3 and 1.4 respectively. The values for 2047 (i.e. three 10 year successive planning periods) are indicated by the black target lines in all cases.

Table 1.1: Indicative socio-economic forecasts for the LTNDP

	Nominal GDP	Population	Average Income/capita
2018	45,564,368,220	28,595,511	1,545.61
2021	72,985,307,591	31,350,200	2,237.81
2025	119,000,617,944.12	34,256,905	3,350.00
2029	194,027,367,132	37,145,602	4,959.90
2033	310,794,325,134.34	40,329,218	7,336.34
2037	497,832,413,869	43,590,722	10,927.58
2041	783,348,941,258.02	47,031,554	16,156.14
2045	1,189,178,848,428.63	49,862,784	23,133.56
2049	1,728,448,467,519.97	52,442,784	31,969.99
2053	2,512,267,596,736.01	54,895,789	44,434.28
2057	3,651,533,230,870.54	56,998,784	62,202.57

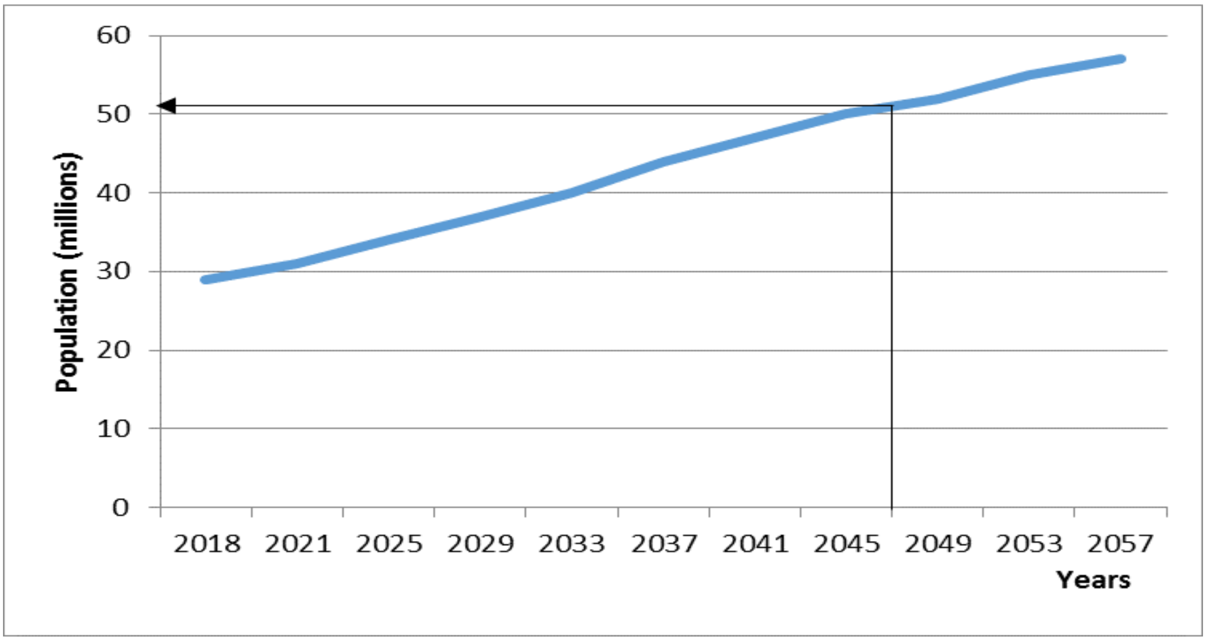
Source: NDPC, 2017

Figure 1.2: Estimated Nominal GDP (billions) 2018-2057



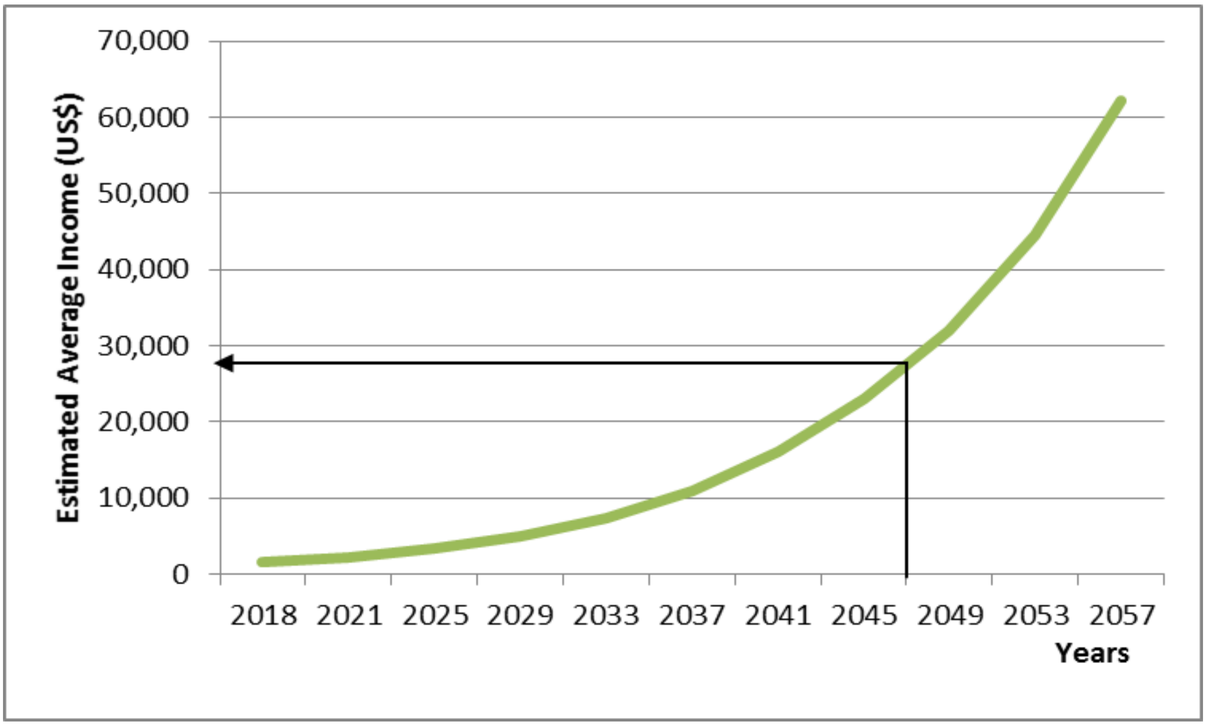
Source: NDPC, 2017

Figure 1.3: Estimated Population (millions) 2018-2057



Source: NDPC, 2017

Figure 1.4: Estimated Average Income 2018-2057



Source: NDPC, 2017

1.2 Status of Infrastructure Sector

Ghana has made major strides in modernising and extending some its infrastructure stock, including roads, telecommunications, and ports. However, service delivery in other areas, such as water, sanitation and electricity lag behind significantly. Population and economic growth have thrown a harsh spotlight on infrastructure bottlenecks and accentuated the demand for increased infrastructure services in these areas.

The 2016 Afrobarometer survey reflects these concerns and asserts that some residents of the country still do not have access to basic services. This is confirmed by a survey by the Association of Ghana Industries (AGI), which indicates that infrastructure quality is still perceived by business users to be unsatisfactory. Again, the Global Competitiveness Report 2015/16 ranks Ghana's infrastructure quality 120th out of 140 countries. This establishes the extent Ghana has to go, as a country, in order to reach standards befitting a country aspiring to be high-income. According to the report, Ghana ranks low in overall quality of transport and electricity supply, at 120th and 127th respectively, out of 140 countries and 94th in terms of port infrastructure. It is important to acknowledge these issues as a useful starting point to identify and understand the fundamental challenges that the infrastructure sector of Ghana is facing. Electricity, transport, water and sanitation, and housing are probably the most important services required by the majority of the population.

1.2.1 Electricity

The rapid growth in electricity demand and low water inflows to the Akosombo and Kpong hydropower reservoirs as well as lack of coherent sector planning, led the country into a crisis, with an electricity supply deficit and a consequent power load shedding severe enough that it derailed the achievement of economic growth targets. The power shortages slowed down businesses and manufacturing activities including the operations of mines.

Although Ghana is doing relatively well in overall electricity access in Africa, as reflected in an estimated overall rate of access of approximately 65% in 2012 according to the World Bank, this pales in comparison to Ghana's peer group of middle income countries.

1.2.2 Transportation

The country has a transportation system consisting of two large deep-water ports, a 947 km railway system, a 72,000 km maintainable road network, one international airport and eight regional airports and airstrips located throughout the country. Certain inefficiencies exist in the transport sector that pose a major threat to growth and development. First of all, there are no available alternatives to road transport for movement of bulk commodities for export. These would be better handled by rail. The railway system, which has limited coverage, serves only the southern part of the country, including Tema, and is virtually broken. Related to the rail transport is also an efficient public rail transport system to serve the masses.

1.2.3 Water and Sanitation

Numerous economic and social activities in both private and public sectors rely on the supply of clean water and adequate sanitation for their operations (e.g. large retail, wholesale, food, and agro-processing sectors). However, almost a third of the population does not have access to safe drinking water and two-thirds do not have access to adequate sanitation. Managing the urban water delivery system is fraught with such challenges as intermittent water supply, inadequacy in extending supply to new customers and weak financial performance by the Ghana Water Company Limited (GWCL). With facilities being obsolete, the ability to deliver service to an urban population, growing at an average annual rate of 3.5%, is unduly stretched.

The increasing urban population also puts a strain on limited infrastructure, which, in the case of sanitation, calls for improved systems for the collection, management, treatment and disposal of urban wastes in order not to aggravate the pollution of the environment, water bodies and thus stimulate flooding.

1.2.4 Science and Technology

The speed with which quality information can be accessed, processed and utilised for technological, social and economic gains requires increased commitment to the deployment of science, technology and innovation (STI) in our public and civic institutions. The optimal technology for high-speed telecommunications is fibre optic cable, but its widespread deployment is expensive. Currently, only a relatively small proportion of the country, primarily key business centres, is serviced with fibre optic cable.

1.2.5 Housing

The demand for housing far outpaces supply, resulting in relatively high cost of housing. Of particular concern is the current housing deficit, officially 1.7 million, but unofficially about 3 million. This huge backlog is estimated to be growing at 70,000 units per year. The provision of housing by the state has been characterised by high cost and cost overruns, rendering much of the housing units unaffordable to the many Ghanaians. This has contributed to emergence of slums and informal housing delivery systems, with such issues as overcrowding, decline in the quality of housing and associated facilities.

1.2.6 Other Sectors

Other challenges exist in the irrigation and drainage and flood control sectors, etc.

1.3 The Ghana Infrastructure Plan (GIP)

The GIP is a major component of the long-term development framework. It is based on the National Spatial Development Framework (NSDF), which was completed in February 2015 as well as the economic, social and spatial development of the long-term plan. The GIP encapsulates Ghana's vision and strategic direction for infrastructure development. It also defines investment principles and priorities over the first 30 years of the implementation of the long-term development framework. The aim of the GIP is to deliver economic, social, and environmental benefits to the country through the production of a defined and budgeted investment framework.

The development of the GIP, therefore, is to serve as a framework to address the challenges, using a combination of effective policy, institutional and financing measures, within a 30-year planning horizon. The document recognises the potential social consequences and provides the necessary interventions to avert possible socio-economic and spatial challenges.

1.3.1 Vision and Strategies for the GIP

The GIP will guide the formulation and implementation of the LTNDP that will run from 2018 to 207 and also chart a new strategic direction for infrastructure, guide the future direction of infrastructure delivery and define the nation's investment priorities for the first 30 years of implementation.

The GIP provides a coordinated and integrated approach to infrastructure planning, prioritisation, funding and delivery by engaging with key stakeholders across government, industry and communities while prioritising Ghana's infrastructure needs from the perspective of a prosperous nation. Although the GIP focuses largely on public infrastructure projects, it also addresses the need to create enabling conditions for developing private infrastructure, and highlights opportunities for the private sector to engage government to find creative solutions for infrastructure delivery. Indeed, a large part of the programme will be financed by the private sector.

1.3.2 Ghana’s Infrastructure by 2047

The new development framework envisages that by 2057 the country would be ranked among high-income countries of the world, with an industrialised, diversified and export-oriented economy that is resilient against the vagaries of the global economy. Ghana needs a modern network of infrastructure, well-planned and maintained, to support such a transformative national development agenda.

1.4 Benchmarking Ghana’s Infrastructure against International Standards

Ghana’s infrastructure performance in key sectors in terms of stock, access rates, quality and costs of services was compared to those in Middle-Income Countries (MICs) and High-Income Countries (HICs). This benchmarking exercise is useful to get a sense of the areas in which the scope for improvements is the largest, in order to help policy makers determine the level of interventions needed as the country transition from lower middle-income country to high-income country. Table 1.2 shows international infrastructure benchmarks for Lower Middle Income, Upper Middle Income and High Income Countries, while Table 1.3 shows the provisional infrastructure targets by 2057 as Ghana transitions to achieve high-income status[8].

[8] The information was obtained from the World Development Indicators and MDA reports submitted to NDPC.

Table 1.2: Benchmarking Ghana's Infrastructure access with international average benchmarks

Indicators		Year	Ghana	LMIC	UMIC	HIC
ENERGY	Electronic power consumption per capita (kWh)	2015	348	743	3,214	8,508
	Electricity generated by hydropower (% of total)	2015	64	16.8	20.1	13.1
	Access to Electricity (% of total population)	2012	64.1	78	98.7	99.8
	Electric power transmission and distribution losses (% of output)	2015	23	15.22	8.7	7
	Electricity production from coal sources (% of total)	2013	0	46.10	51.9	6.12
	Electricity production from natural gas sources (% of total)	2013	10.40	20.88	17.13	11.77
	Electricity production from nuclear sources (% of total)	2008-13	0	4.99	3.79	26.39
	Electricity production from oil sources (% of total)	2013	0	6.58	3.08	17.70
	Electricity production from oil, gas and coal sources (% of total)	2013	10.40	73.56	72.11	3.74
	Electricity production from renewable sources, excluding hydroelectric (% of total)	2013	0.023	3.75	3.07	61.49
FOREST COVER	Proportion of land area covered by forest (ha/annum)	2016	40.1	28.7	28.8	34.5
	Annual Rate of Deforestation	2016	-0.3	0.4	0.0	0.0
WATER	Internal Freshwater resources per capita (cu. m)	2015	1,131	3,065	6,594	11,319
	Access to improved water source (% of total population)	2016	89	90	95	99
	• *Rural (% of Rural population)*	*2016*	*84*	*87*	*91*	*97*
	• *Urban (% of Urban population)*	*2016*	*93*	*94*	*97*	*99*
	Households using piped water as major source of drinking water (%)	2015	15	52	80	96
	• *Rural (% of Rural population)*	*2015*	*9*	*42*	*67*	*97*
	• *Urban (% of Urban population)*	*2015*	*20*	*67*	*88*	*97*
	Households reporting access to a flush toilet (%)	2016	15	52	80	96
	• *Rural (%)*	2016	9	42	67	93
	• *Urban (%)*	2016	20	67	88	97
ICT	Mobile Cellular subscriptions (per 100 people)	2014	114.8	87.6	101.4	125.7
	Individuals using the Internet (% of population)	2014	18.9	22.6	47.7	80.6
	Fixed broadband subscriptions (per 100 people)	2014	0.27	2.35	12.71	30.62
	Fixed telephone subscriptions (per 100 people)	2014	1	4	-	42
	Internet users (per 100 people)	2014	18.9	22.6	-	83
	Ownership of a Personal Computer (per 100)	2007	0.6	4.6	12.4	67.4
HOUSING	Proportion with access to secure housing (%)	2010	13.5			
	Population living in slums (% of urban population)	2014	38	30	0.0	0.0

Source: World Development Indicators 2015; Energy Commission

Table 1.3: Indicative Infrastructure Targets envisaged under the LTNDP

INDICATOR	***Base Year***	***Baseline***	***Target (2047)***
General			
Nominal GDP US$ Billion	2016	44.0	1,370
Per Capita GDP US$	2016	1,546	27,195
Population in Millions	2010	24.659	51
Urbanisation Rate	2012	51	70
Annual Rate of Deforestation % (93,790 ha/y)	2006	-1.7	0
Shelter			
Household Size	2010	4.6	3.5
Number of Dwelling Units (in Millions)	2010	5.818	13.8
Number of Rooms (in Millions)	2010	5.467	23.39
Proportion with access to secure housing (%)	2010	13.5	90
Population living in slums (%)	2014	38	4
Energy			
Access to Electricity (% of total population)	2012	64.1	99
Total Energy Capacity (Installed) - MW	2016	3,800	50,168
Total Electricity production / GWh (Installed)	2016	16,401	297,200
Electricity consumption per Capita/KWh	2015	348	5,800
Total electricity losses (%)			
- Transmission	2016	4.5	3
- Distribution	2016	22.8	8
Renewable Energy stock (% in energy mix)	2016	0.7	18
Renewable Energy (Total installed in MW)	2016	28	9,000
Irrigation			
Total Irrigated land per arable land (ha)	2012	12,042	834,804
Irrigated lands per arable land (%) [7.93 mil]	2012	0.15	10.5
Water Supply			
Internal Freshwater resources per capita /m3	2015	1,131	2,262
Total Freshwater resources per capita/m3	2015	1,941	2,911
Per Capita Water consumption (litres)	2012	50	300
Access to improved water source (% of total population)	2016	89	99
Households using piped water as major source of drinking water (%)	2015	15	90
Non-Revenue Water (% of water produced)	2014	50	10
Sanitation (Sewerage)			
Access to Safe Sanitation (%)	2014	15	95
Households reporting access to flush toilet (%)	2013	14	70
Sewerage network system (% of safe sanitation)	2013	3	50
Solid Waste Collection (% of waste generated)	2012	20	90
Transport			
Length of road network (km)	2014	71,419	253,000
Road Density (road-km/1000 km2)	2014	300	1,060
Road network in good condition (% network)	2014	35	70
Ratio of paved to total Road network %	2014	23	70
Vehicular population per 1000 persons	2015	64	250

Source: GLSS 6; Energy Commission and GIP Team, 2017

1.5 Global Commitments underpinning the GIP

While the strategic thrust of Ghana's long-term development framework is primarily driven by the objective to become a high-income country by the end of the planned period, the plan also accommodates regional and international commitments, which the government seeks to implement. The following regional and international commitments are integral part of the GIP:

i. The United Nations Sustainable Development Goals – Agenda 2030
ii. The African Union Agenda 2063
iii. Intended Nationally Determined Contributions (INDCs) of the Global Climate Change Agreement

1.5.1 The UN Sustainable Development Goals – Agenda 2030

In its 70th Session held on 15 September, 2015, the UN General Assembly adopted an outcome document titled "Transforming our World: The 2030 Agenda for Sustainable Development" to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. Over one hundred and fifty heads of state attended that UN summit. The SDGs, made up of 17 goals and 169 targets adopted at that meeting address the root causes of poverty and the universal need for development that works for all people.

The goals cover the three dimensions of sustainable development: economic growth, social inclusion and environmental protection. It includes recommendations on how nations should proceed in the implementation of the goals. It is expected that governments will develop their own national indicators to assist in monitoring progress made on the goals and targets. One of the key recommendations in "Transforming Our World" basically boils down to involving everybody. Governments, businesses, communities, educational institutions - everyone has a role to play in making the SDGs a reality.

The President, Nana Akufo-Addo, is the co-Chair of the Eminent Group of Advocates for UN SDGs. The implementation of the SDGs was reinforced in September 2017 with the President's inauguration of the High Level Ministerial Committee for SDG inclusion in national planning, budgets and implementation. These inter-ministerial bodies, at technical, strategic, and political levels, recognise that the SDGs are not stand-alone goals. They are all interconnected; therefore, working to achieve one goal helps achieve another. In June 2018, 22 United Nations Agencies in Ghana agreed to provide coherent and efficient support for key sectors of the economy to help the country achieve the SDGs.

The document, the United Nations Sustainable Development Partnership (UNSDP) 2018-2022, reflects Ghana's national goals and its commitments to global development initiatives and sets out the UN system's collective contributions to help the Government and other stakeholders achieve these goals. The 22 UN bodies made a commitment of $442 million for the 4-year partnership programme. The UNSDP partnership programme is aligned to the Coordinated Programme of Economic and Social Development Policies, 2017-2024, which sets out a vision for agricultural modernization, industrial diversification, and youth employment; embeds national strategies to localize and achieve the SDGs; and articulates a self-reliant pathway to economic transformation and inclusive growth through four results areas:

- Shared prosperous economy
- Social investment in people
- Protected and safe environment
- Inclusive, accountable governance

The UNSDP reflects the conviction that the UN works should support the SDGs attainment and expresses the nature of work with the UN as a partnership rather than as a source of assistance. In order to achieve the SDGs, substantial investment will be required in both developed and developing countries. This agenda will require the mobilization of significant resources—in trillions of dollars. But these resources already exist. There are far more than enough savings in the world to finance the agenda. The Ghana Infrastructure Plan fully addresses most of the objectives of the SDGs including how to direct investment so that it supports sustainable development.

Table 1.4: Alignment of the GIP sector goals with the SDGs

Sector	**Sector Goal**	**Applicable SDG**
Energy	Provide reliable and robust energy infrastructure that stimulates economic growth, poverty alleviation and general wellbeing.	Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all.
Transport	Provide an integrated, efficient, cost effective and sustainable transportation system responsive to the needs of society, supporting growth and poverty reduction and capable of establishing and maintaining Ghana as transportation hub of West Africa.	Goal 1. End poverty in all its forms everywhere. Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable.
Water	Provide assured water and healthy ecosystems for the present and future through an efficient management system	Goal 6. Ensure availability and sustainable management of water and sanitation for all
Human Settlements and Housing	Create viable and sustainable communities through the provision of adequate, decent and affordable housing that is accessible and sustainable to satisfy the needs of Ghanaians	Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
Social, Civic and Commercial Infrastructure	Build dynamic, robust social infrastructure facilities that will create the enabling environment for Ghana's accelerated and planned transition from a middle-income status to high-income status.	Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable.
Information and Communication Technology (ICT)	Build a 21st century digital infrastructure to drive the economic growth, improve governance, enhance competitiveness, and support social development, while positioning Ghana to play a leading role in the development and export of technology globally.	Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Source: Author's construct

1.5.2 The Africa Union Agenda 2063

The Africa Union Agenda 2063 is a strategic framework document for the socio-economic transformation of African economies by 2063. It seeks to accelerate the implementation of past and existing continental initiatives for growth and sustainable development. It was adopted at the 24th Ordinary Session of AU Assembly of Heads of State and Government held in Addis Ababa, Ethiopia, on 30-31 January 2015. The First 10- Year Implementation Plan (2013-2023) requires member states to domesticate Agenda 2063 into their plans for development at national and regional levels.

The overall goal of Agenda 2063 at national level is to assist member states to craft new self-driven and Africa-centric visions for development and socio-economic transformation on a common long- term 50-year continental framework. The specific objectives are threefold: (i) to build citizens' awareness, engagement and appropriation to catalyse and sustain momentum for change and transformation, (ii) ensure that member states translate commitments enshrined into national visions and plans for medium term socio-economic development and transformation, and (iii) facilitate collective progress of member states leading to the transformation of the continent and ensuring that Africa assumes her rightful place on the global stage, including her ability to finance her own development. Agenda 2063 will be implemented, monitored and evaluated as an integral part of Ghana's national development framework and plan.

Table 1.5: Alignment of the GIP with the goals of the AU Agenda 2063

Sector	Sector Goal	Applicable AU Agenda 2063 Goal
Energy	Provide reliable and robust energy infrastructure that stimulates economic growth, poverty alleviation and general wellbeing	Goal 1. A High Standard of Living, Quality of Life and Well Being for All Citizens
Transport	Provide an integrated, efficient, cost effective and sustainable transportation system responsive to the needs of society, supporting growth and poverty reduction and capable of establishing and maintaining Ghana as transportation hub of West Africa	Goal 10. World Class Infrastructure criss-crosses Africa
Water	Provide assured water and healthy ecosystems for the present and future through an efficient management system	Goal 7. Environmentally sustainable and climate resilient economies and communities
Human Settlements and Housing	Create viable and sustainable communities through the provision of adequate, decent and affordable housing that is accessible and sustainable to satisfy the needs of Ghanaians	Goal 1. A High Standard of Living, Quality of Life and Well Being for All Citizens Goal 7. Environmentally sustainable and climate resilient economies and communities
Social, Civic and Commercial Infrastructure	Build dynamic, robust social infrastructure facilities that will create the enabling environment for Ghana's accelerated and planned transition from a middle-income status to high-income status	Goal 1. A High Standard of Living, Quality of Life and Well Being for All Citizens Goal 7. Environmentally sustainable and climate resilient economies and communities

Information and Communication Technology (ICT)	Build a 21st century digital infrastructure to drive the economic growth, improve governance, enhance competitiveness, and support social development, while positioning Ghana to play a leading role in the development and export of technology globally	Goal 10. World Class Infrastructure criss-crosses Africa

Source: Author's construct

1.5.3 Ghana's Intended Nationally Determined Contributions

Ghana's international obligation as a Party to the United Nations Framework Convention on Climate Change (UNFCC) is to develop a policy framework that integrates adaptation, mitigation and other climate related policies within broader development policies and planning in order to safeguard developmental gains from the impacts of climate change and build a climate resilient economy.
At the milestone the 17th Session of the Conference of the Parties (COP) held in Durban, South Africa in December 2011, the Parties decided to "develop a protocol, another legal instrument or an agreed outcome with legal force under the Convention applicable to all Parties" for adoption at the twenty-first session of the COP and for it to come into effect and be implemented from 2020. Parties agreed that their work will address inter alia, mitigation, adaptation, finance, technology development and transfer, transparency of action and support, and capacity building.

Based on its national circumstances, Ghana has put forward mitigation and adaptation actions in its Intended Nationally Determined Contributions (INDC). In all, 20 mitigation and 11 adaptation programme of actions in 7 priority economic sectors are being proposed for implementation in the 10-year period (2020-2030). The implementation of the actions is expected to help attain low carbon climate resilience through effective adaptation and greenhouse gas (GHG) emission reduction in the following priority sectors:

- Sustainable land use including food security
- Climate proof infrastructure
- Equitable social development
- Sustainable mass transportation
- Sustainable energy security
- Sustainable forest management; and
- Alternative urban waste management.

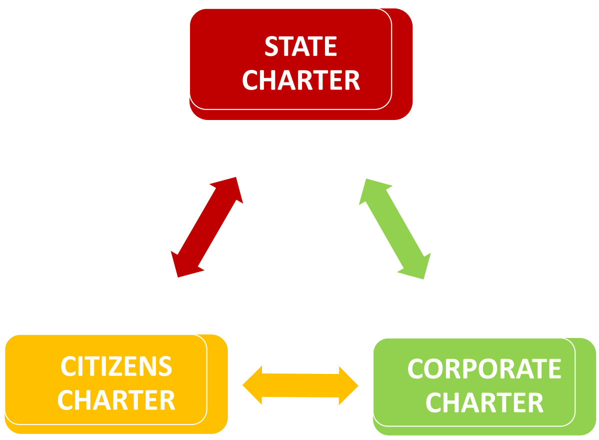
1.6 Inculcating a Habit of Discipline among the Citizenry

Towards attaining a high-income country status, it is necessary to ensure that the average citizen has a mindset and attitude that fits within the contexts of a high-income country status. Discipline should therefore be strongly encouraged both at home and in schools, as a foundation to building more responsible adult citizens. While parents should be charged with the responsibility of raising responsible youth and young adults, the role of education and training, whether formal or informal, should also not be downplayed.

The Plan crafts a recovery programme for the State, Corporate Ghana, and citizens called 'The Ghana Charter'. The Ghana Charter will be a tripartite deal aimed at establishing a more secure environment, develop infrastructure, reform business and financial practices, nurture good citizenry, and offer work to the unemployed. It aims to modernise the industrial and agricultural sectors, reduce crime, improve credit in the financial sector, and promote development. The essence of the deal is that while the country needs the State to provide adequate security and protection, corporate Ghana and industry are needed to drive the growth agenda through business innovation, while citizens put up law-abiding and responsible behaviour.

The Citizens Charter ensures that good, responsible and hardworking citizens are needed in a industrializing economy. It shall ensure that every Ghanaian citizen gets the chance to make the most of him or herself. The key message to the Ghanaian is that if they pursue life-long education and work hard, they are better off and be rewarded. If they play by the rules, the State will stand by them. These shall be the best of Ghanaian values and responsibilities required in return for rights; fairness not just for some but all who earn it.

Figure 1.5: The Ghana Charter



Source: Author's construct

Chapter 2 Electric Power

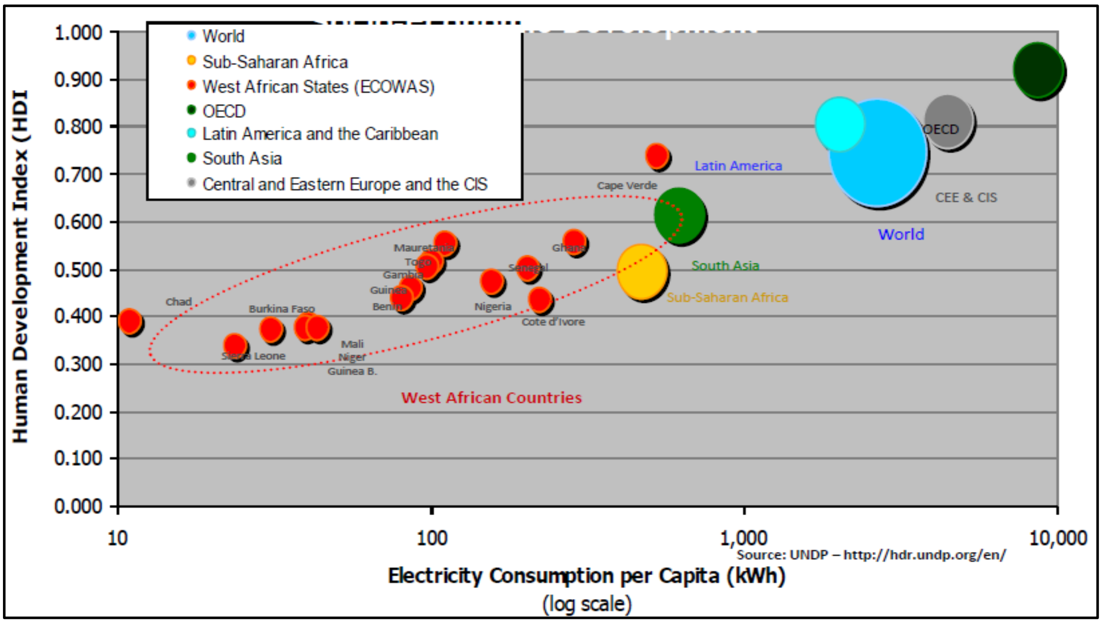
2.1 Introduction

The significance of a National Energy Infrastructure Plan is derived from the fact that a reliable and robust national energy infrastructure stimulates economic growth, alleviate poverty and improve the general wellbeing of citizens. The remarkable economic and social development achieved in high-income countries such as South Korea, Australia and the United States of America could not have been accomplished without significant increase of reliable and affordable energy services to industries, social services and households. It is imperative therefore, that if the country is to develop to achieve economic growth and prosperity, and eradicate poverty as anticipated under the Long-term National Development Plan (LTNDP), then huge amounts of reliable and affordable electricity would have to be available to industry, social services and households.

This section of the report outlines the issues affecting electricity infrastructure in Ghana and proposes an electricity infrastructure expansion framework as part of the GIP, towards the attainment of the 40-year LTNDP objectives. It also proposes some recommendations necessary for the effective implementation of the power infrastructure expansion plan for sustainable national development towards the fulfilment of objectives of this long-term development plan.

Access to modern energy forms such as electricity has therefore been identified as critical to economic development. Figure 2.1 shows that a country's electricity consumption per capita is directly related to its Human Development Index (HDI)[9].

Figure 2.1: Relation between HDI and Electricity consumption per capita



Source: Energy Commission

The impetus for a national energy infrastructure plan is therefore underscored by the direct linkage between increased access to electricity and human development as measured by the United Nations HDI. In 2007 for example, Ghana's electricity

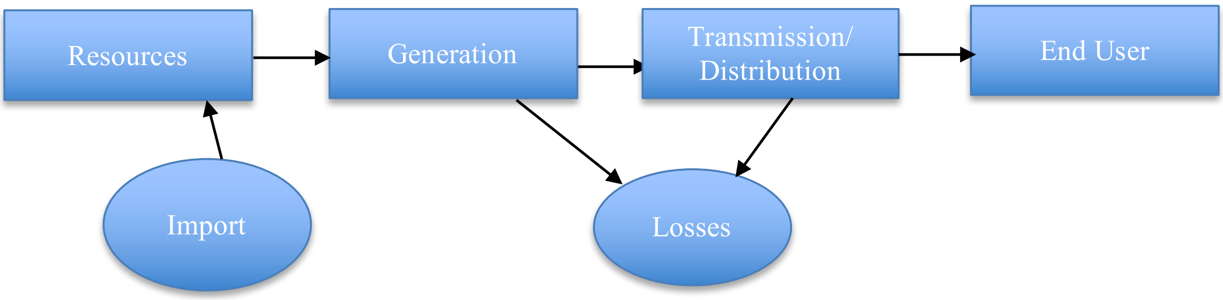
[9] UNDP Http://hdr.undp.org/en

consumption per capita was about 246 kWh/cap with a corresponding HDI of 0.57. On the other hand, the average electricity consumption for Organisation of Economic Cooperation and Development (OECD) countries was 8,355 kWh/cap with corresponding HDI of 0.80 (Figure 2.1).

2.2 Electricity Supply System

Ghana's current electricity supply system is dependent on fossil fuels, with hydro, gas and some renewables contributing to the total electricity supply of the Country. A number of physical and economic activities are involved to capture the energy and to deliver it in a usable form to users. The chain of systems or activities required to ensure supply of energy is known as the energy supply system. The supply system is simply made up of the supply sector, the energy-transforming sector and the energy-consuming sector depicted in Figure 2.2.

Figure 2.2: A Generic Electricity Supply System



Source: Author's construct

The supply involves indigenous production, imports or exports of resources. Transformation converts different forms of primary energies to secondary energies for ease of consumers. Transformation processes normally involve a significant amount of losses before the power is transmitted and distributed, and finally reaches end-users to utilise for cooling, heating, lighting, motive power, etc.

2.3 Ghana's Energy Resources and Fuel Supply Issues

2.3.1 Hydropower Potentials

The country has a number of rivers and streams with suitable hydropower potential. The hydropower potentials in the country have been classified into renewable (capacity less than 100 MW) and non-renewable (capacity exceeding 100 MW) categories. Renewable hydropower systems are classified into large, medium, and small-scale systems. Table 2.1 presents the capacity and the average generation of the hydropower systems in the country.

Table 2.1: Hydropower Potentials

Hydropower Systems	Capacity range (MW)	Number of Sites	Total Capacity (MW)	Average Generation (GWh)
Non-renewable	more than 100	3	1,580.0	6,300.0
Renewable	less than 1 to 100	38	838.8	3,545.9
Large-scale	between 10 - 100	16	837.0	3,544.0
Medium-scale	between 1 - 10	0	0	0
Small-scale	less than 1	22	1.8	1.9
Total Hydro Potential		41	2,418.8	9,845.9

Source: Energy Commission

The country's total hydropower potential is estimated to be about 2,420 MW, of which 1580 MW or 65.3 percent of this potential has been exploited. These are the Akosombo Hydropower Plant - 1020 MW, with a dependable capacity of 900 MW and the Kpong Hydropower Plant - 160 MW, with a dependable capacity of 148 MW, all on the Volta River. The third is the Bui Hydropower Plant - 400 MW, with a dependable capacity of 342 MW on the Black Volta River. The remaining 840MW is yet to be exploited and could yield a dependable capacity of 500MW.

2.3.2 Domestic Natural Gas Resources

In 2007, crude oil associated natural gas was discovered in the Jubilee Fields, offshore Cape Three Points in the country's sedimentary basins. Natural gas was again discovered in the Tweneboa, Enyenra and Ntomme (TEN); and Sankofa-Gye Nyame (SGN) fields. The total associated and non-associated natural gas reserves-in-place discovered increased from 0.57 Tcf (trillion cubic feet) in 2010 to about 2.38 Tcf in 2014, a four-fold increase. Exploration activities are going on to discover more reserves. Assuming 80 percent of the country's natural gas reserves-in-place would be recovered for electricity generation, that would be adequate to generate electricity for 25 years from a 1,200 MW combined cycle power plant with a heat rate of 7800 BTU/kWh. Table 2.2 shows the reserves and other features of the associated and non-associated natural gas fields discovered.

Table 2.2: Natural gas discoveries and reserves

Natural Gas Fields	Associated Gas-in-place (BCF)	Non-Associated Gas-in-place (BCF)	Year of discovery	Year of start production	Year of end of production	Expected Peak daily production (mmscf/day)
Jubilee	568	0	2007	2015	2022	100
TEN	294	59	2009 - 2012	2016	2027	85
SGN	287	1071	2009 - 2012	2016	2038	180

Source: Energy Commission

The main challenges with relying on domestic gas are:

i. The irregular natural gas supply from the Jubilee Field due to frequent shut-downs of the FPSO and Atuabo gas processing plant;
ii. The Atuabo gas processing plant, with a name-plate capacity of 150 MMscf/day (150,000 standard cubic feet/day) limits gas supplies from the domestic natural gas fields;
iii. Natural gas supply from the Jubilee Field is expected to peak in 2019 and then start a terminal decline up to 2035;
iv. Despite Tweneboa Enyenra Ntomme (TEN) and Sankofa Gye Nyame (SGN) coming online in 2016 and 2018, the long-term supply of domestic natural gas for

electricity generation is uncertain unless intense exploration activities are undertaken to discover new fields;

v. The high price of domestic natural gas, which varies from US$ 2.50/MMBTU (million BTU) for Jubilee gas to US$ 9.50/MMBTU for Sankofa gas compared to US$ 8.00/MMBTU for WAGP gas.

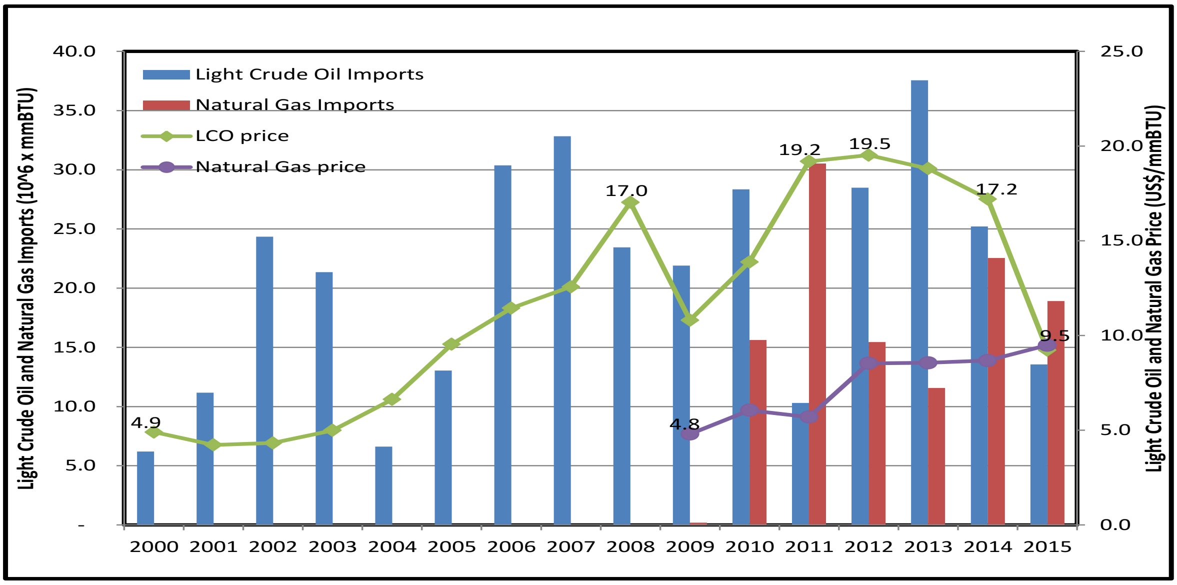
2.3.3 Natural Gas Imports

Ghana imports natural gas from Nigeria for electricity generation. Nigeria has proven natural gas reserves of about 180 Tcf[10]. Some experts however put Nigeria's natural gas reserves at about 110 Tcf and some even put it as low as 47 Tcf if strict commerciality criteria are applied[11]. Nigeria's current total natural gas export commitments are about 27 Tcf. However, commitments to increasing domestic gas demand leaves about 12 Tcf of uncommitted natural gas resources, which is sufficient to generate 50 GW of power for 50 years[12].

N-Gas, a subsidiary of Nigeria National Petroleum Corporation (NNPC) is expected by contract to supply an initial amount of 170 MMscf/day of natural gas through the 678 km West African Gas Pipeline (WAGP). The capacity of WAGP can however accommodate future growth in gas demand up to 474 MMscf/day maximum with compresssion additions. In case the gas volume increases to 474 MMscf/day, this would suffice for a 3,000 MW combined cycle power plant. However, since the commissioning of the pipeline in 2009, it has operated on the average below the contracted volume of 120 MMscf/day (which can generate about 750 MW from a combined cycle power plant) due to gas supply constraints in Nigeria, accidental damage to the pipeline on two occasions and non-payment for gas supplies. Figure 2.3 shows annual light crude oil and natural gas imports and the prices of these fuels.

[10] BP Statistics 2016
[11] Harnessing Africa's Natural Gas Resources: A New Opportunity for Africa's Energy Agenda by the World Bank
[12] Harnessing Africa's Natural Gas Resources: A New Opportunity for Africa's Energy Agenda by the World Bank

Figure 2.3: Annual light crude oil and natural gas imports and their prices



Source: Energy Commission

The key issues, with regards to the purchase of fuels for electricity generation from 2000 to 2016 are summarised as follows:

i. The average price of light crude oil increased from US$ 4.9/mmBTU in 2000 by 250 percent to US$ 17.0/MMBtu in 2008. It then decreased in 2009 before increasing to an all-time high of US$ 19.5/mmBTU in 2012. The price has however, decreased thereafter to US$ 9.2/MMBtu in 2015;

ii. The price of imported natural gas almost doubled from US$ 4.5/mmBTU in 2009 to US$ 9.5/MMBtu in 2015;

iii. The price of fuel imports for thermal electricity generation faced the challenges of: (a) foreign exchange erosion; and (b) instability and escalation of prices, which exerted pressure on the cost of procuring these fuels. For example in 2015, the average exchange rate of the GHS to the US$ was about GHS 3.77 compared to GHS 0.70 in 2000, which means the local currency depreciated by 440 percent and as such the cost of procuring fuels in GHS terms ballooned;

iv. These developments exerted an upward pressure on electricity tariffs and the cost of goods and services in the country;

v. Natural gas supplies through the West African Gas Pipeline since 2012 have been erratic and inadequate leading to periodic generation shortfalls of about 500 MW in 2015 and associated power supply crises[13].

Due to the existing challenges, it has been projected that domestic demand for natural gas will outstrip supply from domestic fields and imports through WAGP by 2025. Consequently, a Floating Storage and Regasification Unit (FSRU) will be constructed for the importation of liquefied natural gas (LNG) for electricity generation by 2020.

[13] Energy Commission, National Energy Outlook, 2016

2.3.4 Nuclear Energy

Studies conducted in the 1970s and more recently indicate that there are pockets of uranium deposits in some parts of Ghana. There are ongoing follow up studies to assess the commercial viability of these deposits. If the country is to depend solely on nuclear fuel imports, the supply of nuclear fuel is considered a lesser problem because nuclear fuel is cheap, constituting about 14 percent of the entire electricity generation costs, compared to 89 percent in gas and 78 percent in coal. In addition, a relatively very small quantity of fuel is needed per unit power generated and there is also the possibility of storing nuclear fuel for some time before usage. Nuclear power therefore enhances energy security due to these factors.

2.3.5 Coal

Generally, supply of coal in global markets does not change significantly like that of gas and crude oil. This is due to the relative ease of its ability to follow the market and increase or decrease output. This militates strongly against the price volatility of other fossil fuels. As an example, from Year 2000 to 2014 the cost of coal on the global market stayed generally below $5.0 /MMBtu, whereas price of crude oil and LNG rose from about $5 /MMBtu to above $15 /MMBtu. This explains why despite its environmental impacts, coal remains the world’s number one fuel source for electricity generation.

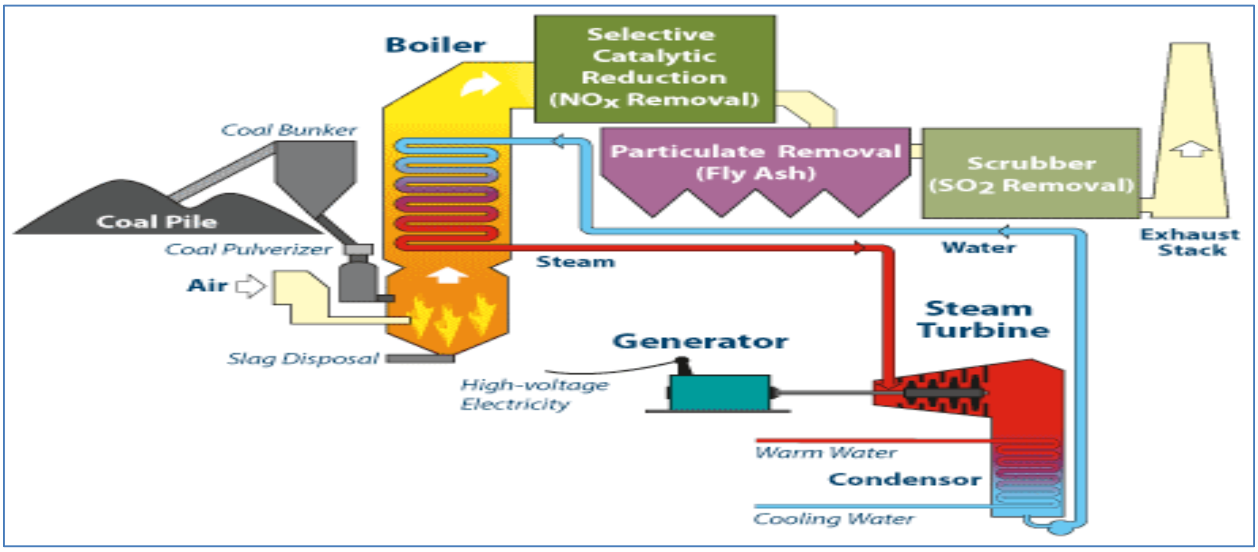
Background

Coal has over the centuries formed the backbone of the power sector of most developed countries. It has over the years provided low cost power to underpin their industrialisation. With electricity growth stagnant in these developed countries, and structural shifts in their economies to less energy intensive service sectors, as well as lower gas prices and increased commitment to mitigate climate change, there is now an increasing shift from coal to renewables and natural gas. However, given Ghana’s limited reserves of gas, and with low cost hydro sites already developed, coal would have to play a role in the country’s effort at ensuring adequate, reliable, competitively electric power for economic development.

Technology

Significant advances in coal technology over the past few decades have resulted in increasing efficiency and lower environmental impact. Currently, the main technologies being built are Supercritical and Ultra-supercritical, with efficiencies in excess of 40% net low heat value (LHV) compared to subcritical units, which make up more than 50% of the existing coal fleet that have efficiencies of about 30%. Generally, higher efficiencies mean a smaller quantity of coal is used to generate a unit amount of electricity, and therefore lower emissions per unit. Additionally, improvements in pollution abatement technology have considerably reduced other emissions such as SOx, NOx, particulates and dust, thereby reducing the impact of coal generation on the environment.

Figure 2.4: Schematic of Coal Plant



Source: IEA, 2012

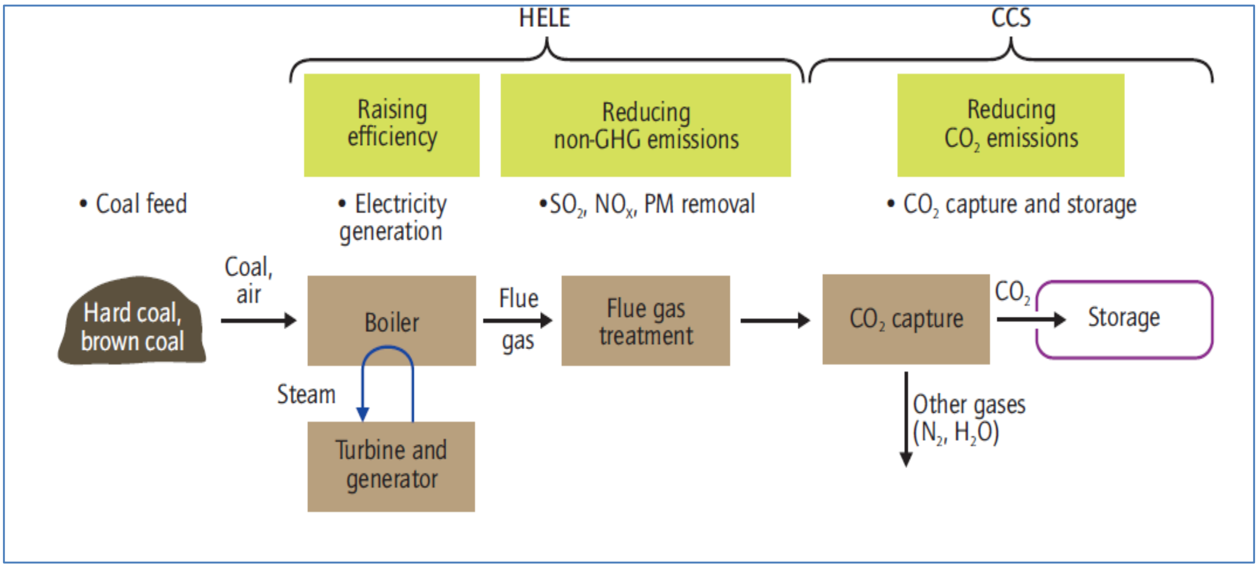
Regardless of the improvements in coal plant efficiencies, coal is noted to produce the highest carbon emission per unit of generation, and increased use of coal will result in an increase in pollution levels. Nonetheless, with the available emission control technologies and a well-balanced energy generation mix, it should be possible to still meet the country's greenhouse gas targets, while still ensuring reliable cost-effective and stable electricity prices.

Every modern economy needs a well-diversified energy mix to function well. To support Ghana's plans to industrialise and create a more mature economy, there is a need to diversify energy sources, while ensuring that power is cheap and sustainable to drive economic activity, and the kind of structural change that advanced countries have experienced in their economies.

Considering the above, and recognising that coal will generally continue to play a substantial power generation role, the International Energy Agency (IEA) in its 2012 Technology Roadmap, *Higher Efficiency, Low Emissions Coal Fired Generation Report*[14] presents the coal technologies of the future as follows:

[14] International Energy Agency, Technology Roadmap, Higher Efficiency, Low Emissions Coal Fired Generation Report, 2012

Figure 2.5: IEA Illustration of Higher Efficiency, Lower Emissions Coal Technologies



Source: IEA, 2012

Higher efficiency, low emissions (HELE) refers to using high quality hard coal, pulverised to ensure efficient burning, fed into a super critical or ultra-supercritical power plant, and employing the best available technologies to treat the flue gas to remove pollutants such as SO_2, NOx and particulate material. The HELE coal technologies increase the efficiency of a coal-fired power plant and significantly reduce emissions. For example, every 1% efficiency improvement results in 2%-3% reduction in CO_2 emissions.

The HELE technologies are very important not just for their emission benefits, but also for the essential steps they incorporate towards carbon capture and storage (CCS), which stores CO_2 underground. The CCS technology is the capture and sequestration of carbon dioxide underground to eliminate carbon emissions into the atmosphere. CCS is currently largely under development, and is yet to be commercially deployed anywhere in the world. The expectation is that CCS will become viable and will become an essential part of any new coal plant in future.

The SaskPower Boundary Dam coal-fired CCS project in Canada for example, reduces 100% of the power station's SOx emissions, as well as 90% of CO_2 emissions, and 56% of NOx emissions. The project captures one million tonnes of CO_2 annually, while producing 115 megawatts (MW) of power, which is enough to power approximately 100,000 homes.

Rationale for Coal

Coal has been considered in Ghana's power system master plans in the past and was also recommended as one of the favourable options by SNEP 2006-2020[15], but was not approved for construction for a number of reasons including:

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[15] Strategic National Energy Plan (SNEP) released by Energy Commission in 2006. www.energycom.gov.gh/planning/SNEP

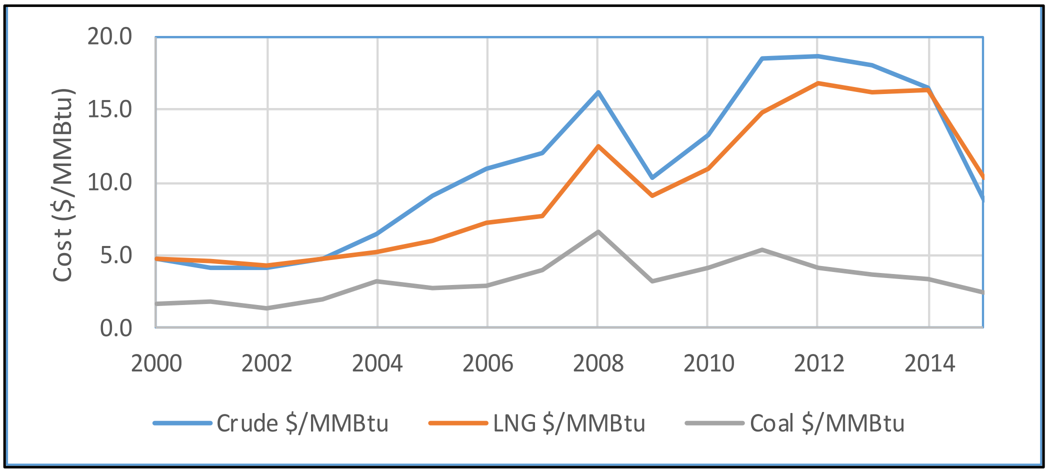
- Coal plants come in large sizes and will require significant supporting infrastructure such as ports and storage since Ghana did not have indigenous reserves;
- The small size of Ghana's power system meant it could not achieve the economies of scale required to make coal cost efficient;
- The small size of Ghana's power system placed a limit on the maximum generation unit size required for system stability;
- And recently, coal's environmental impact due to high greenhouse gas emissions.

The first three reasons are now no longer valid due to increasing demand, and Ghana's quest for strong industrial growth that is being put forward by the GIP.

Additionally, as noted in other sections, Ghana's indigenous gas will be depleted within twenty years, and the country will have to resort to imported LNG to make up. Given the highly volatile nature of the LNG price, a generation mix based on a high prominence of LNG would make future electricity prices very uncertain. Ghana will also have to rely on coal if it is to create the needed base load energy to power industries, firms and households.

Generally, coal supply in global markets is relatively elastic. That is to say that at different price levels, production can easily be adjusted in relation to available demand. The relative elastic supply of coal compared to other fuels contributes largely to its relatively lower price volatility. The relative advantage coal has in terms of price volatility will allow for relatively more stable electricity markets (especially in terms of revenues) and also facilitate energy planning especially in the area of costs and pricing, all other things being equal. Adding coal to the country's energy mix therefore provides an efficient hedge against fuel volatility, such as expected with gas prices.

Figure 2.6: Historical cost of fuels



Source: BP World Energy Statistics, 2015

Development of Coal Plants in Ghana

The Volta River Authority (VRA) and its partner Shenzen Energy of China have conducted detailed studies into the feasibility of developing a coal plant in Ghana, and the results show that coal will be competitive to gas fired generation if developed at significant scale. The chosen location of a coal plant is along the coast, at Ekumfi Aboano, near

Mankesim in the Central Region. The scope of the project includes a first phase of 2 x 350 MW supercritical units that will eventually be expanded to 2000 MW. Employing the efficient supercritical technology in the first phase of the project is possible due to the unit size. For the second phase, however, the more efficient ultra-supercritical technology would be considered for larger units in the range of 600 MW.

The first phase of the project also includes a dedicated port, fuel storage terminal, and ash storage area. Coal will be brought from South Africa and Colombia. The study shows the project to achieve maximum economies of scale at a capacity of 2000 MW.

Table 2.3: Cost comparison of Ghana's coal plant with plants in other countries

Plant	VRA/Shenzen (Phase 1)	VRA/Shenzen (Phase 1&2)	Medupi	Moropule	Safi	Kot Addu
Location	Ghana	Ghana	South Africa	Bostwana	Morocco	Pakistan
Capacity (MW)	700	2,000	4,800	600	1,386	660
Completion	2021	2025	2015	2013	2018	2015
Technology	Supercritical	Supercritical	subcritical	subcritical	supercritical	supercritical
total cost ($ mill)	1,454	3,192	8,000	990	2,600	1,000
specific cost ($/MW)	**2.08**	**1.52**	**1.67**	**1.65**	**1.88**	**1.52**

Source: Ghana Atomic Energy Commission

The table shows that the specific cost for the first phase is 2.08 $/MW which reduces to 1.52 $/MW after full development to 2000 MW. The reduction is due the spreading of the significant infrastructure cost over a larger output. This cost could possibly be reduced further if the available infrastructure such as the port is used to support an even larger capacity of plants. It must be emphasised that these costs do not take into account the cost of carbon emission into the environment. Funding for the project is expected to come from commercial sources including Chinese banks.

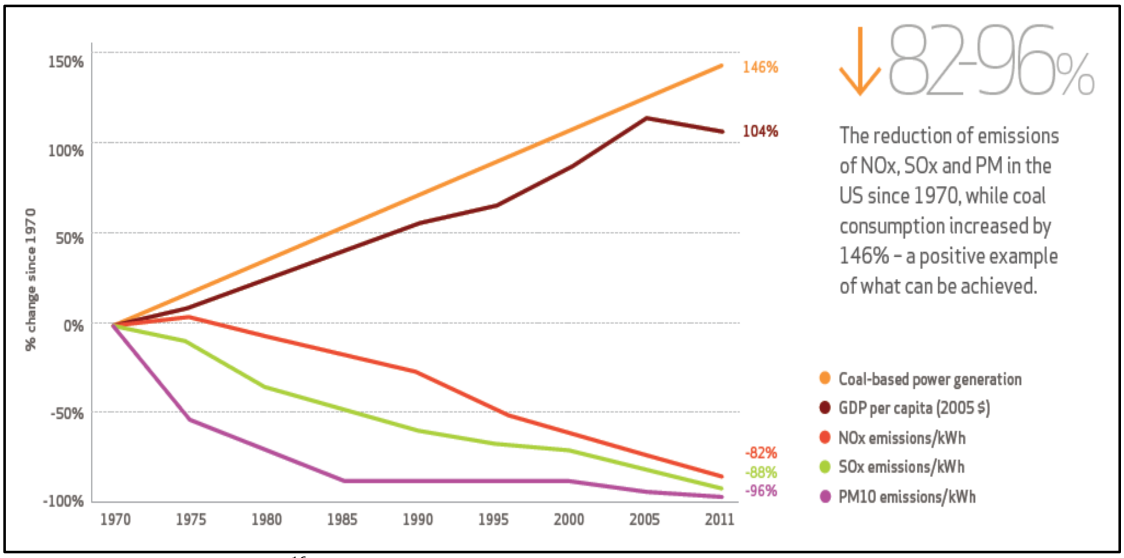
Mitigating Environmental Impact

Energy is an enabler of economic growth, development and progress. It must be understood that every technology has associated risk and environmental impacts. Producing energy invariably leads to some degree of environmental impact. Mitigating the environmental impacts associated with such technologies is of the greatest priority.

As discussed in the previous section, the use of coal for power generation would cause some associated negative environmental impacts, primarily through greenhouse gas emissions. The new clean coal technologies discussed above are means by which the coal industry is working to ameliorate the impact of coal on the environment. It has been noted in various circles that coal has demonstrated the ability to meet such challenges in the past, and the expectation is that the industry will successfully rise to the occasion to meet certain future environmental challenges.

Figure 2.7, taken from the World Coal Association article, *Coal and Air Quality*, shows the per kWh reduction in CO_2 emissions for coal plants in the US, relative to average emissions in 1970. The figure shows a remarkable reduction in emissions per kWh, mainly due to better generation technology.

Figure 2.7: Change in emissions of greenhouse gases per kWh compared to 1970 levels



Source: Loftus et al., 2015[16]

As part of efforts to secure a low-carbon coal future, every year between 2002 and 2011, Alstom saved 207 million tonnes of CO_2 (t CO_2) from being emitted by retrofitting new technology to existing coal plants[17]. The company is also currently actively involved in developing carbon capture technology methods in order to increase efficiency and combat climate change of existing and yet to be constructed coal power plants.

Furthermore, the foundation of the COP21 Paris Agreement was the commitment of countries to do more to lower world greenhouse gas emissions, particularly from coal based energy generation. Over fourty-four countries pledged to deploy HELE coal technologies to support their commitment to the reduction target.

It is estimated that about two gigatonnes of CO_2 emissions would be saved as a result of raising the average global efficiency of coal power plants from 33% to 40%. It is noted in some literature that the two gigatonnes saved as a result of this intervention would make far more positive impact on climate change, than many of the other actions that are being taken. The comparison is shown in the figure below.

[16] Loftus, Peter J., Cohen Armond M., Long Jane C. S., Jenkins Jess D. A critical review of global de-carbonization scenarios: what do they tell us about feasibility? WIREs Climate Change 2015, Vol. 6, Issue 1, pages 93-112

[17] World Coal Association, Leadership and Excellence Awards, 2013, UK.

Figure 2.8: Emissions reductions by policies/actions, t $CO_{2\ eq}$

Emission reductions by policies / actions, m tonnes $C0_2$ equivalent

Policy / Action	Cumulative emissions	Period	Annual emission*
Montreal protocol	135,000m	1989-2013	5,600m
Hydropower worldwide	2,800m	2010	22,800m
Nuclear power worlwide	2,200m	2010	2,200m
Increase average global efficiency coal-fired power plant to 40%			2000m
China one-child policy	1300m	2005	1,300m
Other renewables worlwide	600m	2010	600m
US vehicle emisions & fuel economy standards⁺	5,000m	2012-2025	460m
Brazil forest preservation	3200m	2005-2013	400m
India land-use change	177m	2007	177m
Clean Development mechanism	1,500m	2004-2014	150m
Collapse of USSR	709m	1992-1998	118m
Global Environment Facility	2,300m	1991-2014	100m
EU energy efficiency	230m	2008-2012	58m
EU renewables	117m	2008-2012	29m

* Annual emissions are cummlative emissions divided by relative period
The estimate of the current emissions avoided under the Montreal protocol is eight Billion tonnes of CO_2 equivalent
The annual figure of the collapse of USSR refers to the year 1992-1998, ⁺Cars and light truck

Source: The Economist 2014 and International Energy Agency 2013

Overcoming Public Resistance

As already discussed, increasing awareness of the impact of climate change as well as global initiatives to reduce greenhouse gas emissions has resulted in increasing public resistance to new coal plants. To overcome this, it is important to ensure transparent dialogue among all stakeholders on the rationale for the need for coal to be part of the country's energy mix. Such measures help efforts to mitigate local and global resistance to the establishment of new coal plants.

Apart from the impact coal makes to provide global baseload energy, its by-products are also used extensively in the construction industry. Some of these by-products, also called coal combustion products include fly ash, bottom ash, boiler slag, etc. Fly ash, for instance, can be used to replace or supplement cement in concrete. It is important to note that fly ash produces concrete and is a good substitute for ordinary Portland cement, and is more durable, and resistant to corrosion, alkali-aggregate expansion, sulphate and other forms of chemical attack. This is due to the inherent plasticity properties of fly-ash.

In the USA, for example, more than half of the concrete produced is blended with fly ash, which is a big industry in itself. Among the most significant environmental benefits of using fly ash over conventional cement is that greenhouse gas emissions can be significantly reduced. That is, for every ton of fly ash used in lieu of Portland cement, approximately one ton of carbon dioxide is prevented from entering the earth's atmosphere. This is because fly ash does not require the energy-intensive kilning process required by Portland cement.

Regulation

The Energy Commission of Ghana exercises regulatory oversight over the development of power plants in the country. The EC will therefore remain the institution responsible for regulatory oversight regarding the introduction of coal power plants in Ghana. To ensure that coal energy is developed in a safe and sustainable manner, a section or division will be detailed specifically for coal power plant regulation. This is significant since it will provide confidence to the public that coal power would be developed in an environmentally acceptable manner. Among others, the group can work to promote the role coal plays in the national energy agenda. This is particularly important since similar to nuclear, coal now faces stiff public opposition.

A critical initial requirement of the proposed coal regulatory group is the development of guidelines and requirements for emissions, technology and supporting infrastructure guidelines that prospective developers would have to meet. Noting the need to quicken the development of this energy source, the establishment of the proposed coal regulatory division at the Energy Commission must be considered in earnest.

2.3.6 Energy from Renewable Sources

Ghana has several renewable energy resources like wind, solar, mini and small hydro, tidal wave, biomass and biogas that can be exploited for electricity production and supply in the country. The government has therefore identified renewable energy as one of the options to contribute to the overall energy supply mix and minimise the adverse effects of energy production on the environment.

2.4 Electrical Energy Generation

2.4.1 Electricity/Power Generation Overview

The total electricity generation output almost doubled from 7,223 GWh in 2000 to 13,224 GWh in 2016 at an average annual growth rate of 3.9 percent. The total installed electricity generation capacity more than doubled, increasing from 1,418 MW in 2000 to 3,737 MW by the end of 2016. The development of electricity generation power plants, their installed and dependable generation capacities in 2000, 2010 and 2016 (Table 2.4).

Table 2.4: Installed capacity of electricity generation systems

Power Plant	Fuel Type	2000 Installed Capacity (MW)	2000 Dependable Capacity (MW)	2000 % of Total Installed Cap	2010 Installed Capacity (MW)	2010 Dependable Capacity (MW)	2010 % of Total Installed Cap	2015 Installed Capacity (MW)	2015 Dependable Capacity (MW)	2015 % of Total Installed Cap
Akosombo	hydro	788	700	55.6	1020	900	47.0	1020	900	26.2
Kpong	hydro	160	148	11.3	160	148	7.4	160	148	4.1
Bui	hydro	0	0	0	0	0	0	400	342	10.3
Sub-total		948	848	66.9	1180	1048	54.4	1580	1390	40.6
Takoradi T1	LCO/Gas	330	300	23.3	330	300	15.2	330	300	8.5
Takoradi T2	LCO/Gas	110	100	7.8	220	200	10.1	330	300	8.5
Tema TT1	LCO/Gas	0	0	0	110	100	5.1	110	100	2.8
Tema TT2	Gas	0	0	0	48	45	2.2	48	45	1.2
CENIT	LCO	0	0	0	0	0	0	110	100	2.8
MRP	Gas	0	0	0	80	40	3.7	80	40	2.1
Tema Diesel	Diesel	30	20	2.1	0	0	0	0	0	0
Sunon Asogli	Gas	0	0	0	200	180	9.2	200	180	5.1
Sunon Asogli Upgrade	Gas	0	0	0	0	0	0	360	320	9.2
Kpone	DFO	0	0	0	0	0	0	230	200	5.9
Karpower	HFO	0	0	0	0	0	0	245	210	6.3
AMERI	Gas	0	0	0	0	0	0	250	230	6.4
Sub-total		470	420	33.1	988	865	45.6	2293	2025	58.9
VRA Grid Solar PV	Sunshine	0	0	0	0	0	0	2.5	1.9	0.1
BXC	Sunshine	0	0	0	0	0	0	20	15.2	0.5
Sub-total		0	0	0	0	0	0	22.5	17.1	0.6
Total		1418	1268	100	2168	1913	100	3895.5	3432.1	100

Source: Energy Commission

2.4.2 Power Generation Challenges

Electricity supply in Ghana has been unreliable over the past three decades, characterised by periodic nationwide power crises as well as localised power outages in certain areas of the country. Droughts have resulted in power generation shortfalls, leading to three major nation-wide power rationing exercises since 1984. Besides the droughts, periodic short falls in power supply from the hydroelectric power system have led to two additional major power crises occurring in 1998 and 2006 through 2007. These have compelled a shift to the introduction of thermal power generators since 1997, which run mainly on gas. Unreliable gas supply from Nigeria has in turn plunged the nation into periodic power shortfalls in recent times. As an immediate solution to these crises, efforts have been made to utilise local gas resources from the Atuabo gas project as well as constructing emergency plants, thereby improving the situation.

2.4.3 Long-term Plans to deal with recurring Power Crises

In order to deal with the recurring energy crises, the government has decided to explore alternative sources of power such as renewable sources, nuclear and coal to enhance energy security. In the case of the renewables, two grid connected solar plants with capacities 2.5 MW and 20 MW have been constructed. There are plans to construct additional solar plants as well as other renewable systems such as wind, mini hydro, biogas, etc. In the case of nuclear, a Presidential Committee was set up to assess its viability in 2007[18], and based on the committee's recommendations, a cabinet decision was taken in 2008 for the inclusion of nuclear power in the national energy mix within a decade[19]. Since then, the nation has undertaken a nuclear power planning programme

[18] Report of Presidential Committee to Advise Government on the Potential Use of Nuclear Energy for Electricity Generation in Ghana, 2007. p. iii.

[19] Ghanaweb, 2008, *Nuclear Power Plant by 2018*; http://www.ghanaweb.com/GhanaHomePage/NewsArchive/Nuclear-energy-power-plant-by-2018-144732

with the assistance of the International Atomic Energy Agency. There are also plans to construct two coal plant units with a total installed capacity of 700MW by 2020. From then on, additional coal plant units with a total capacity of 1400MW have been planned. The Energy Infrastructure Plan of the GIP is an effort to secure the country's electricity future as part of efforts to become a high-income country.

2.5 Generation Expansion Plan

2.5.1 Power Generation Plan Objectives

The development of the electricity infrastructure plan is based on the vision to transform the country's economy into a high-income status by 2057. The fulfilment of this vision is premised on the availability of adequate, reliable, least-cost and environmentally sustainable electricity to foster sustainable socio-economic growth. Consequently, the objectives of the electricity infrastructure plan are to:

i. Expand, modernise and maintain an electricity supply infrastructure, which ensures enhanced generation, transmission and distribution of electricity for domestic use and export;
ii. Develop an optimal electricity generation mix, which can ensure security of electricity supply;
iii. Exploit all fuels and develop an optimal fuel mix for electricity generation to ensure least-cost energy service delivery;
iv. Promote efficiency along the electricity supply chain.

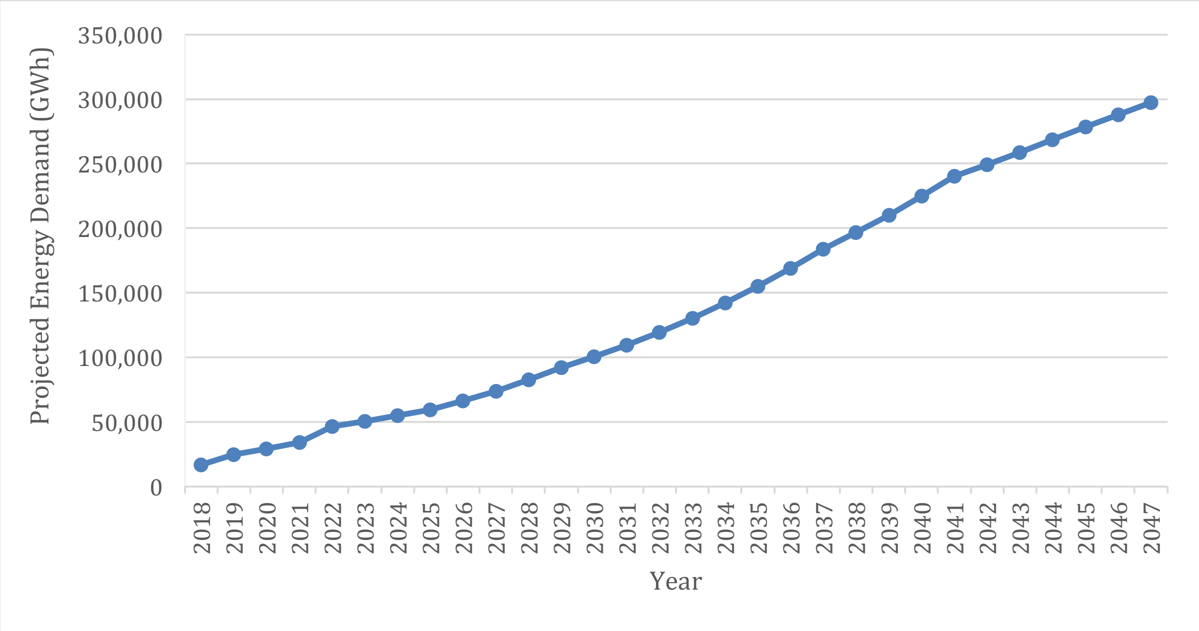
The fulfilment of these objectives would be augmented by the implementation of appropriate energy policies, legal and regulatory frameworks, institutional arrangements, human capacity development and innovative financing schemes.

2.5.2 Electricity Generation Planning Methodology

The planning methodology involves the determination of electrical energy demand within the period set for the GIP (i.e. 2018 to 2047). The associated peak load requirement is determined from which an optimal electricity generation mix is also determined. The electrical energy demand projection was done based on demographic factors, macro-economic factors, technological factors and government policies. Regarding demography, the total population of the country was projected to increase at an average annual rate of 2.1 percent from 28.6 million in 2018 to 51.0 million in 2047[20]. Regarding macro-economics, the total GDP was projected to increase from about US$ 46.0 billion in 2018 to about US$ 1,370 billion by 2047 at an average annual rate of 11.8 percent. The per capita GDP was projected to increase from US$ 1,546 in 2018 to US$ 27,195 in 2047 at an average rate of 9.9 percent. It is also expected that government policy on energy efficiency coupled with the emergence of energy efficient technologies will lead to a significant reduction in energy intensity as the country industrialises to move its economy forward. The projected energy requirements are presented in Figure 2.9 below. Also presented is the associated peak load demand in Figure 2.10.

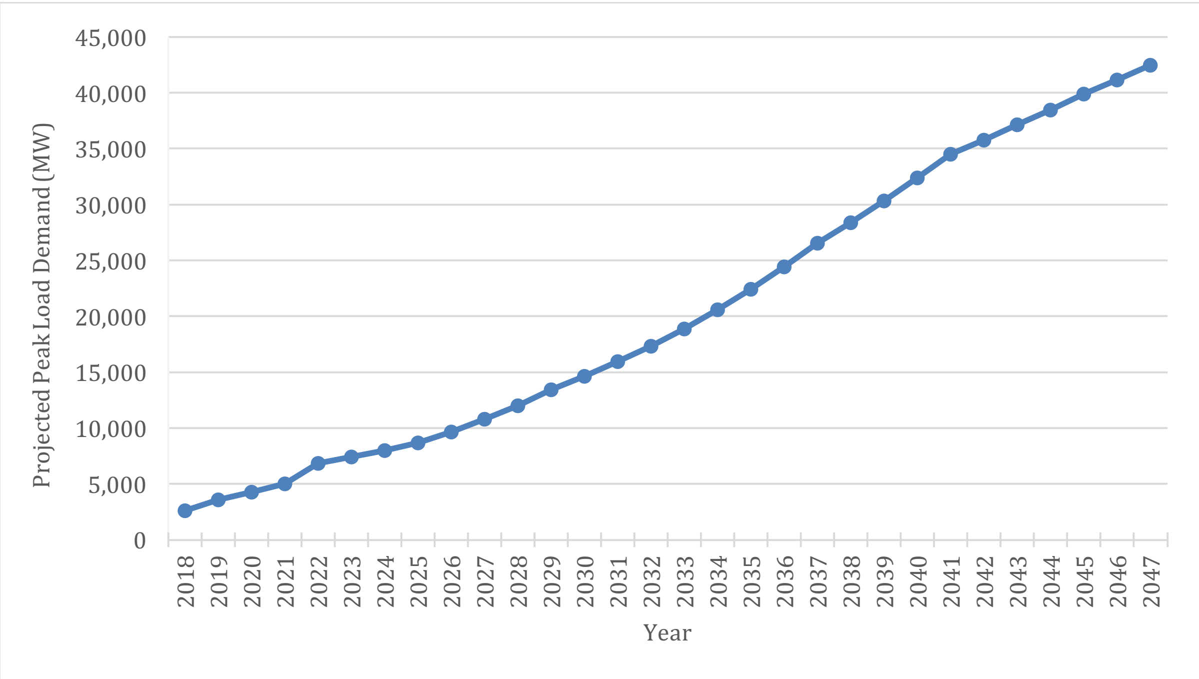
[20] National Development Planning Commission, Ghana Infrastructure Plan (2018-2047), November/December 2016 Progress Report.

Figure 2.9: Projected energy demand (2018-2047)



Source: Author’s Construct

Figure 2.10: Projected peak load demand (2018-2047)



Source: Energy Commission

An energy demand of about 297,200 GWh is required to meet the national developmental objectives in 2047 with a peak load of about 42,479 MW.

2.5.3 Optimal Generation Mix

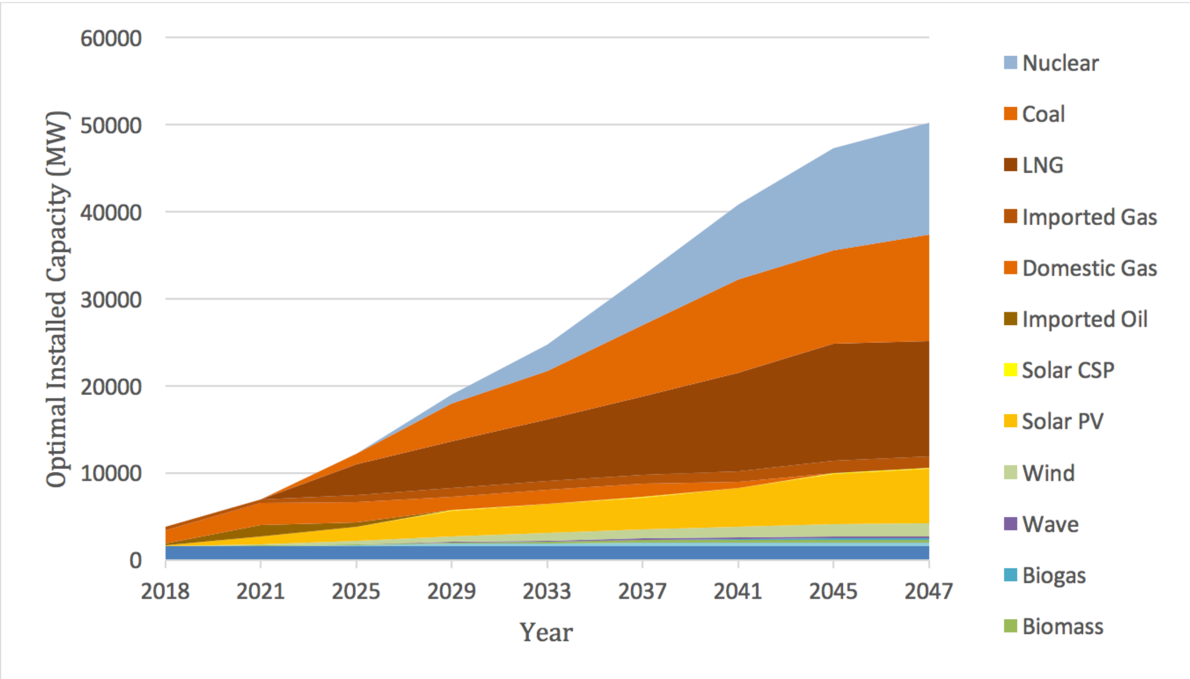
The LEAP model methodology was used to undertake the electricity generation capacity expansion planning. The results of the analysis of energy demand, peak demand requirements, power plant capacities, fuelling options and costs, and other factors influencing electricity generation within the study period 2018 to 2047 are presented in Table 2.5 and Figures 2.11 and 2.12 below. It is important to note the effect of the high capacity factor for nuclear energy, which provides roughly 39% of generation with a 25% installed capacity of the energy mix at 2047.

Table 2.5: Optimal installed capacity

	Installed Capacity (MW)										
	2018	**2021**	**2025**	**2029**	**2033**	**2037**	**2041**	**2045**	**2047**	**% installed at 2047**	**% generation at 2047**
Large Hydro	1,580	1,580	1,580	1,580	1,580	1,580	1,580	1,580	1,580	3.1	2.8
Small Hydro	0	6	114	291	346	446	446	446	446	0.9	0.7
Biomass	0	69	100	150	200	250	300	300	300	0.6	0.6
Biogas	0	4	10	17	20	80	120	150	200	0.4	0.3
Wave	0	10	25	75	100	150	200	200	200	0.4	0.2
Wind	0	125	400	600	900	1,000	1,200	1,500	1,500	3	1.5
Solar PV	88	873	1,615	2,981	3,274	3,675	4,384	5,754	6,254	12.5	5.5
Solar CSP	0	2	10	10	50	50	50	100	100	0.2	0.1
Imported Oil	194	1,387	447	0	0	0	0	0	0	0	0
Domestic Gas	1,545	2,494	2,330	1,580	1,580	1,580	650	0	0	0	0
Imported Gas	393	393	786	943	1,022	1,022	1,258	1,336	1,336	2.7	2
LNG	0	300	3,235	5,399	7,059	8,975	11,645	13,137	13,230	26.4	24.2
Coal	0	700	1,250	3,618	5,579	8,179	10,661	10,722	12,222	24.4	27
Nuclear	0	0	0	1,000	3,000	5,600	8,600	11,800	12,800	25.5	35.1
Total	**3,800**	**6,943**	**12,202**	**18,945**	**24,710**	**32,587**	**40,794**	**47,325**	**50,168**	**100**	**100**

Source: Energy Commission

Figure 2.11: Optimal installed capacity



Source: Energy Commission

The strategies adopted for the supply side are as follows:

Existing Hydro Plants

The existing hydro power plants, i.e. Akosombo, Kpong and Bui will be operating at their dependable generation capacities throughout the planning horizon. It is envisaged that the Akosombo plant, which underwent a retrofit in year 2000, will undergo refurbishment during the planning period. In the case of Kpong, its units are currently being retrofitted so it is not expected to undergo any further refurbishment. Bui will also be retrofitted in the course of the planning period. Therefore, the current total hydro capacity of 1580 MW will be maintained. However, their share in the generation mix is expected to drop from the current 26 percent to 2 percent by 2047.

Renewable Sources

The capacity of each of the untapped hydro resources is below 100 MW. They are therefore considered as renewable sources per the country's renewable energy law definition. These untapped hydro resources sum up to about 800 MW, including Hemang (90 MW), Juale (90 MW) and Pwalugu (60 MW) will yield a dependable capacity of 500MW. It is expected that all of these identified mini hydro sources will be developed during the planning period. Their share of the generation mix is expected to be 1 percent in 2047 therefore bringing the total share of hydro, i.e. existing and potential to 4 percent. The total output of all hydro plants is expected to provide a baseload generation in the mix.

The plan also includes other renewable sources like solar, wind, and biomass, which are in line with Government policy to promote renewable sources to mitigate greenhouse gas emissions, reduce air pollution and contribute to energy security. It is expected that the full potential of wind, approx. 1,500 MW capacity, will be developed. Installed capacity of solar plants is also expected to exceed 6,300 MW by 2047. The total installed capacity of renewable energy sources by 2047, including mini hydro is projected at 9000 MW, constituting 18 percent of total energy installed capacity, excluding the big hydroelectric plants.

Gas

Gas fuelled thermal plants are expected to initially provide the main source of electricity generation by the end of the first decade of the plan. Domestic gas plants will constitute 19 percent share of the installed capacity whereas imported gas takes 32 percent share. Domestic gas supply is expected to peak in 2019 with capacity of 1580 MW and will thereafter decline due to limited reserves, grinding to a halt by 2044. Imported gas is capped at 1336 MW from 2033 onwards due to the capacity limit of the West African gas pipeline. It is envisaged that no additional pipeline will be constructed and that gas imports from Nigeria and elsewhere will be in the form of LNG, will be introduced in 2020. LNG will be the main fuel for gas plants constituting a 26 percent share in the generation mix with installed capacity of 13,230 MW in 2047.

On the technology side, there will be a high proportion of combined cycle plants, which are more cost effective and generate baseload energy. In order to provide the primary frequency regulation, it is expected that there will be a sizable number of single cycle gas turbine plants in the mix. In addition, a number of existing thermal plants will be retired and replaced with new ones.

Coal

It can be said that most developed countries around the world have developed and transformed their economies through the use of coal technologies. Ghana is expected to be on the path to developed country status by 2047, and needs a base load energy source like coal. Currently, Ghana has no coal technology but is expected to have its first coal plant in the near future. It is expected that the share of coal, which is expected to be part of the energy mix will come on line in 2020 with a first capacity of 700MW. This share is then expected to grow to 26 percent of the total installed capacity by 2047 with a coal installed capacity of 12,222MW.

Nuclear

One key consideration in the proposed plan is to provide for a significant amount of nuclear. This is expected to provide baseload power alongside coal and the hydro plants. In line with the strategic vision to operate a least cost generation mix, it envisaged that coal and nuclear will be the main baseload generation options from 2023 to 2047. In line with the on-going nuclear power planning programme, the entry point of nuclear is expected to be 2029. Its share will increase to 32 percent by 2047 with a total installed capacity of 12,800MW.

Reserve Margin

In order to guarantee supply security and ensure a very reliable and stable power generation system, a reserve margin will be maintained throughout the period. Due to the improved efficiencies and diversities expected in the network, the reserve margin will be reduced gradually from the current 20 per cent to 5 percent.

2.6 Defining Baseload Generation

Traditionally, the electricity industry refers to baseload generation as power plants that are used to meet 'base' load, i.e., the minimum level of electricity that customers demand around the clock. Such plants are normally run at high, sustained output levels and high capacity factors, with limited cycling or ramping. In other words, baseload generation can be defined as generation units that operate the great majority of hours of the year to meet load requirements[21].

The North American Electric Reliability Corporation (NERC) also offers an insightful discourse on base load generation. A paraphrased version of this is provided below[22]:

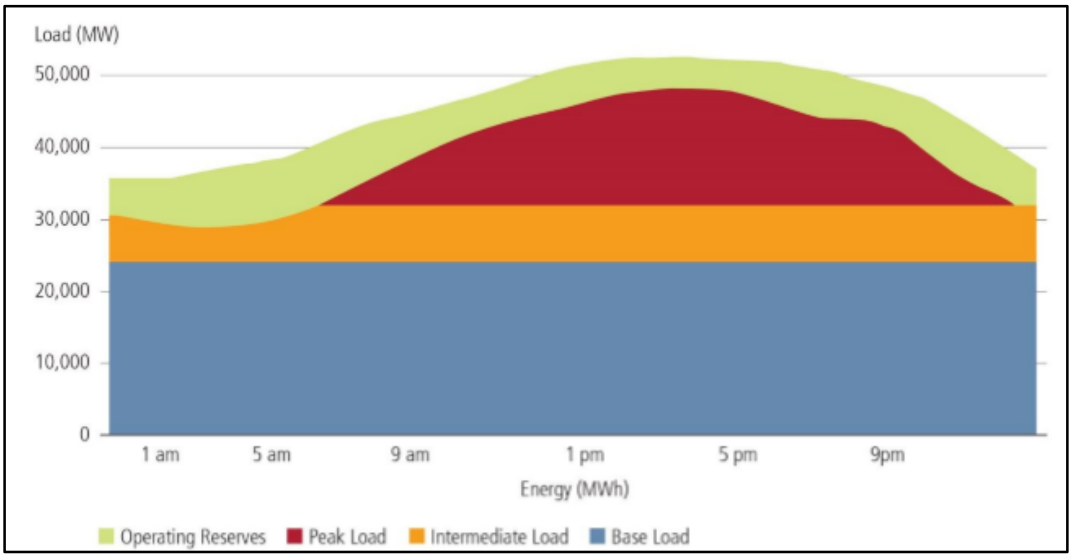
> There is a distinction between baseload generation and the characteristics of generation providing reliable 'baseload' power. Baseload as a term refers to generation that falls at the bottom of the economic dispatch stack, meaning

[21] Staff Report to the Secretary on Electricity Markets and Reliability, US Department of Energy, August 2017.
[22] North American Electric Reliability Corporation (NERC), "Synopsis of NERC Reliability Assessments, the Changing Resource Mix, and the Impacts of Conventional Generation Retirements," unpublished materials, Department of Energy, May 9, 2017.

power plants that are the most economical to run. Such plants (in the US, traditionally coal and nuclear plants) are by policy, designed for low cost operation and maintenance and continuous operation.
However, it is neither the economics nor the fuel type that make these plants attractive from a reliability perspective. Rather, these plants traditionally have low forced and maintenance outage hours and have low exposure to fuel supply chain issues. This results in a high level of resilience and reliability of electrical energy supply, which is a key requirement of a robust and stable jurisdictional electrical energy system. In other words, 'baseload' generation can also be referred to as generation that is more resilient to disruptions in energy generation.

Table 2.13 shows the profile of daily load curve showing the network's baseload cycle by 2047.

Figure 2.12: Schematic layout of Daily Load Curve showing Base Load by 2047



Source: Staff Report to the Secretary on Electricity Markets and Reliability

Traditionally, intermediate or mid-merit plants are used to do 'load following'. These plants are easier to ramp up and down, and are affected less by load cycling to meet daily variations in demand. Generally, based on the mix of generation resources available in a region, and relative fuel prices, natural gas and/or coal units are typically used for 'load following' (based on the US case). In an ideal system, short-duration demand peaks would be met by variable resources such as renewable energy. The time of availability for variable renewable energy, however, does not always make this possible, and there is a need for a balancing act between the dispatch from intermittent sources and that of renewable energy.

Generation from variable renewable energy can change widely over the course of a single day, which requires dispatchable power plants to be operated more nimbly. In a market-based system, over-generation by variable renewable energy can drive prices to very low levels in a short time, and require very quick ramping up levels when it subsides. This places a premium on flexible output rather than the steady output of traditional baseload power plants. This can be very challenging for ensuring the reliability and resilience of an electrical grid system. There is therefore the need to ensure that in market-based systems, an additional premium is placed on reliability and resilience of the electrical grid system in regards to the dispatch from different generation sources.

2.7 Transmission System

2.7.1 Overview of the Transmission System

Ghana's transmission system currently comprises four main high voltage levels: 330 kV, 225 kV, 161 kV and 69 kV. The overall transmission network consists of about 5,216 circuit kilometres (km) of high voltage lines interconnecting the generating centres across the country: namely, Akosombo, Kpong, Tema, Bui and Aboadze; and some sixty-four (64) Bulk Supply Points (BSPs). The breakdown of the transmission network per voltage level is as follows:

- 364 circuit-km of 330 kV lines;
- 4,636.6 circuit-km of 161 kV lines;
- 132.8 circuit-km of 69 kV lines.

In addition, there is a 74.3 km single circuit 225 kV tie-line linking Ghana with La Cote d'Ivoire and a double circuit 161 kV line linking Ghana with Togo. The transmission network has about 123 transformers (including spare transformers) installed at various load centres across the country with a total transformation capacity of 5,517 MVA. There are also sixty-four (64) bulk supply points including switching and generating stations across the network.

2.7.2 Current Transmission Network Challenges

Due to many years of under-investment, the National Interconnected Transmission System (NITS) is bedevilled with a number of operational challenges. These challenges existed prior to the power sector restructuring and the subsequent operationalisation of the Ghana Grid Company (GRIDCo) and include over-aged equipment, overloaded transformers and transmission lines.

After its operationalisation in 2008, GRIDCo embarked on an ambitious network upgrade and reinforcement project to meet mushrooming challenges imposed by the ever-increasing electricity demand and the need for operational reliability and security improvements. Due to a lack of available funding, there are still major network expansion projects that are yet to be undertaken. This has led to a situation where the NITS does not meet critical industry benchmarks across all segments of the network. Overall transmission losses are high due to high line loading on some transmission corridors, and in some cases occasional overloads and low customer-end power factors.

2.7.3 On-going and Planned Projects

As part of efforts to increase overall transfer capacity and improve network reliability and operational flexibility, GRIDCo, as the System Operator (SO), has embarked upon a number of reinforcement and expansionary programmes. Also, in line with the Government of Ghana's policy objective of making Ghana a net exporter of power, the

SO has embarked upon a number of interconnection projects to interconnect the power systems of neighbouring countries with the objective of exporting power to the mostly power deficient neighbours including the Sahelian countries, under the West Africa Power Pool (WAPP) programme.

2.8 Electricity Transmission Plan

2.8.1 Overview of the Electricity Transmission Plan

A reliable power system is critical to the development of acceptable socio-economic improvement in the lives of the citizenry of every nation. A robust transmission network is the foundation of a stable and reliable power system. In turn, achieving the required level of reliability of any transmission network depends on developing and complying with the Reliability Planning Criteria. GRIDCo together with the key stakeholders in the power sector, particularly the regulatory agencies, has developed the reliability planning criteria over time to accurately plan and operate the transmission system and assess its performance. The Ghana Grid Code served as the basis for the development of the required reliability planning criteria together with other international standards such the IEEE, IEC and ANSI. The criteria also act as a guide for GRIDCo engineers and operations personnel. In line with the policy objectives and to provide the required level of grid reliability, the foregoing provides the standards to which the NITS of Ghana should be planned, designed and developed. These criteria will be reviewed from time to time in line with current standards in the industry that include the following:

Available Transmission Capacity (ATC)

The transmission system shall be so planned, designed and developed to ensure the maintenance of available transmission capacity at all times. This shall take into consideration all corridors from or to generating plants and all major substations and associated load centres.

N-1 Criterion

The transmission network shall be planned and designed to meet N-1 criterion and for some sensitive loads and installation, N-2 criterion. This would ensure that in every transmission corridor, when the biggest transmission line goes out of service, the remaining lines would be able to evacuate the full load requirement without any load shedding.

Firm Capacity at all Substations

All substations shall be planned and designed such that the station shall comply with the Firm Capacity criterion. This means that if the biggest transformer at the station is lost, the remaining transformers should be able to carry the total load without any incidence of load shedding.

Voltage Criteria

The design of the transmission system should be such that its voltage variations meet the criteria used to assess the reliability of the transmission system during normal or contingency conditions. The substation distribution transformers and/or voltage regulators provide for +/- 10 percent voltage swings about the NITS voltage level of 69 kV, 161 kV, 220 kV and 330 kV. The acceptable voltage range for the transmission system during normal operating conditions is from 95% to 105% of nominal. Voltages outside this range would still be considered acceptable if they meet the contingency criteria. Based on prudent utility practice, and as recommended in IEEE Standard 1453, capacitor switching should result in a steady-state voltage fluctuation limited to a maximum of 3.3 percent of nominal. An evaluation should be conducted of single contingency conditions considering the strongest area source element or facility (largest contributor of short circuit current).

Maximisation of Existing Right-of-Way

The planning and design of new transmission lines should seek to maximise existing right-of-ways. Existing electric transmission, gas pipe line, railroad, and highways corridors should be identified in all comparisons of alternatives and utilised where possible. Environmental features should also be considered.

Minimum Clearances for Transmission Lines

Clearance ratings for transmission lines should be assigned based on the minimum allowable clearances as specified by IEEE/ANSI or other governing body in effect at the time of construction, or by GRIDCo transmission line design criteria.

Location of Power Pants

In view of the current configuration of the NITS where majority of the generating plants are located in the south apart from Bui which operates typically in peak mode, the planning and design of the power system should take into serious consideration extension of fuel pipelines to the middle part of Ghana. This would facilitate wooing interested IPPs to construct power plants in the middle part of the country, and also improve the overall security and stability of the NITS.

Fast, Reliable and High Capacity Communication Infrastructure

In order to improve communication and enhance protection system performance, the transmission grid should be incorporated with a high capacity and reliable fibre optic network. This would also enhance general communication and critical data exchange.

Wholesale Electricity Market

In line with on-going and emerging trends in the electricity industry world-wide, the development of Ghana’s energy sector to meet the level of reliability required under the 30 year plan, should be pursued to enhance efficiency in the wholesale electricity market. This would help deal with the current incidences of non-payment for energy generated, transmitted and sold by the utilities as an effective energy sale clearing house is one of the key aspects of a wholesale electricity markets.

Reduction in Transmission Losses

To achieve the set objective in the long-term 30 year plan of increasing transmission capacity and reducing transmission losses from the current 4percent to below 3percent, power transmission should be based on high capacity transmission networks of mostly double-circuit 330 kV lines and appropriate level compensation. The grid should also be continually improved and upgraded with higher voltage lines to at least up to 400 kV from the current highest voltage of 330 kV.

Supply to High Consuming and Sensitive Loads

As is the practice in most industrialised economies, supply to high power consuming and sensitive loads should be provided with a level of reliability of the order N-2. These loads should also be supplied at the highest voltage possible and be provided with dedicated substations.

2.9 Electricity Distribution System

2.9.1 Status of Distribution System

Effective and efficient power distribution network infrastructure is critical for the development of the country's economy into that of a higher income nation. Power distribution utilities will be required to play the leading role in developing the distribution network infrastructure to meet best industry standards and bring efficiency into their operations. Over the past years, the power distribution network infrastructure in Ghana has been growing at a rate inadequate to meet the rapidly growing power demand in major cities and rural communities. Baseline figures for the country's power distribution infrastructure at the end of 2015 are shown in Table 2.6 below.

Table 2.6: 2015 Electricity distribution infrastructure in Ghana

Company	No. of Primary Substations	Circuit Length of 33 kV Network (km)	Circuit Length of 11 kV Network (km)	Circuit Length of Low Voltage Network (km)	Total Capacity of Power Transformers (MVA)	Total Capacity of Distribution Transformers (MVA)
ECG	101	17,197	13,975	67,465	3,297	3,892
NEDCo	11	9,438	2,197	16,861	75	675
Total	112	26,635	16,172	84,326	3,372	4,567

Source: ECG & NEDCo

The electricity access rate in Ghana has been growing and this reflects the degree to which the government is making electricity infrastructure accessible to the public. It should be noted that electricity infrastructure accessibility is estimated as the percentage of communities connected with electricity, either through the grid or via off-grid networks in a country. The electricity access rate in the country was about 81percent at the end of 2015. Going forward, the mode of measurement will be changed from percentage of community connections to the percentage of household connections.

2.9.2 Distribution System Challenges

Over the years, the country's power distribution utilities have been confronted with many challenges ranging from an absence of modern systems in the power distribution network, perceived interference from the government in the management of the utilities, inefficient payment of electricity bills by state agencies, and inadequate cost reflective tariff by the PURC. In addition to the above challenges, an inadequate and slow rate of investment has resulted in network expansion lagging far behind demand growth, with unavoidable consequences such as high system losses, poor network reliability, poor supply quality and high suppressed demand, to name a few. These challenges have affected the performance of the power utilities. A number of the challenges are expatiated below:

i. The slow growth in investment has resulted in the high demand for electricity catching up and overwhelming the limited infrastructure available. Without any redundancy, the system has no cushion in the event of an unforeseen failure of a network component arising from maintenance activity or a fault. This condition has made the distribution system vulnerable and unreliable.

ii. ECG and NEDCo's aggregate technical and commercial (AT&C) losses at the end of 2015 were 22.72 percent and 23.10 percent respectively. This gave a weighted AT&C figure of 22.75 percent for the entire power distribution network. This is significantly higher than the benchmark of 13.06 percent projected to be achieved by 2015 for ECG and NEDCo according to a study done by the Global Energy Consulting Engineers, India, for the Ministry of Energy in 2012. Power distribution networks with poor reliability indices affect productivity in the economy and also the financial position of the utility companies. For instance, ECG recorded a System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) of 73.5 inter-cust/yr (interruptions-customers/year) and 161.3 hour-cust/yr respectively, which far exceeds the PURC benchmarks of 6 inter-cust/yr and 48 hour-cust/year.

iii. Poor voltage levels and network overloading in some parts of the distribution network have resulted in suppressed demand and high technical losses.

iv. There is a perceived interference from government in the operation and management of the distribution utilities, hindering management from making critical decisions to improve the operational efficiency of the distribution companies. Some state agencies are unable to pay for electricity consumed regularly and timeously, therefore culminating in huge debts to the utilities.

Going into the future, the anticipated population growth coupled with economic growth targeting a high-income country status will result in high growth in power demand in the country. Power distribution utilities in Ghana will therefore be required to adequately plan their networks to cater for the anticipated load growth and also operate in an efficient and effective manner. They will be expected to develop robust and resilient network infrastructure that will meet the projected power demands in agriculture, industry, transport and other sectors in the country.

2.9.3 Addressing the Power Distribution Challenges

Critical issues that should be addressed in the country's power distribution sector are as follows:

i. Network infrastructure expansion and modernisation;
ii. Distribution system loss reduction;
iii. Distribution network reliability improvement.

Finding lasting solutions to the above issues will contribute to achieving the high-income level the country seeks by the end of the plan period.

2.10 Electricity Distribution Plan

2.10.1 Efficient and Reliable Power Distribution System

An efficient electricity distribution system that provides reliable delivery of power is expected to accomplish the following:

i. A robust and modernised power distribution infrastructure with very wide electricity coverage (i.e. having the best electricity access rate in Africa);
ii. A power distribution network having very low system losses and high reliability performances comparable with the best in the industry;
iii. Cost effective/affordable electricity tariff for consumers;
iv. Well trained human resources (i.e. technical & non-technical experts) to effectively and efficiently operate and manage the power distribution system.

With the high-power demand projections for Ghana, economic activities in the cities and rural communities are expected to increase. This will call for strategic planning of the distribution network infrastructure to meet the anticipated high projected power demands. Electric utility companies are expected to undertake power distribution master plans every ten (10) years to review their plans for providing cost effective power infrastructure for all sectors of the economy. These plans are to be monitored by a national body to ensure that they are reviewed periodically and implemented on schedule.

2.10.2 Modernisation of the Distribution Network Infrastructure

Upgrading and modernisation of power distribution grids has been a major concern for power utilities all over the world due to their immerse benefits. The upgrade/modernisation will boost security, efficiency and reliability of the distribution power grid. Going into the future in the power distribution industry in the country, the under-listed technology will become very critical in that regard.

2.10.3 System Wide Geographic Information System (G.I.S) Platform

In modern times, geographic information systems (GIS) play a very critical role in the effective and efficient operation of electric distribution utilities. GIS platforms are required by power utilities to assist the analyses, management and mapping of spatial data. Deployment of GIS platforms for mega cities will assist power utilities in the following:

i. Spatial load forecasting and optimization of the planning of substations and feeder locations and their capacities;
ii. Automated route selection for the construction of power lines;

iii. Provision of accurate up-to-date information on network assets. This will in turn connect database information such as customer service operations, material auditing, power distribution analyses and studies, outage reporting, power theft detection etc;
iv. Acts as a platform for the implementation of smart grid technologies in the power distribution network.

2.10.4 Smart Grid Technologies

Technological advancements will affect all players in planned mega cities. In light of this, the under-listed Smart Grid[23] technologies will be required to bring efficiency and effectiveness into the operations of the electricity utilities in the country:

Distribution Management System (DMS)

Distribution Management System (DMS) is a collection of applications designed to monitor & control the entire distribution network efficiently and reliably. DMS applications such as Distribution SCADA System, Advanced Fault & Network Analysis, Distribution Automation System, Volt–Var. Control, Conservation Voltage Reduction (CVR) etc. should be deployed for the modernisation of the operations of the power distribution networks.

Advanced Metering Infrastructure (AMI)

This refers to systems that measure, collect and analyse energy usage from advanced devices such as electricity meters, gas meters, and water meters through various communication media. The use of AMI will offer the following:

i. Two-way communication with every customer which enables remote meter reading and home area networks;
ii. Measurement of site-specific information, allowing utility companies to introduce different tariffs for consumption based on the time of day and the season;
iii. Remote connection/disconnection of service;
iv. Estimation of customer bills, which are a major source of complaints for many customers and also serve as a tool to help consumers to better manage their energy purchases.

Outage Management System (OMS)

An outage management system (OMS) is a computer system used by operators of electric distribution systems to track outages and assist in restoration of power. These smart grid technologies will be riding on a power distribution GIS platform.

2.10.5 Electric Vehicle Charging & Electric Train Systems

An efficient transportation sector will play a critical role in mega cities. Electricity utility companies will have to provide service to modern electric vehicles that will require

[23] Smart Grids are operational systems and applications, field devices and communication networks that work together to add intelligence to the basic electrical infrastructure.

reliable power supply for their day-to-day activities. The government and electric distribution companies will establish electric vehicle (EV) charging stations in mega cities and towns. Charging stations can be deployed where there is on-street parking, at taxi stands, in parking lots (at places of employment, hotels, airports, shopping centres, convenience shops, fast food restaurants, coffeehouses etc.), as well as in driveways and garages at home. Fuel pump stations should also incorporate charging stations. Their services should address the following[24]:

i. Provision of residential charging stations where an EV owner plugs in when the vehicle returns home and it recharges overnight;
ii. Charging while parked (including public charging stations): This is a commercial venture for a fee or free, offered in partnership with the owners of the parking lot. It can include parking stations, parking at malls, small centres, and train stations;
iii. Fast charging at public charging stations: These chargers may be at rest stops to allow for longer distance trips. They may also be used regularly by commuters in metropolitan areas, and for charging while parked for shorter or longer periods;
iv. Battery swaps or charge centres: This intends to match the refuelling expectations of regular drivers;
v. Electric trains system will require a separate power supply network with a dedicated frequency for its day-to-day operations.

2.10.6 Greenhouse Gas Reduction Schemes

To address climatic changes and greenhouse gas (GHG) reduction in mega cities, distributed generation from renewable sources such as solar, biomass and wind should be deployed at strategic locations in the electrical distribution system. This will ensure improved electrical efficiency, greater grid resilience and a lower carbon footprint. In consultation with the Ministry of Energy, the Energy Commission and the electricity distribution companies, incentive packages should be planned for solar energy on rooftops of public and commercial buildings and homes to provide additional impetus towards strengthening the distributed generation model. Energy storage technologies (e.g. battery storage systems) should be considered to stockpile excess power from renewable energy sources.

2.10.7 Demand Side Management

Demand-side management (DSM) includes activities, programmes, and information systems that are designed to encourage consumers to modify (i.e. reduce) their level and pattern of electricity usage, and/or add distributed generation. Economics also plays a major role in the adoption of DSM. Major capital investment projects with low utilisation are not in the best interest of a developing nation with limited resources. Hence management of demand side factors can be a powerful tool in improving resource adequacy. Some of the DMS techniques that should be considered are as follows:

Time of Use (TOU) Tariff

Time of use (TOU) pricing which is also known as dynamic pricing or flexible pricing is a way of pricing electricity depending on the time of day it is used. This reflects the

[24] http://en.wikipedia.org/wiki/charging_station (Accessed on: 28th November, 2016)

different costs of generating and distributing electricity throughout the day. To benefit from TOU pricing, consumers must have smart meters installed at home. These technologically advanced meters accurately measure when and how energy is used, so that a retailer can offer different prices depending on the time of day. Smart meters have the added benefit of providing real-time information about consumers' energy use, so one can easily monitor and potentially manage when and how much energy is used each day. Implementation of the TOU tariff will encourage peak time customers to shift or level their consumption uniformly over a 24 hour period.

Reactive Power Management

This approach will consider improving the overall power factor of a system to a near unity value by the installation of fixed and switchable shunt capacitor banks. It should be noted that during the peak load period of a system, the average system power factors could be very poor and as a result of that, power would be poorly utilised. To ensure efficiency in the usage of power during peak load period, shunt capacitors will be installed at industrial customer ends to improve peak load system power factors.

Demand Response

This is any reactive or preventative method to reduce, flatten or shift peak demand. Demand response includes all intentional modifications to consumption patterns of electricity of end user customers that are intended to alter the timing, level of instantaneous demand, or the total electricity consumption.

Conservation Voltage Reduction (CVR)

It is a proven technology for reducing energy and peak demand. It is a measure implemented upstream of end service points in the distribution system so the efficiency benefits are realised by consumers and the distributor. This is done without any intervention on the part of consumers. CVR is implemented by controlling the voltage on a distribution circuit to the lower end of a tolerance band. Conservation then occurs on the circuit when certain end-use loads draw less power when voltage is lowered. Now, with smart grid technologies and real-time operating systems, utilities can realise energy savings and demand reductions[25] of about 3percent or more on a continual basis.

Replacement of high pressure sodium (HPS) lamps with light emitting diode (LED) lamps: Replacement of the high pressure sodium (HPS) street lamps (with average power rating of 250 W) with light emitting diode (LED) street lamps (with average power rating of 150 W) will reduce the street lighting consumption by about 40 percent. The Ministry of Energy should consider the deployment of LED street lamps in all communities in the country.

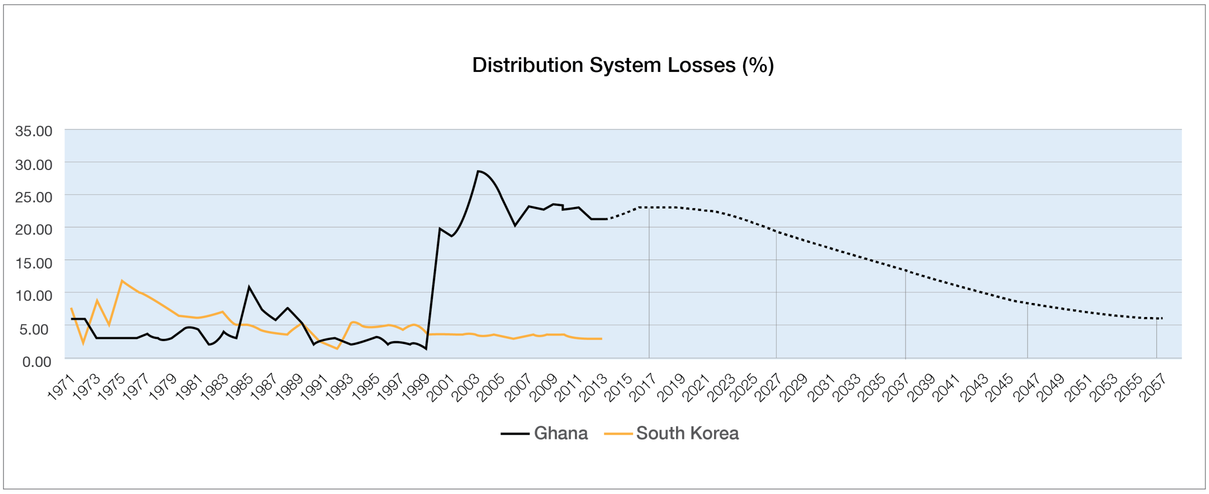
2.10.8 Distribution System Losses Reduction

Distribution system losses or aggregate technical & commercial (AT&C) losses are a transparent measure of the overall efficiency of the power distribution business, as it measures technical as well as commercial losses. This involves the estimation of the

[25] The source of this information is from the Smartgrid.ieee.org/april-2013/842-conservation-voltage-regulation-an-energy-efficiency-resource

difference between the energy purchased and energy sales in particular electric distribution network expressed as a percentage of the energy purchased. Over the years, the AT&C losses of the major electricity distribution utilities in the country have been a major concern as it has been impacting negatively on the finances of these companies. As at December 2015, the AT&C losses figures of ECG and NEDCo were 22.72 % and 23.10 % respectively. This gave a weighted AT&C figure of 22.75% for the entire power distribution network in Ghana. Figure 2.14 shows the historical transmission and distribution system losses values for Ghana and South Korea.

Figure 2.13: Historical Distribution Losses for Ghana and South Korea[26]



Source: World Bank, updated by GIP Team

The figure above depicts the historical distribution losses for both Ghana and South Korea. From this figure, it can be seen that Ghana was averagely doing well from 1971 through to 1999 than South Korea. However, from the year 2000 to 2013, the distribution system losses increased rapidly whiles that of South Korea reduced due to several factors. Among such factors contributing to the high losses in Ghana are high demand growth, inadequate network expansion investments, insufficient planning of the transmission and distribution, sub-transmission and the distribution systems with short term objective of extension of power supply to new areas, large scale rural electrification through long medium and low voltage lines, improper load management, inadequate reactive power compensation, power theft, poor metering systems and etc. Under the plan, the transmission losses will be reduced to 2.5% while the distribution losses will be reduced to 6% over the next 40 years.

Technical Losses Reduction

Distribution technical losses occur naturally and consist mainly of power dissipated in electricity system components such as transmission and distribution lines, transformers, and measurement systems. A number of solutions have been recommended for addressing electrical distribution networks losses in Ghana.

[26] World Bank - http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS – Projection by GIP Team

Commercial Losses Reduction

Commercial losses in the electrical network are caused by actions external to the power system. It consists primarily of electricity theft, non-payment by customers, and errors in accounting and record keeping. To handle this canker effectively and efficiently will require the undertaking of the following drastic measures:

i. Advanced Metering Infrastructure and Automatic Meter Reading;
ii. Automatic Meter Reading (AMR) system will provide a facility for remote disconnection and reconnection of electricity supply from an AMR control centre;
iii. Replacement of legacy credit meters with pre-payment meters to improve collection efficiency and timely closing of monthly financial statements;
iv. Customised application software;
v. Customer installation sealing;
vi. Re-routing of concealed service tails;
vii. Energy audits;
viii. Legal measures for control of theft.

Collection Losses Reduction

Collection losses are also a challenge to the attainment of financial efficiency by power distribution companies. Going forward, a number of industry best-practices should be considered by power distribution companies in addressing losses, including:

i. Efficient payment system;
ii. Meter installations for all non-metered customers;
iii. Provision of customer call centre;
iv. Credit card/debit card payments.

2.10.9 Commercial Losses Reduction

Commercial losses in the electrical network are caused by actions external to the power system. It consists primarily of electricity theft, non-payment by customers, and errors in accounting and record keeping. To handle this canker effectively and efficiently will require the undertaking of the following drastic measures outlined below:

Advanced Metering Infrastructure and Automatic Meter Reading

Advanced metering infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. The deployment of such a system into the operation of distribution utilities will facilitate an efficient and effective means of remotely metering, reading and monitoring customers' electricity consumption. This tool will detect and discourage theft and other modes of un-metered consumption in an enormous way as reflected in the experience of developing countries in Latin America like the Dominican Republic, Chile, Honduras, Brazil and also India[27].

The Automatic Meter Reading (AMR)

AMR system will provide a facility for remote disconnection and reconnection of electricity supply from an AMR control centre. With the latest technology, the AMR

[27] Global Energy Consulting Engineers (GECE), National Technical and Commercial Loss Study for ECG & VRA/NED, Ghana 2012. India.

enables remote disconnection and reconnection of electricity supply to low and medium voltage users of electricity at very competitive prices. This facility will improve revenue collection by instilling the fear of being disconnected automatically in case of default of payment.

Replacement of Legacy Credit Meters

Legacy credit meters will be replaced with pre-payment meters to improve collection efficiency and timely closing of monthly financial statements.

Customised Application Software

Distribution utilities are to develop utility specific application software which will analyse the energy consumption and load survey data and give alerts to customer service managers as well as top management regarding customers who need to be watched based on changes in their consumption patterns.

Customer Installation Sealing

Utilities should photograph details of the seals used for securing meters, sealing of switches/circuit breakers and metering installations. Records shall be kept like specimen signatures similar to those maintained by banking institutions. E.g. photograph of seals, capturing seal number, sealing impression, etc.[27]. This will help in analysing any suspected tampering.

Re-routing of Concealed Service Tails

Service wiring from the service pole to customer meter boards concealed in ceilings and walls serve as points of direct connection or meter by-passes. Customers bent on stealing power connect high energy consuming equipment directly on these service tails, thereby bypassing the meter. Therefore, re-routing of concealed service tails will help in reducing the energy theft in the network.

Energy Audits

Distribution utilities are to implement energy audit programmes for regional and district operational boundaries to determine the level of system losses and the sections of the network contributing to such high losses within selected boundaries. The audit exercise should consider the following:

i. Metering of the boundaries (*using import and export metering devices*) of the selected regions and districts to determine the levels of system losses. Specific loss reduction strategies can then be applied for such regions/districts;
ii. Metering of power and distribution transformers at the incomer and outgoing feeders to determine the total energy units billed for all the customers served by that transformer as compared with the total energy throughput. This will bring out the total energy losses on that transformer. Specific loss reduction methodology can then be applied to remedy the situation.

Legal Measures for Control of Theft

Government is expected to support the utilities in combatting commercial losses by the enactment of special legislation, declaring theft of energy an offence, providing deterrent punishment, summary trials and creation of special courts to deal with energy theft cases. Speedy trials are necessary to address this power theft problem. The case studies of utilities that have achieved substantial commercial loss reduction worldwide show the important role of legislation [27].

Efficient Payment System

The payment system should aim at reducing the time it takes the customer to make a payment when standing in the queue. The system should be linked to customer mobile phones and must tell how much has been paid and the amount pending to be paid by the customer in real time. Provision must be made available for making payments in cash, via cheques, credit and debit card and bank transfers [27].

2.10.10 Collection Losses Reduction

Meter Installations for all Non-Metered Customers

All unmetered customers should be provided with meters to reduce misuse of energy and loss of revenue.

Deployment of Electricity Units Scratch Cards

Electricity utilities should modernise the sale of energy by deploying electric meters that are compatible with electricity units scratch cards which work in the same manner as mobile phone scratch cards. These cards should be sold to consumers at appropriate channels such as malls, shops, fuel filling stations and other retail exits. Upon buying a card, the consumers will simply scratch the foil area at the back for the PIN. Consumers will simply send SMS text messages containing their prepayment meter serial numbers plus the scratch card PIN number using their mobile phone, to a designated telephone number on the scratch card. SMS message should be sent to the customers, indicating the energy credit number. This number will then be entered into their prepayment meters to obtain credit for their energy consumption[28].

Provision of Customer Call Centres

Power distribution utilities must have a call centre for dealing with customers by phone/integrated voice response system (IVRS). The service must include dealing with both reporting of service calls as well as trouble calls. An IVRS should be provided with a unique number and must be programmed to receive the complaints automatically guided by interactive voice response. Adequate numbers of operators to receive the calls must also be provided in case the customer wants to get his complaints recorded manually. Provision for making complaints to the call centre via the Internet must also be provided. After the complaints are resolved, a message must be sent to the customer through SMS/internet systems if the mobile number or email ID is available. GIS maps

[28] https://www.metering.com/scratch-cards-for-pay-as-you-go-electric-customers (Accessed on 26th November, 2016)

should be available which should be linked to the customer master database to provide better interactivity with them. [27]

Credit Card/Debit Card Payments

Provision for bill payment can be made available through credit or debit cards by using bank payment gateways. The utility needs to sign up with one or more payment gateways that provide data security for customers paying the bills. The amount is credited to the utility's account and receipts generated immediately for the customer's record [27].

2.10.11 Other Loss Reduction Measures

Strategies for the Reduction of High Tariffs

- Develop a Power Subsector Masterplan in line with integrated energy sector plans and implement the laid down recommendations and findings.
- Ensure that competitively priced power generation systems are procured.
- Ensure the development of cost competitive diversified generation mix.
- Ensure the reduction of commercial and technical losses in electricity transmission and distribution.
- Ensure that electricity utilities employ industrial best practices in their operations to reduce cost.
- Develop a mechanism whereby the electricity sale functions of ECG are ceded to private entities to sell electricity at cost competitive prices with ECG focusing on the distribution aspects of electricity alone.

Strategies for dealing with Utility Debt

- Ensure the establishment of cost reflective tariffs
- Introduce effective revenue collection mechanism by the distribution utility
- Government should ensure the payment of debt owned by state organisations
- Put in place effective mechanisms to check illegal connections

2.10.12 Savings for Implementing Loss Reduction Measures

Tables 2.7 and 2.8 show the extent of savings for implementing loss reduction measures in the transmission and distribution systems. It shows that if the appropriate cost reduction measures are put in place and the targets are achieved, more than $130 Billion of power would be saved over the next 40 years.

Table 2.7: Savings to GRIDCo by implementing transmission system loss-reduction measures

Year	Energy Generated (GWh)	Transmission losses - Technical & Commercial %	Actual Transmission losses (GWh)	Average price of bulk power transmitted (in US$)	Annual savings to GRIDCO (US$ million)	Duration (10 Years)	Savings to GRIDCO for decade (in US$ million)	Cumulative Total savings to GRIDCO (in US$ million)
2017	16,000	4.5	720	0.1	72	0	-	-
2027	73,800	4	2,952	0.1	295	10	2,952	2,952
2037	184,000	3.5	6,440	0.1	644	10	6,440	9,392
2047	297,200	3	8,916	0.1	892	10	8,916	18,308
2057	350,000	2.5	8,750	0.1	875	10	8,750	***27,058***

Source: GIP Team

Table 2.8: Savings to ECG by implementing distribution system loss-reduction measures

Year	Energy Generated (GWh)	ECG share of power - % Generated	Energy distributed by ECG (GWh)	ECG Distribution losses - % (Technical & Commercial)	ECG Actual Distribution losses (GWh)	Average price of electricity (in US$)	ECG Annual savings (in US$ million)	Duration (No. of Years)	Savings to ECG over duration – 10 years (in US$ million)	Cumulative Total savings to ECG (in US$ million)
2017	16,000	70	11,200	22.75	2,548	0.25	637	0	-	-
2027	73,800	67	49,446	19	9,395	0.23	2,161	10	21,608	21,608
2037	184,000	63	115,920	13	15,070	0.21	3,165	10	31,646	53,254
2047	297,200	60	178,320	8	14,266	0.2	2,853	10	28,531	81,785
2057	350,000	59	206,500	6	12,390	0.19	2,354	10	23,541	***105,326***

Source: GIP Team

2.11 Investment Requirements

The huge infrastructure expansion of the electricity network has an associated high investment cost as presented in Table 2.9 below. The required investment covers the entire generation mix as well as transmission and distribution networks. The cumulative investment requirement for the entire planning period is about 168 billion US dollars.

Table 2.9: Investment Requirements (million US dollars)

	2018-2021	2022-2025	2026-2029	2030-2033	2036-2037	2038-2041	2042 - 2045	2046 - 2047	TOTAL
Large Hydro	0	0	80	60	0	0	0	0	140
Small Hydro	40	822	330	120	115	0	0	0	1,427
Biomass	294	180	160	165	155	132	0	0	1,086
Biogas	7	32	45	12	212	185	124	112	729
Wave	48	63	152	106	173	141	32	0	715
Wind	450	663	523	785	311	560	760	32	4,084
Solar PV	1,630	1,460	2,150	540	840	1,140	2,460	1,270	11,490
Solar CSP	4	18	7	110	25	40	140	25	369
Imported Oil	1,387	447	12	0	0	0	0	0	1,846

Domestic Gas	3,650	3,450	2,230	790	790	220	0	0	11,130
Imported Gas	650	320	0	0	0	0	0	0	970
LNG	1,200	5,800	2,750	2,660	3,960	5,400	3,800	510	26,080
Coal	2,100	1,600	1,800	3,900	4,800	3,200	1,200	2,300	20,900
Nuclear	568	2,274	5,500	12,700	11,800	17,800	1,600	8,800	61,042
Transmission	840	1,840	1,840	1,840	1,840	1,840	1,840	1040	12,920
Distribution	800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	13,400
Total	**13,668**	**20,769**	**19,379**	**25,588**	**26,821**	**32,458**	**13,756**	**15,889**	**168,328**

Source: GIP Team

2.12 Recommendations

The following recommendations are being made to ensure the development of an effective generation, transmission and distribution infrastructure for the supply of affordable and reliable electricity for the fulfilment of the aims and objectives of Ghana's 40-year development plan:

i. There is the need to diversify the electricity generation mix to enhance energy security, in view of the issues raised in the report regarding security of fuel supply and the recent energy crises in the country;
ii. Plans and funding negotiations for the development of the necessary infrastructure in the power sector should be done well ahead of time, considering the length of time taken for infrastructure development in the power sector;
iii. Develop the appropriate policy guidelines with the necessary enforcement strategies for the promotion and use of energy efficient equipment as well as energy efficient practices;
iv. An appropriate reserve margin of 20% should always be put in place in order to ensure a very reliable and stable power generation system;
v. There should be well laid down plans to ensure supply of the required level of fuel for all relevant power plants;
vi. There should be effective intra and inter sectional coordination in the various sections of the power sector to ensure effective implementation of the generation expansion plan.
vii. There must be enough transmission capacity across all corridors so that in case of a loss of the biggest line within a corridor, the network should be able to meet full requirements;
viii. There must be a conscious scale up of the transmission voltage to 400kV to ensure larger amounts of power transmission per line with lower transmission losses;
ix. All substations should be designed and constructed to meet firm capacity requirements such that the full load of the station can be supplied even when the biggest transformer is out of service;
x. Supply to critical and sensitive loads should be at the highest level of reliability to meet the N-2 criteria as pertains to all developed countries;
xi. The appropriate voltage improvement devices should be installed and be in service at all times to ensure sustained system security;
xii. Regulatory bodies should effectively monitor power distribution utilities to ensure strict adherence to the implementation of the existing power distribution master plan.

Chapter 3 Renewable Energy

3.1 Introduction

Ghana is signatory to several international conventions, treaties and regional programmes such as the ECOWAS White Paper on Energy Access, the ECOWAS Renewable Energy (RE) and Energy Efficiency Policies among others, aimed at promoting sustainable energy development. The aforementioned conventions, treaties, and regional programmes all aim at vigorously promoting renewable energy and thereby reducing the advance and effects of climate change, to ensure a future that is conducive enough for future generations.

The Government of Ghana has therefore identified renewable energy as one of the options to contribute to the overall energy supply mix and minimise the adverse effects of energy production on the environment. Indeed, renewable energy programmes and projects implemented in recent years have demonstrated that renewable energy interventions have enormous potential to reduce poverty and improve the socio-economic development of the country, particularly, in rural communities. A well-developed renewable energy sector will also create home-grown jobs. Again, should the manufacturing of basic components be able to take root, the country's trade balance deficit will be significantly reduced.

In view of this, efforts towards the creation of a clear regulatory framework for the RE sector have been on going, with the formulation of policies and strategy documents. A major milestone for the RE industry was the enactment of the Renewable Energy Act (Act 832) in 2011. This, together with targeted policies and strategies, has helped in increasing investments from both the public and private sectors in RE. Section 2 of the Renewable Energy Act, 2011 (Act 832), defines renewable energy as energy obtained from non-depleting sources including:

i. Wind;
ii. Solar;
iii. Hydro;
iv. Biomass;
v. Biofuel;
vi. Landfill gas;
vii. Sewage gas;
viii. Geothermal energy;
ix. Ocean energy and any other energy source designated in writing by the Minister.

3.1.1 Renewable Energy Act, 2011 (Act 832)

The Renewable Energy Act (RE Act) aims to create an enabling regulatory environment to attract private sector involvement in the development, management and utilisation of renewable energy in an efficient and environmentally sustainable manner.
The key provisions in the RE Act include:

i. Feed-in-Tariff (FiT) Scheme under which electricity generated from renewable energy sources is offered a guaranteed price;

ii. Renewable Energy Purchase obligations under which power distribution utilities and bulk electricity consumers must purchase some percentage of their electricity from electricity generated from renewable energy sources;
iii. Designating biofuel blend as a petroleum product;
iv. Licensing regime for commercial renewable energy service providers, among others, to ensure transparency of operations in the renewable energy industry;
v. Establishment of the renewable energy Fund to provide incentives for the promotion, development and utilisation of renewable energy resources; and
vi. Establishment of a Renewable Energy Authority.

The RE Act defines the roles and responsibilities of key institutions to facilitate implementation of the provisions of the Act. The following have been achieved under the RE Act:

i. FiTs have been developed and gazetted;
ii. Framework for the RE Fund has been developed;
iii. Net metering code and renewable energy sub-codes for transmission and distribution systems have been developed;
iv. Licensing manual developed for RE service providers; and
v. Guidelines for the Renewable Energy Purchase Obligation have been drafted.

The latest FiT published on October 1, 2016 is presented in Table 3.1 below.

Table 3.1: Feed-In-Tariff Rates

Type of Technology	Ghana Pesewas per kWh	US cents equivalent per kWh*
Wind	65.3529	17.02697
Solar PV	59.7750	15.57371
Hydro <=10	52.9428	13.79365
Hydro (10MW>and<=100MW)	56.5312	14.72857
Tidal Wave (Ocean Wave)	52.9428	13.79365

Source: REMP, 2017 * Exchange rate: 1 USD = 3.8382 GHS (September 2016)

3.1.2 RE Institutional Framework

Ministry of Energy

The Ministry of Energy is the policy making body for RE, with a primary responsibility of ensuring policy development, coordination and implementation as well as supervision of operations and activities of sector institutions in the country. The Renewable Energy Directorate of the Ministry is mandated to perform key functions under Section 53 of the RE Act.

Energy Commission

The Energy Commission is mandated to:

i. Provide technical regulation for the energy sector;
ii. Advise the Minister responsible for energy on RE matters;
iii. Promote public education and awareness on RE technologies;
iv. Recommend for exemptions from customs levies and other duties on RE equipment and machinery;
v. Promote the local manufacture of components to facilitate the rapid growth of RE sources;

vi. Promote plans for training and supporting local experts;
vii. Set targets for the development and utilisation of RE sources; and
viii. Implement the provisions of the RE Act.

3.2 Status of RE Technology Developments

Table 3.2 presents an estimate of RE installations deployed up to December 2015 by technology type and capacity

Table 3.2: Estimated installed capacity of RE systems in Ghana

Technology Type	Installed capacity of units (estimated)	Unit
Utility scale grid-connected renewables	22.5	MWp
Other grid-connected renewables (distributed generation)	<1.40	MWp
Mini-grid (hybrid systems)	0.2	MWp
Off-grid solar (including street/community lighting)	>5	MWp
Solar Lanterns	>72,000	No. of units
Biogas	9,000	m^3
Biomass/Biogas	5.6	MW
Solar dryers	50	Tonnes

Source: REMP, 2017

3.2.1 Grid-Integrated Renewable Energy

More than 24 MW of solar PV grid-connected systems had been installed in Ghana as of 2015. Of this total, 22.5 MW was from two utility-scale projects: a 20 MW plant by BXC Company Ltd. and another 2.5 MW by VRA. The remaining systems are mainly household and institutional grid-connected systems, either self-funded, donor funded, or funded with government support.

Grid-connected systems have also been installed in the biomass industry, notably from oil palm and fruit processing companies in the Eastern and Ashanti Regions. Examples include the Juaben Oil Mills at Juaben in Ashanti Region and GOPDC at Kwae, which own biogas plants of 2000 m^3 capacity with an electricity generation potential of 4 MW.
Grid connected systems also face challenges, including:

i. High cost of capital;
ii. Lack of access to capital from the local market;
iii. Lack of indigenous investors; and
iv. Uncertainties in Feed-in-Tariff (FiT) rates beyond the guaranteed period of ten years.

3.2.2 Manufacturing/Assembly Capacity

The potential exists for the manufacturing of all renewable energy components in Ghana. The Government has therefore, put in place incentives and created the enabling environment for local manufacturing and/or assembly of RETs. Four companies are taking advantage of these market incentives to locally manufacture and assemble PV modules with details as follows:

i. Strategic Security Systems International Limited (3SiL), began the solar PV module assembly in Ghana since 2015, with the capacity of up to 30 MW of modules per year;

ii. Halo International also completed a solar PV module plant in 2016 with production capacity of 15 MW per year;
iii. Tradeworks Ghana Ltd., is in the process of completing a solar PV module assembly plant with 12 MW per year capacity; and
iv. Atlas Business and Energy Systems (ABES) has a smaller scale solar PV module assembly plant in place since 2012.

3.3 Scaling up Renewable Energy Technologies

3.3.1 Support for Manufacturing/Assembly Centres

In order to reduce the over reliance on imported RETs, government shall support local manufacturing/assembly initiatives by providing incentives such as tax breaks, capital subsidies, loan guarantees, etc. Specific incentives for renewable energy manufacturing and assembling would be as follows:

i. Substantial tax reduction for manufacturing and assembling;
ii. Materials, components, equipment and machinery (that cannot be obtained locally) for manufacturing or assembling, shall be exempted from import duty and VAT, up to the year 2025;
iii. Materials, components, equipment and machinery that Ghana has competitive advantage over, shall attract the relevant import duty and other applicable taxes to promote the local industry;
iv. Import of plant and plant parts for electricity generation from renewable energy resources, shall be exempted from import duty and VAT;
v. Allocation of a quota for local industries in all Government projects to facilitate expansion of the existing market; and
vi. Government shall provide a vehicle through existing facilities such as the Venture Capital Trust Fund to provide soft loans to local industries.

3.3.2 Local Content

A Local Content Policy (2017) for the Electricity Supply Industry (ESI), including electricity from renewable energy resources has been drafted. The Government of Ghana is committed to the implementation of an effective local content policy as the platform for achieving the goals for the power sector with full local participation in all aspects of the ESI value chain of at least 60% by 2025. This target is a very ambitious proposal and needs committed resources and programming to see this local content target being met.

The following shall be in line with the local content policy:

i. Ownership;
ii. Engineering, procurement and construction contracts;
iii. Construction and installations works;
iv. Post construction works supplies;
v. Services;
vi. Management;
vii. Operations & maintenance staff;
viii. Operation and maintenance contract.

The above requirements shall apply to all the other renewable energy initiatives under the REMP.

3.3.3 Technical Capacity Development

A sustainable human and institutional capacity building initiative is required for the effective implementation of the development of renewables. Government shall therefore identify and collaborate with relevant training institutions and industries to develop tailor-made technical and entrepreneurial programmes for targeted groups and individuals along the entire renewable energy value chain. Focus will be placed on areas such as assembling, manufacturing and installation of RETs; design, construction and maintenance of biogas digesters, gasifiers, kilns, improved household and institutional cook stoves; and biomass briquetting and pelleting. The private sector shall be the major beneficiary of this intervention.

3.3.4 Research and Development

There is limited capacity and technical know-how in renewable energy research and development (R&D) in Ghanaian universities and research institutions. In addition, funding of R&D activities has not been properly streamlined, and this has led to a lack of focus and duplication of resources. Currently, total government budgetary support in terms of GDP for R&D in all sectors is about 0.25% according to the World Bank as opposed to over 4% in Israel and South Korea. It is therefore imperative that sufficient financial resources are allocated to boost R&D.

Government shall provide adequate support to existing universities, research institutions and incubation centres such as the Ghana Climate Innovation Centre (GCIC), the Brew-Hammond Energy Centre, Centre for Renewable Energy and Energy Efficiency at Kumasi Technical University, Department of Energy Systems Engineering at Koforidua Technical University, Council for Scientific and Industrial Research (CSIR) etc., to deliver on their core mandates.

The key areas for R&D in the renewable energy sector would include:

i. Existing and new materials for production of the components of RETs;
ii. Improvement of the technical characteristics of indigenous RETs (cook stoves, kilns, inverters, controllers, etc.);
iii. Advanced assembling and manufacturing techniques and processes for the components of RETs;
iv. Innovations in RET solutions; and
v. Policies and socio-economic issues for effective planning and development of the renewable energy and energy efficiency (REEE) sectors.

In consultation with industry, renewable energy R&D priorities would be established and implemented in partnership with the relevant stakeholders. In this regard, efforts would be made to strengthen individual and institutional research capabilities, increase cost sharing in financing proposals, and upgrade equipment and instrumentation.

3.3.5 Development of Standards and Codes

Standards and technical codes are needed to ensure that optimal benefits are derived from the utilisation of RETs. The Ghana Standards Authority (GSA) has adopted standards for solar modules, batteries, inverters, solar lanterns, liquid biofuel and selected electrical appliances, and is also in the process of completing the minimum performance requirements for biomass cook stoves.

The Energy Commission (EC) in collaboration with relevant institutions has developed technical codes for connecting renewable energy generating systems to the transmission and distribution systems. In order to keep pace with emerging trends in the sector, the GSA shall continue to update these standards. The existing laboratory for testing solar systems at the GSA must also be upgraded to provide the full range testing services for all RETs as defined in the RE Act. Standards shall also be adopted for mini-grid development in Ghana.

3.3.6 Financing

Limited access to long-term financing and high cost of capital are major constraints to the growth of the renewable energy sector. At the moment, local banks are unable to offer long-term lending for infrastructural projects including RE projects.

Investment and commercial banks in the country would be encouraged to develop long term financing portfolios for renewable energy projects. Having attained lower middle-income status, concessional funding facilities from development partners have dwindled. There is, therefore, the need to develop and explore innovative funding mechanisms to support renewable energy projects. Utility-scale renewable energy projects shall be supported with risk mitigation instruments (e.g. Renewable Energy Put Call Option Agreement (PCOAs), liquidity support, insurance, etc.).

3.4 Indicative Strategies for Renewable Energy

In line with the Renewable Energy Act, 2011 (Act 832), the Ministry of Energy and the Renewable and Alternative Energy Directorate will adopt the following strategies in order to meet the stated objectives of the Act:

- viii. The utilities will play key roles, especially in relation to utility scale projects. The Volta River Authority, Bui Power Authority and the proposed Renewable Energy Authority will be encouraged to grow and expand the renewable energy electricity space through public and private sector led investments;
- ix. GRIDCo will drive strategic investments and expansion of the National Interconnected Transmissions System (NITS) to accelerate the interconnection of utility renewable energy projects;
- x. The Renewable Energy Purchase Obligation (REPO) will be implemented to ensure that the distribution companies, ECG and NEDCo and all other bulk customers integrate electricity generated from renewable resources in their distribution and consumption mix;
- xi. ECG and NEDCo are to ensure that net-metered systems have access to the distribution grid, in line with the 'Net-Metering Code';
- xii. Private sector investment is at the centre of the REMP. Private sector investments toward achieving the targets in the REMP, especially, utility scale projects, will be given the utmost priority. The REMP will continue to create

opportunities through the RE-FiTs, competitive procurement of RE projects and purchase obligations to increase investment in the sector;

xiii. The government will give financial incentives and procurement preferences to private sector actors engaged in the local assembly and manufacturing of renewable energy technologies and related services. Manufacturing and assembling of renewable energy technologies is pivotal to the overall success of the plan, and strategic links in the renewable energy value chain would be fully implemented;

xiv. The Ghana Standards Authority will be strengthened to ensure that local production of renewable energy technologies meet international standards.

3.5 Targets and Action Plan

For each of the RET areas (solar, wind, hydro, biomass, etc.), the action plan analysed the resource availability, opportunities in developing the resource, and recommended interventions for their promotion and development. Further details and actions are provided for each of the technologies/ interventions under every resource type, with specific considerations given to the challenges and strategies to promote it. The REMP proposes strategies to minimise the adverse impact of the various renewable energy technologies and targets on land use through spatial planning.

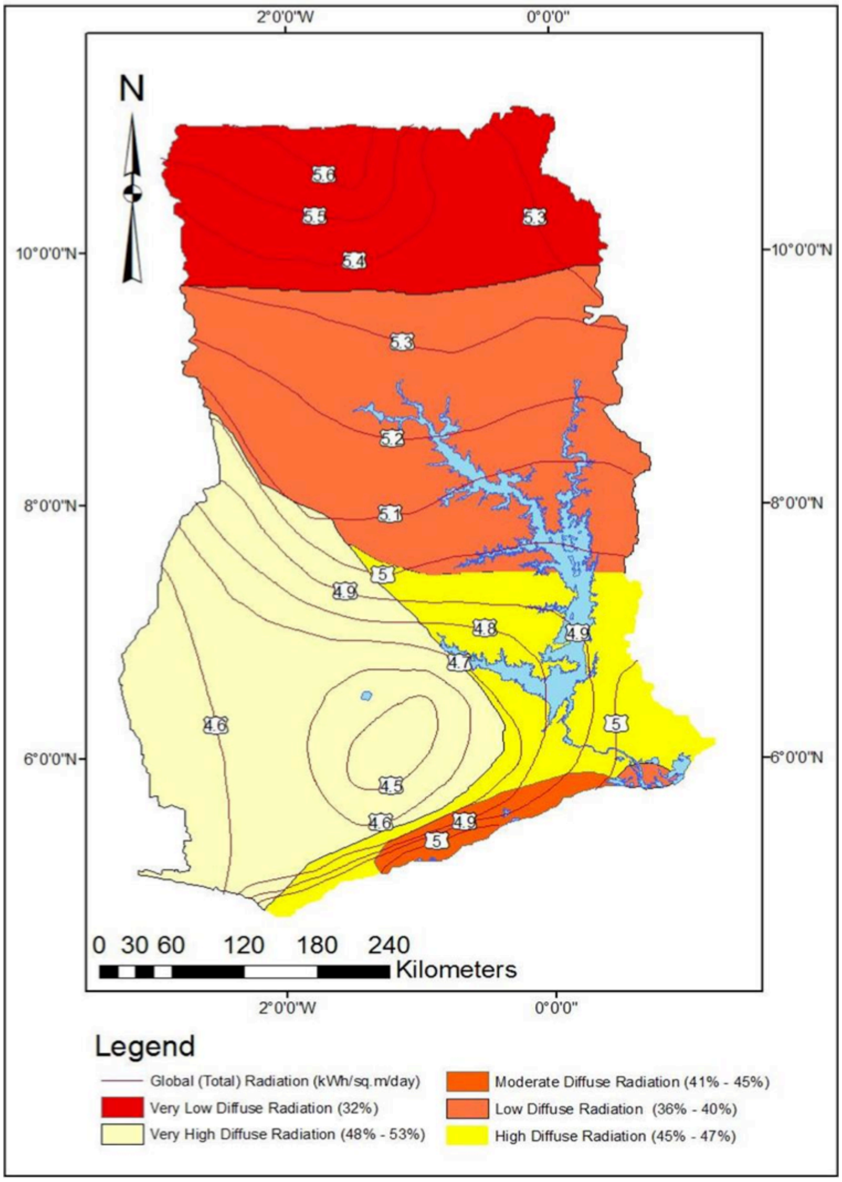
3.5.1 Targets and Action Plan for Solar Energy

Ghana's geographical location gives it good exposure to solar radiation, which is ideal for both electricity and thermal energy applications. The country's average solar irradiation ranges from 4.5–6.0 kWh/m^2/day, with the highest levels of solar irradiation mostly in the northern part of the country. The annual sunshine duration ranges from 1,800–3,000 hours annually. On the other hand, daily average sunshine duration varies from 5.3 hours in the cloudy and semi-deciduous forest zones like Kumasi in the middle-belt, to 7.7 hours in the dry and savannah zones like Wa in the northern part of the country[29]. The average solar irradiation in other parts of the country ranges between 4.4 and 5.6 kWh/m^2/day with a very low diffused radiation of about 32%.

In terms of monthly average solar irradiation in different parts of the country, this ranges from 4.4 to 5.6 kWh/m^2/day. Specifically, the monthly average solar irradiation is considered very high, ranges from 4.0 to 6.5 kWh/m^2/day in Northern Ghana, which includes the northern parts of Brong Ahafo and the Volta Regions. On the other hand, other parts of the country like Ashanti, parts of Brong Ahafo, Eastern, Western and parts of Central and Volta Regions have relatively lower monthly average irradiation in the range of 3.1 to 5.8 kWh/m^2/day. The monthly average irradiation along the coast of Greater Accra, Central and Volta Regions is moderate and ranges from 4.0 – 6.0 kWh/m^2/day (Figure 3.1).

[29] Togobo, W.A., *Investment Opportunities in the Power Sector*. 2011.

Figure 3.1: Solar Radiation Map of Ghana



Source: REMP, 2017

The targets and potentials of solar energy for the plan period are presented in Tables 3.3 and 3.4 respectively.

Opportunities

Several opportunities exist to develop solar energy in Ghana. These include the following:

i. Increase generation capacity – through utility scale projects, mini-grids, standalone applications in street lighting, traffic controls, aviation signals, telecommunication, light electronic devices, etc.;
ii. Demand side management (distributed generation) – integration of solar PV and solar water heaters into existing and new buildings, to reduce increasing cost of conventional power;

iii. Applications in agriculture – irrigation and crop drying;
iv. Assembling/manufacturing – principally in the areas of solar PV modules and balance of systems, including inverters, batteries, solar water heaters etc., to service both the domestic and the fast-growing ECOWAS market;
v. Reuse and recycling of e-wastes resulting from local manufacture and use of renewable energy systems;
vi. Increase research, development, demonstration and commercialisation of solar energy technologies.

Solar water heaters have the potential to contribute 2GWh of savings from energy demand according to research by the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) in 2015.

3.5.2 Targets and Action Plan for Hydro

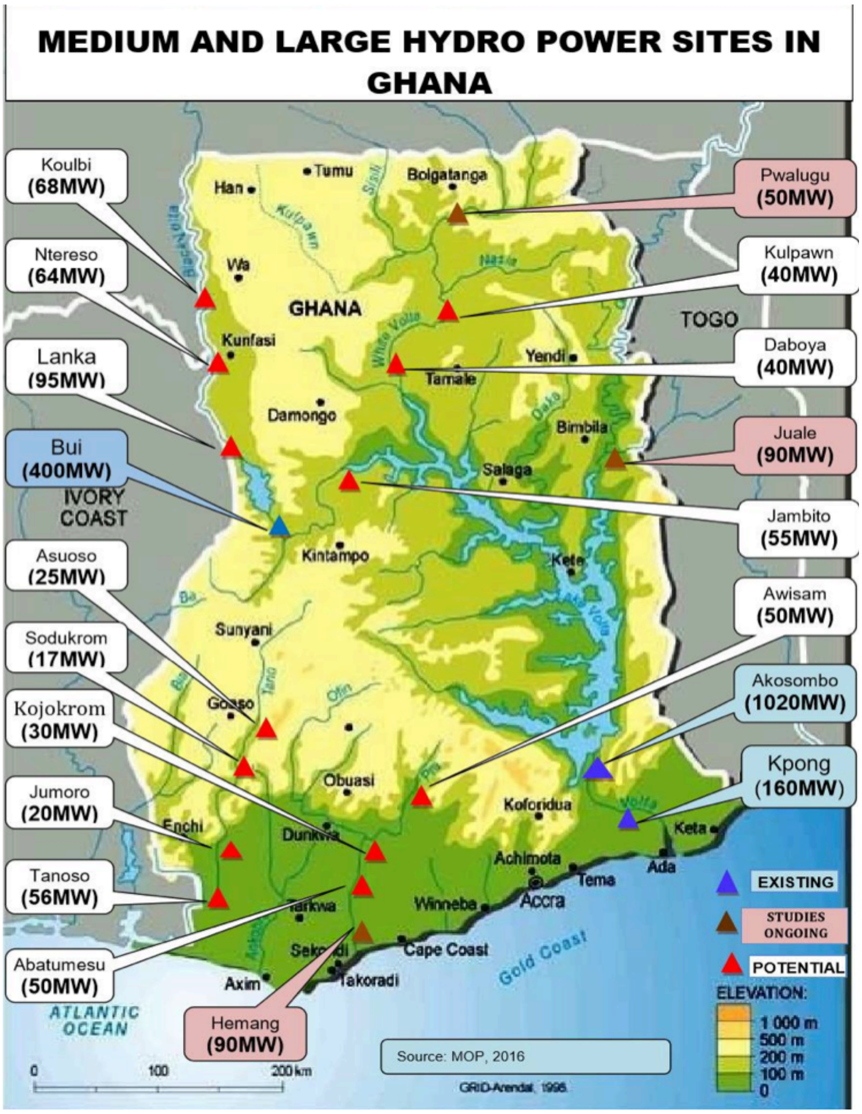
Hydro has been a dominant power source in Ghana, providing cheap power for industrial development post-independence. Currently, all of Ghana's large hydro resources have been exploited. The potential of the remaining sites fall below 100 MW capacity. These sites include Pwalugu (50 MW), Juale (90 MW) and Hemang (90 MW) among others (Figure 3.2). These sites will be developed during the plan period. The targets and potentials of energy from hydro sources for the plan period is presented in Tables 3.3 and 3.4 respectively.

Opportunities

Opportunities for small and medium hydropower development includes the following:

i. Increase generation capacity using less variable hydro power;
ii. Export power to neighbouring countries;
iii. Develop irrigation projects as co-benefit;
iv. Develop river transportation as co-benefit;
v. Create jobs;
vi. Build capacity in small and medium hydro project management.

Figure 3.2: Developed and Potential Hydro Sites

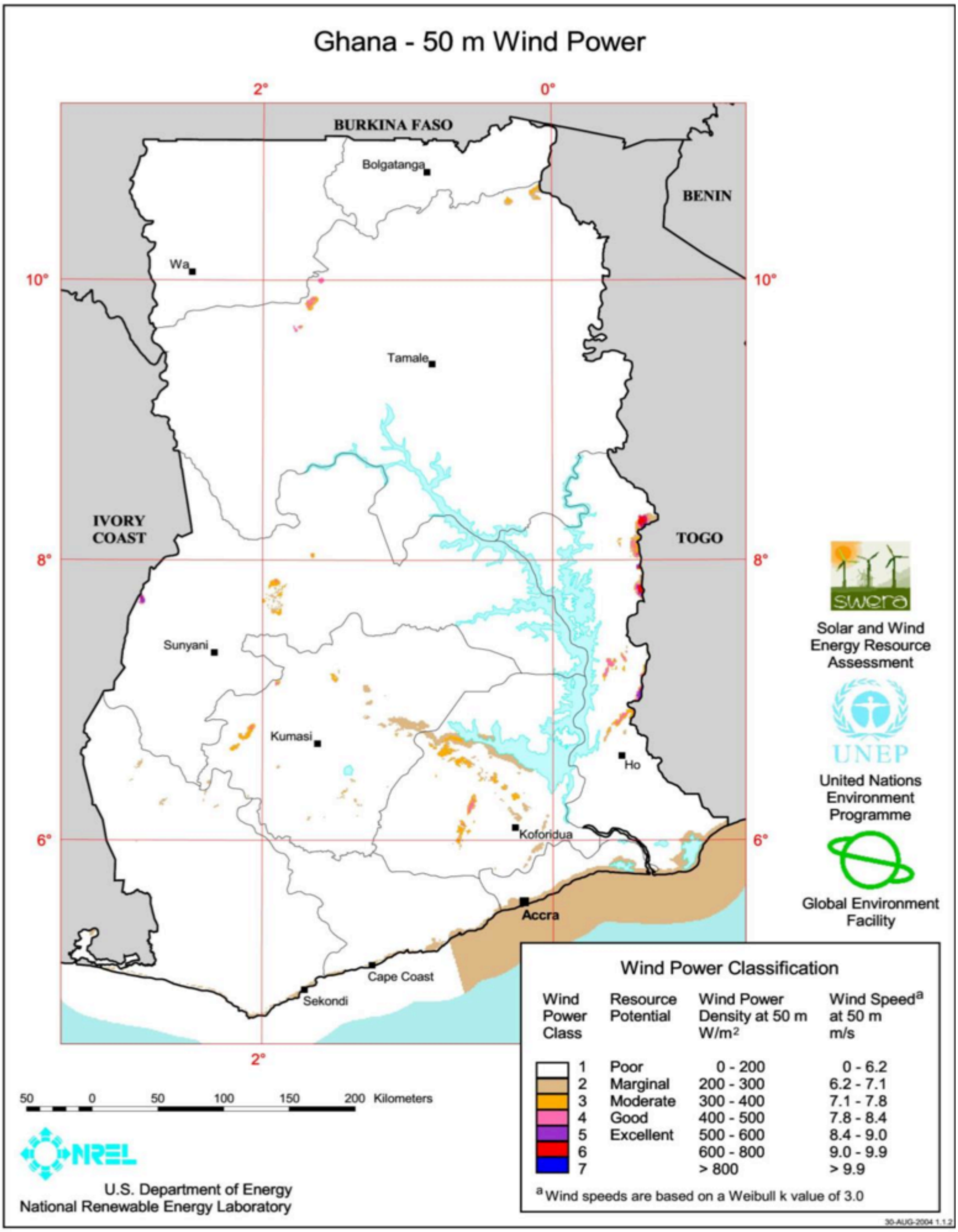


Source: REMP, 2017

3.5.3 Targets and Action Plan for Wind Power

The country's wind potential is considered as marginal with average annual wind speeds of between 4m/s to 6m/s at 50m-hub height above sea level especially along the coast, east of Greenwich Meridian and on some island communities in the Volta Lake. According to NREL satellite data, wind speeds in some mountainous regions in the country especially along the Ghana–Togo border are estimated to be above 8m/s. An assessment of wind resource at eight sites along the coast between 2011 and 2013 indicated average monthly wind speeds at 60m elevation as capable of development of a utility scale wind farm with a capacity of about 200–400 MW. Total wind energy resource is estimated to be more than 1500 MW. The targets and potentials of energy from wind power for the plan period is presented in Tables 3.3 and 3.4 respectively.

Figure 3.3: Wind Resource Map of Ghana



Source: REMP, 2017

3.5.4 Targets and Action Plan for Wave Power

Preliminary assessment has shown that the waves at the East of the meridian are strong, indicating strong potential for tidal wave development. There is opportunity to develop tidal resource with higher capacity factor than wind and solar which would complement generation capacity. During the plan period, tidal energy will be harnessed from viable sites for power generation. The targets and potentials of wave power for the plan period is presented in Tables 3.3 and 3.4 respectively.

3.5.5 Targets and Action Plan for Energy from Biomass Sources

The country produces abundant energy from biomass sources such as (i) wood/plant waste materials, (ii) municipal solid waste such as tires/landfill gas (LFG), and (iii) other biomass such as agricultural by-products, which can be utilised for the generation of electricity.

The challenges of utilising energy from renewable sources include the following:

vii. Finding suitable sites for the development of large utility scale wind and solar farms;
viii. Intermittency of energy supply from wind and solar, which requires additional power storage (e.g. battery and ancillary services);
ix. As a result of the low energy intensity of solar, this requires large tracts of land for grid-connected solar PV;
x. Integration of intermittent wind and solar PV into the national grid requires assessment of other associated costs such as the need for reinforcements of the grid.

The targets and potentials of energy from biomass sources for the plan period is presented in Tables 3.3 and 3.4 respectively.

Table 3.3: Renewable Energy Targets - 2018 to 2047

REMP IMPLEMENTATION PLAN-RE TARGETS BY 2030								
Renewable Energy Technologies (RETs)	**Reference 2015**		**Year 2020**		**Year 2030**		**Year 2047**	
	No. of Units	**MW**	**No. of Units**	**MW**	**No. of Units**	**MW**	**No. of Units**	**MW**
Solar Energy								
Solar utility scale PV	-	22.5	-	200	-	1000	-	800
Rooftop/net metering solar PV			20,000	20	200,000	200	1,000,000	3,554
Standalone solar PV systems			7,000	2	47,000	14		14
Solar PV street/community lighting		4.93	10,000	7	40,000	25		25
Solar PV lanterns	72,000		200,000	0.8	2,000,000	10		10
Concentrated solar power						100		100
Railway Corridor solar						700		2,000
Mini-grids			100	4	500	20	500	20
Solar PV water pumping for irrigation and water supply			100	0.5	500	2.5	500	2.5
Solar water heaters (thermal)	4700	-	20,000	-	135,000	-	135,000	-
Wind Energy								
Wind utility scale			-	275	-	800	-	1,500
Standalone wind systems (including net-metered)			-	0.1	-	2	-	-
Wind irrigation/water pumping			35	-	100	-	100	-
Biomass/Waste-to-Energy								
Biomass utility-scale (plantations, forest residues, etc.)			-	75	-	150	-	300
Waste-to-energy (utility Scale; solid & liquid)		0.8	-	12	-	12	-	12
Agricultural/industrial organic waste (biogas)	<20	-	30	-	200	-		-
Institutional (biogas)	<100	-	180	-	400	-		50
Domestic (biogas)	<50	-	80	-	200	-		-
Landfill	1	2	3	6	10	20		150
Hydropower/Wave Power								
Medium hydropower			-	100	-	300	-	300
Small hydropower			-	1	-	10	-	200
Wave power			-	10	-	100	-	200
Total RE Installed Capacity (Electricity)		***30***		***713***		***3773***		***9,000***

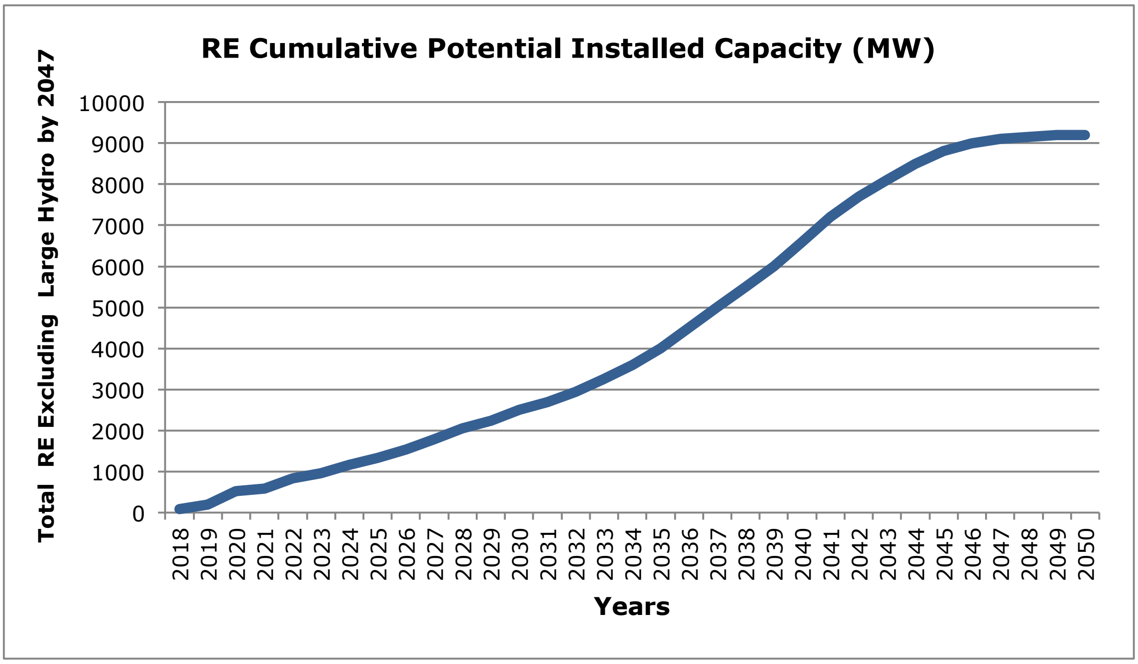
Source: REMP 2007, updated by GIP Team

Table 3.4: Renewable Energy Potential 2047

Utility Scale Solar	800 MW
Rooftop Solar	3,554 MW
Conc. Solar Power	100 MW
Railway Solar	2,000 MW
Wind	1,500 MW
Wave	200 MW
Small Hydro	446 MW
Biomass	300 MW
Biogas	200 MW
Total	**9,000 MW**

Source: REMP, 2017 and updated by GIP Team

Figure 3.4: Renewable Energy Cumulative Installed Capacity (MW)



Source: GIP Team, 2017

3.6 Economic, Social and Environmental Impacts

3.6.1 Economic Impacts

The total investment required for implementing the REMP is estimated at US$ 23 billion over the 30-year period, which translates to an annual average cost of about US$ 0.75 billion. Effective implementation of the REMP is expected to create about 370,000 jobs along the value chains of the various interventions to ensure the following:

i. Boost industrialisation in areas such as manufacturing, assembling, etc.;
ii. Contribute to national energy security;
iii. Increased productivity in sectors such as agriculture and small scale industries;
iv. Increase in foreign exchange earnings and improved balance of trade;
v. Enhance security and improve quality of life of rural and urban people using indigenous resources;
vi. Improved public service delivery particularly in the areas of health and education;
vii. Reduction in household air pollution;
viii. Creation of a sustainable market for RETs;
ix. Improved regulatory and fiscal regime to facilitate ease of doing business in the RE sector;
x. Increased renewable energy penetration;
xi. Increased access to modern energy services for un-served and underserved communities;
xii. Increased energy efficiency (co-benefit – economic and environmental);
xiii. Increased human capacity in the RE sector;
xiv. R&D enhanced to spur innovation, adaptation and localisation of RE technologies.

Other identified benefits include:

i. Compost and biochar for the agriculture sector;
ii. Inputs for the production of organic cosmetics;
iii. Improved soil fertility and bio-diversity for well-developed woodlot plantation;
iv. Activated charcoal for the mining sector;
v. Tar, as a by-product from improved charcoal production for construction sector;
vi. Successful implementation of the REMP will serve as a learning curve towards improving activities in other sectors of the economy; and
vii. Improved socio-economic status of women through increased use of modern energy.

3.6.2 Environmental Impacts

The success of the promoting renewables will lead to significant reductions in carbon dioxide emissions and contribute to the reduction of Ghana’s carbon footprint.

Land Use

Renewable energy technologies such as utility scale solar and wind, and plantation based schemes, require appreciable land mass for development with its attendant effect on other land uses. For instance, the land requirement for solar PV installations ranges from 3.5 to 8 acres per MW. Unlike wind facilities, there is less opportunity for solar projects to share land with other economic uses such as agriculture.

Through spatial planning, the impacts of utility-scale renewable energy systems could be minimised by siting them at locations where there is less competition for land use, for example degraded lands, abandoned mining sites, transportation and transmission corridors, etc.

The use of roof space in commercial, industrial, public and private facilities for solar installations would be strongly encouraged and promoted.

Economic and multipurpose energy crops and tree species for electricity generation and liquid biofuels would be promoted for optimal land use. Further gains envisaged are listed below:

i. Reduction of adverse climate change effects;
ii. Increased forest cover as a result of afforestation and reforestation;
iii. Boost in eco-tourism.

Due to the site-specific nature of wind resources, urgent measures would need to be taken to secure the potential areas where the resource abounds for development. This is to avoid losing such sites, particularly areas along the coastal belts to other competing needs. Several models would be deployed, such as land acquisition through executive instruments or contribution of land as equity by owners in the development of renewable energy projects.

Other recommendations with regards to biofuel are:

i. Grasslands that are not used for grazing or food production should be demarcated and used to produce solid and liquid biofuels.
ii. A biofuels plant should be strategically located in Buipe, for transport and delivery of biomass residues via road and railway as well as inland water transport. A plant located in Buipe could receive wood and crop residues from all northern regions and Brong Ahafo, and receive solid waste from Tamale and environs.
iii. Develop other biofuel energy plants in Accra and Kumasi based on the thousands of tons of solid waste produced daily. To ensure sufficient delivery of solid waste, a shared energy generating plant could be located between Kumasi and Accra along a new railway line connecting to solid waste collection points in Kumasi and Accra located along the urban railway line.

Hazardous Materials

Some materials used in the manufacturing process for solar PV cells could be hazardous. For example, industrial chemicals such as hydrochloric acid, sulfuric acid, nitric acid, hydrogen fluoride, 1,1,1-trichloroethane, and acetone are used to clean and purify the semiconductor surfaces. The indiscriminate disposal of batteries could result in serious environmental and public health perils.

As the country industrialises, the volume of these waste materials would increase significantly and therefore would require an improved and aggressive approach to handling and managing their disposal. This could present economic opportunities particularly in the areas of reuse and recycling. However, considering that the informal society contributes significantly to poor waste management and collection, it is critical that a programme of action is implemented to ensure that hazardous waste, particularly from household solar does not become a national menace. This is line with the recent hazardous waste (e-waste act (Hazardous and Electronic Waste Control and Management Act, 2016) that seeks to ensure the safe disposal of all types of e-waste in the country. In this regard, the renewable fund should support the expansion of the existing e-waste disposal and recycling plants in the country and the construction of new ones in strategic locations to convert the voluminous waste into usable materials and see to its proper disposal where required.

Chapter 4 Nuclear Energy

4.1 Introduction

The high economic development aspiration in Ghana's forty-year development plan definitely calls for a high growth in energy demand. Experiences regarding shortages in Ghana's power supply sector have shown that it is necessary for the nation to explore other energy sources, in addition to oil and gas, to enhance national energy security. In this connection, nuclear power has been identified as an alternative energy source that can generate high capacity base load electricity at affordable price and enhance energy security. Since the time of independence, the nation has had a vision for peaceful application of nuclear technology in various fields including power generation.

By the turn of the millennium, the country's ambition to achieve and maintain middle-income status was threatened by a series of recurring national electric power crises. As a result, the sector ministry with the vision to ensure energy accessibility, security and economy and enhance national development formulated the strategic national energy plan and the energy policy. Experiences in the industrialised economies as well as emerging economies attest to the fact that without sustainable, secure and affordable base load electricity supply, national development is likely not to be met.

4.1.1 History of Nuclear Technology in Ghana

Ghana's quest to utilise nuclear energy for electricity generation dates back to the early 1960s when Ghana's first reactor project was launched in 1963 involving the construction of a 2 MW Soviet reactor. The Ghana Atomic Energy Commission (GAEC) was therefore established in the same year to handle it. The nuclear project did not proceed as expected due mainly to political factors. The reactor project was abandoned as a result of the 1966 coup d'etat which ousted the then Nkrumah regime. Even though efforts were made in the succeeding years to revive the project, political interferences put it on a hold. The reactor project however came to fruition in 1995 when GAEC commissioned the nation's first research reactor, a 30kW reactor built by the Chinese. It was meant among other things to train the necessary manpower and prepare the nation towards any future nuclear power project. In an effort to promote nuclear knowledge and technology, GAEC and the University of Ghana with support from the International Atomic Energy Agency (IAEA) established the School of Nuclear and Allied Sciences in 2006.

The nuclear option gained attention during the 2006/2007 energy crisis when a Presidential Commission was set up to consider its viability for power generation in the country. Following the presidential commission report, cabinet took a decision in 2008 to include nuclear energy and to develop a roadmap for its introduction in the national energy mix. Subsequently nuclear energy was included in the national energy policy and strategy in 2010. The government of Ghana declared its intention to pursue a nuclear power programme for peaceful purposes through a letter submitted to the International Atomic Energy Agency in 2012. The Ghana Nuclear Power Programme Organisation (GNPPO) was then established to see to the planning and implementation of the programme and the development of the necessary nuclear infrastructure in line with

International Atomic Energy Agency (IAEA) recommendations, for the successful introduction of nuclear energy into the energy mix. Currently, the GNPPO is under the Ministry of Energy.

In order to accelerate the development of the necessary nuclear infrastructure, the Ghana Atomic Energy Commission acting on behalf of the government of Ghana and the GNPPO, established the Nuclear Power Institute (NPI) to provide technical support to the GNPPO. The NPI has been working to promote the cause of the development of the required nuclear infrastructure for Ghana's Nuclear Power Programme. In addition, Ghana has established an independent Nuclear Regulatory Authority to ensure an effective regulatory regime with respect to nuclear safety, security and safeguards. The Regulatory Authority has the mandate of regulating all activities associated with the handling and utilisation of all radioactive and ionising radiation sources in Ghana. The country is following the infrastructural milestone approach provided by the IAEA which includes 19 infrastructure issues including, safety, security, national position, management, human resource development, stakeholder involvement, funding & financing, regulatory issues, legal issues, etc. At the current pace of progress it is expected that nuclear power will be introduced in the energy mix for the first time by 2029.

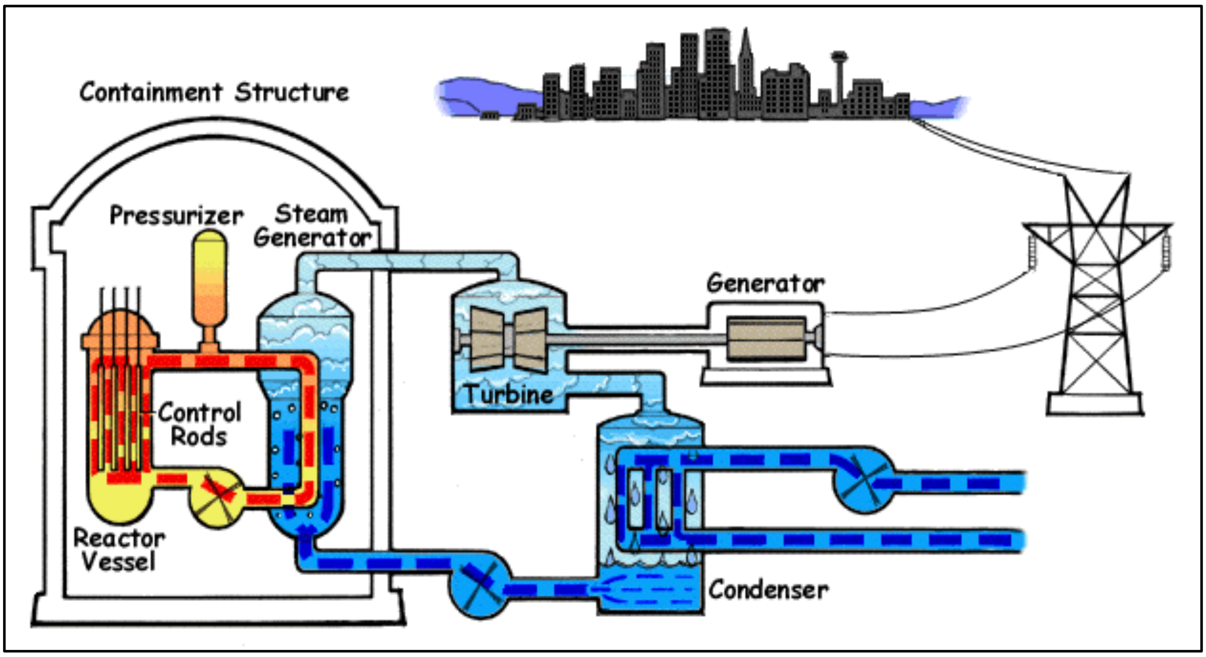
4.2 Nuclear Power Outlook

Nuclear power plants (NPPs) generate electricity by splitting heavy atoms such as uranium through a nuclear fission process in a reactor to produce heat. The heat energy so produced is used to boil water to generate steam, which drives a turbine coupled to a generator to generate electricity (Figure 4.1)[30]. Alternatively, gas instead of water may be heated to drive the turbine for electricity generation. Nuclear power is a clean, safe, reliable and competitive energy source. It is the only source of energy that can replace a significant part of the fossil fuels (coal, oil and gas), which massively pollute the atmosphere and contribute to the greenhouse effect. Nuclear power is a proven technology and it currently accounts for about 12% of global electricity generation[31]. Currently 448 reactors are in operation in 33 countries with 58 under construction in 14 countries (Table 4.1) [2].

Nuclear power has high energy security mainly due to the low fuel requirement as a result of the high energy density of nuclear fuel. A kilogram of nuclear fuel for example can generate 50,000 kWh of electricity whereas that of firewood, coal and crude oil can generate 1 kWh, 3kWh and 4 kWh respectively[32]. This low fuel requirement can also reduce significantly, the risks associated with fuel supply and price instability. Emerging economies like China and India are also dependent on nuclear power for electricity generation. Both countries have plans to expand their nuclear programme.

[30] US Nuclear Regulatory Commission
https://www.nrc.gov/reading-rm/basic-ref/students/animated-pwr.html
[31] World Nuclear Association, *World Nuclear Power Reactors and Uranium Requirements*,
http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx
[32] International Atomic Energy Agency, *Sustainable Development and Nuclear Power*, 1997, p 32.

Figure 4.1: Schematic diagram of a nuclear power plant



Source: US NRC

In China, 20 reactors with capacity 22,596 MW are under construction with additional nuclear capacity of 46,850 MW planned and 156,000 MW proposed (Table 4.1). In the case of India, 5 reactors with capacity 3,300 MW are under construction with additional nuclear capacity of 18,600 MW planned and 51,000 MW proposed. About 45 countries, most of which are the emerging economies have expressed interest in the nuclear power option[33]. This includes the United Arab Emirates where 4 reactors with a total capacity of 5,600 MW are already under construction, Saudi Arabia, Turkey, Vietnam, Indonesia, Belarus, Kenya, Nigeria Ghana, Morocco, Egypt, Uganda, Sudan Algeria, Niger, etc.

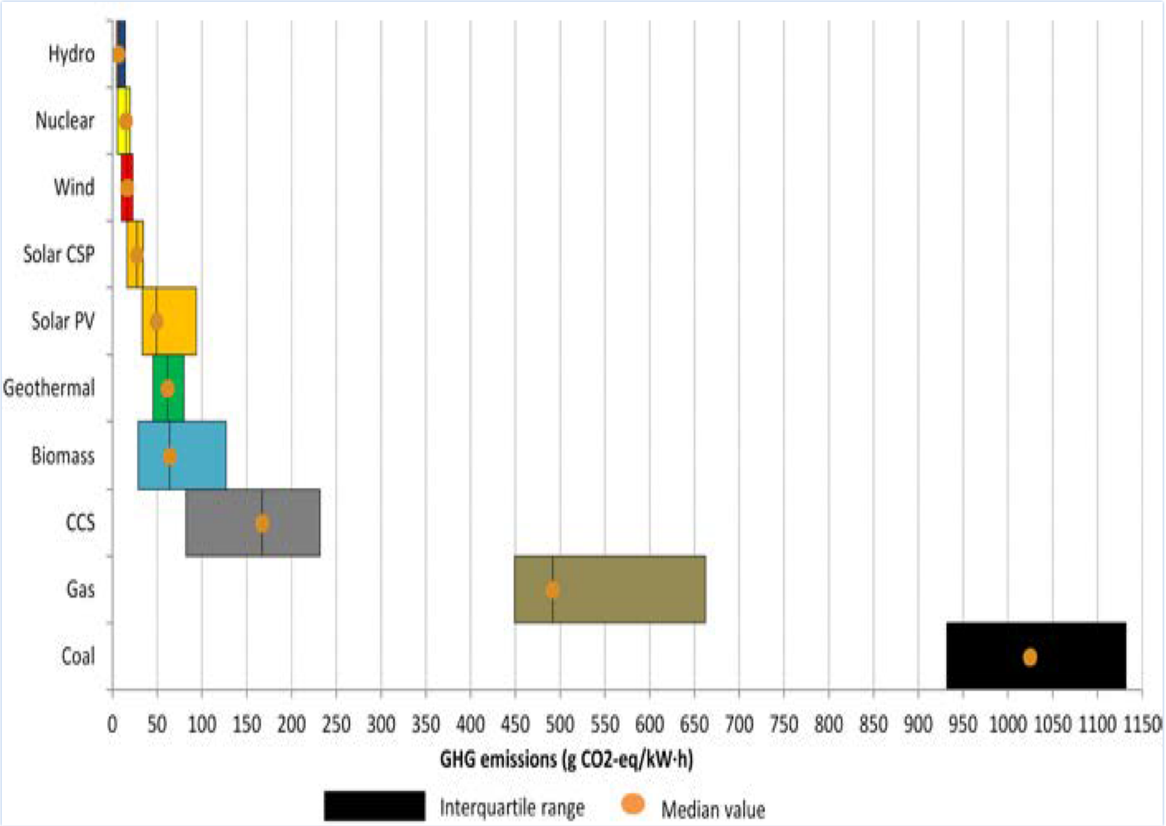
4.2.1 Nuclear Power Advantages

Health and Environment Impact

Nuclear power is a relatively clean source of power emitting no greenhouse gases and gaseous pollutants at the plant operation level. It is also a major contributor to climate change mitigation. Currently the use of nuclear power instead of coal saves the world from an emission of about 2 billion tonnes of CO_2 annually[34]. With respect to gas, about half of the above value is saved. Studies have shown that the life cycle CO_2 emission of nuclear power is low in comparison with other options (Figure 4.2)[35]. Life cycle CO_2 emission of an energy option is its cradle-to-grave CO_2 emission and deals with the amount of emission during fuel extraction, plant construction, plant operation and plant decommission.

[33] World Nuclear Organisation, *Emerging Nuclear Energy Countries* http://www.world-nuclear.org/information-library/country-profiles/others/emerging-nuclear-energy-countries.aspx
[34] World Nuclear Association, *Green House Gas Emissions Avoided by Using Nuclear Power* http://www.world-nuclear.org/nuclear-basics/greenhouse-gas-emissions-avoided.aspx
[35] International Atomic Energy Agency, *Nuclear Power and Climate Change*, 2016, p 19 http://www-pub.iaea.org/MTCD/Publications/PDF/CCANP16web-86692468.pdf

Figure 4.2: Life cycle CO2 emission of various energy options



Source IAEA Note. CCS = Carbon capture and storage, NGCC= Natural gas combined cycle.

Table 4.1: World Nuclear Power Plants

COUNTRY	Nuclear Electricity Generation		Reactors Operable		Reactors Under Construction		Reactors Planned		Reactors Proposed		Uranium Required
	billion kWh	% e	No.	MWe net	No.	MWe gross	No.	MWe gross	No.	MWe gross	Tonnes U
Argentina	6.5	4.8	3	1627	1	27	2	1950	2	1300	215
Armenia	2.6	34.5	1	376	0	0	1	1060			88
Bangladesh	0	0	0	0	0	0	2	2400	0	0	-
Belarus	0	0	0	0	2	2388	0	0	2	2400	-
Belgium	24.8	37.5	7	5943	0	0	0	0	0	0	1,015
Brazil	13.9	2.8	2	1901	1	1405	0	0	4	4000	329

Bulgaria	14.7	31.3	2	1926	0	0	1	950	0	0	327
Canada	95.6	16.6	19	13553	0	0	2	1500	3	3800	1,630
Chile	0	0	0	0	0	0	0	0	4	4400	-
China	161.2	3.0	35	31617	20	22596	41	46850	136	156000	5,338
Czech Republic	25.3	32.5	6	3904	0	0	2	2400	1	1200	565
Egypt	0	0	0	0	0	0	2	2400	2	2400	-
Finland	22.3	33.7	4	2741	1	1700	1	1200	1	1500	1,126
France	419.0	76.3	58	63130	1	1750	0	0	1	1750	9,211
Germany	86.8	14.1	8	10728	0	0	0	0	0	0	1,689
Hungary	15.0	52.7	4	1889	0	0	2	2400	0	0	356
India	34.6	3.5	22	6219	5	3300	20	18600	44	51000	997
Indonesia	0	0	0	0	0	0	1	30	4	4000	-
Iran	3.2	1.3	1	915	0	0	2	2000	7	6300	178
Israel	0	0	0	0	0	0	0	0	1	1200	-
Italy	0	0	0	0	0	0	0	0	0	0	-
Japan	4.3	0.5	43	40480	3	3036	9	12947	3	4145	680
Jordan	0	0	0	0	0	0	2	2000			-
Kazakhstan	0	0	0	0	0	0	2	600	2	600	-
Korea DPR (North)	0	0	0	0	0	0	0	0	1	950	-
Korea RO (South)	157.2	31.7	25	23017	3	4200	8	11600	0	0	5,018
Lithuania	0	0	0	0	0	0	1	1350	0	0	-
Malaysia	0	0	0	0	0	0	0	0	2	2000	-
Mexico	11.2	6.8	2	1600	0	0	0	0	2	2000	282
Netherlands	3.9	3,7	1	485	0	0	0	0	1	1000	102
Pakistan	4.3	4.4	4	1040	2	1501	1	1161	0	0	270

Poland	0	0	0	0	0	0	6	6000	0	0	-
Romania	10.7	17.3	2	1310	0	0	2	1440	1	655	179
Russia	182.8	18.6	36	27167	7	5904	25	27755	23	22800	6,264
Saudi Arabia	0	0	0	0	0	0	0	0	16	17000	-
Slovakia	14.1	55.9	4	1816	2	942	0	0	1	1200	917
Slovenia	5.4	38.0	1	696	0	0	0	0	1	1000	137
South Africa	11.0	4.7	2	1830	0	0	0	0	8	9600	304
Spain	54.8	20.3	7	7121	0	0	0	0	0	0	1,271
Sweden	54.5	34.3	9	8849	0	0	0	0	0	0	1,471
Switzerland	22.2	33.5	5	3333	0	0	0	0	3	4000	521
Thailand	0	0	0	0	0	0	0	0	5	5000	-
Turkey	0	0	0	0	0	0	4	4800	4	4500	-
Ukraine	82.4	56.5	15	13107	0	0	2	1900	11	12000	2,251
UAE	0	0	0	0	4	5600	0	0	10	14400	-
United Kingdom	63.9	18.9	15	8883	0	0	4	6100	9	11800	1,734
USA	798.0	19.5	99	99535	4	5000	18	8312	24	26000	18,161
Vietnam	0	0	0	0	0	0	4	4800	6	6700	-
WORLD	**2,441**	**11.5**	**448**	**391,665**	**58**	**62,049**	**167**	**174,505**	**345**	**388,600**	**63,404**

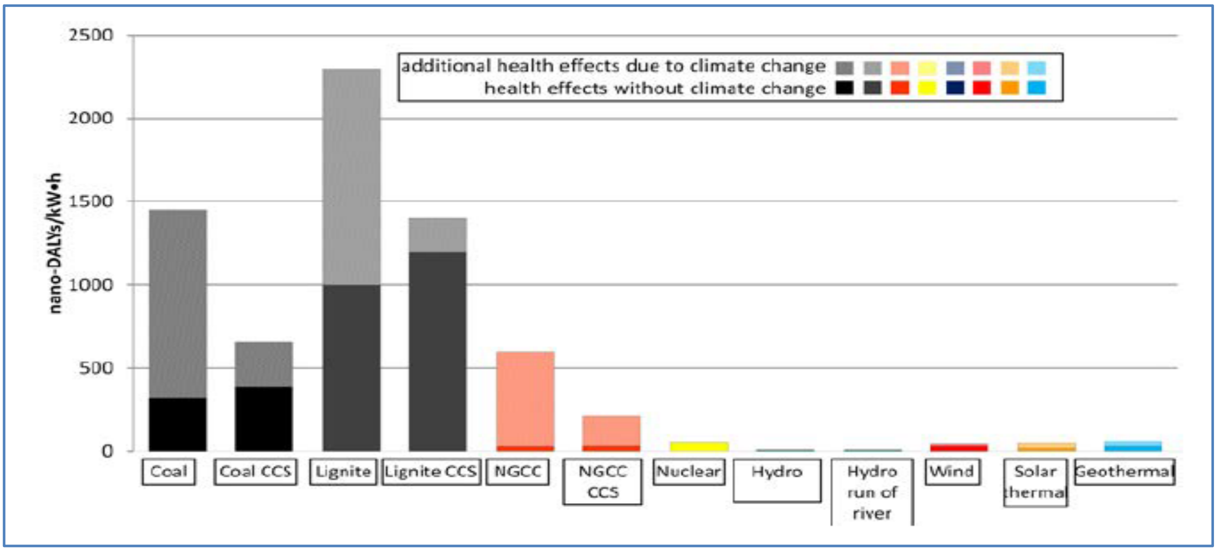
Source: World Nuclear Association

*Note Operable = Connected to the grid.
Under Construction = First concrete for reactor poured, or major refurbishment underway.
Planned = Approvals, funding or commitment in place, mostly expected in operation within 8-10 years.
Proposed = Specific programme or site proposals, timing of start of operation very uncertain.

This assessment is based on the fact that all the energy technologies depend on fossil fuel systems in a way or the other. During fuel extraction and transportation of plant material, a fossil fuelled plant or equipment may be used. Another study conducted by the Paul Scherrer Institute in Switzerland indicates low health effect of nuclear power in comparison with some options; also published by the International Atomic Energy Agency (IAEA)[36] (Figure 4.3). The study considers years of life lost by an individual due to premature death as well as years of disability, which is measured in DALYs. It also accounts for health effects due to climate change.

[36] International Atomic Energy Agency, *Nuclear Power and Climate Change*, 2016, p 55 http://www-pub.iaea.org/MTCD/Publications/PDF/CCANP16web-86692468.pdf

Figure 4.3: Health effects of power options including that due to climate change (top bars).



Source: IAEA

Note. CCS = Carbon capture and storage, NGCC= Natural gas combined cycle.

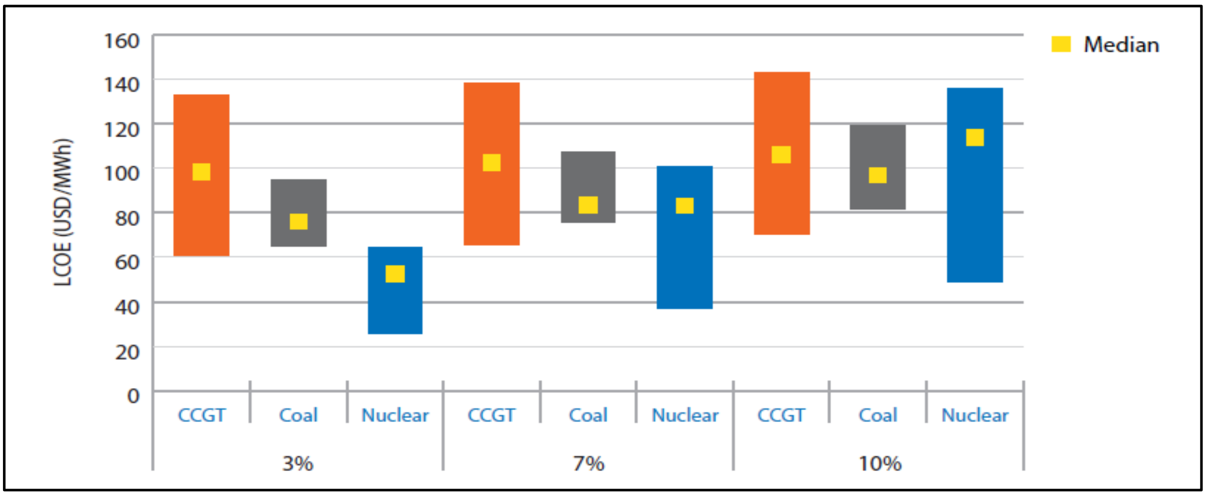
Economics of Nuclear Power

Even though the capital cost of a nuclear power plant is relatively high, the low cost of nuclear fuel and the relatively long lifetime (about 60 years) make nuclear power economically competitive than thermal power plants in the long run. Nuclear fuel constitutes about 14% of the entire electricity generation cost compared to 89% in gas and 78% in coal[37]. This makes nuclear power systems insensitive to fuel price volatility.

The levelised cost of electricity generation of coal, gas and nuclear plants based on a recent study conducted by the International Energy Agency (IEA) is presented in Figure 4.4. The study indicates the cost competitiveness of nuclear power over the other energy options, particularly at low discount rates.

[37] International Energy Agency, *Projected Cost of Generating Electricity*, Paris 2015, p 14

Figure 4.4: Electricity generation cost of nuclear, gas and coal plants at 3%, 7% and 10% discount rates



Source: International Energy Agency (IEA)

The Need for Nuclear Energy

It should be noted that government's agenda of transforming the economy through industrialisation, cannot be achieved without sufficiently available cost-effective electricity in the country. An example is the Ghana Industrial Development Initiative (GIDI)[38] Project being promoted by the Ghana Infrastructure Investment Fund (GIIF)[39] that seeks to develop a full-cycle alumina project in the country. Traditionally, Ghana has relied on hydro power and oil/gas thermal power plants as the components of the country's energy mix. Recently, renewable energy, mainly in the form of solar and wind energy, have been proposed. It is well understood that renewable energy does not provide the needed base load energy option for any country. Examining alternative source of power capable of generating high capacity base load like coal and nuclear energy in the country's energy mix to ensure reliable power supply and emission cuts is therefore considered important, if Ghana is to be energy-sufficient in the future.

Nuclear power is economically competitive over other energy sources for countries that have little or no indigenous fossil fuel reserves and has enhanced the energy security and energy diversity of countries in this category. This is so for countries like France, Japan, South Korea, etc. This is due to the fact that nuclear power plants require low fuel supply and also the fuel can be stockpiled for some years. This can therefore reduce significantly, the risks associated with fuel supply and price instability.

4.2.2 Issues Affecting Nuclear Power Utilisation

Despite its advantages with regards to cost, energy security and environmental impacts, concerns about nuclear plant safety, waste management and weapon proliferation have affected its expansion in some countries. Concerns about nuclear safety heightened in many countries as a result of the Chernobyl accident which took place in Ukraine in the

[38] GIDI, Ghana Infrastructure Development Initiative Information Document, Ghana Infrastructure Investment Fund, December 2015.
[39] Government of Ghana, Ghana Infrastructure Investment Fund Act, Act (877) 2014, Ghana.

former Soviet Union in April 1986 and the recent Fukushima accident which took place in Japan in March 2011. In addition, the Three Mile Island (TMI) accident in the US in March 1979 brought nuclear expansion in the US to a virtual halt. In the case of the TMI accident, malfunctioning of certain components of the reactor cooling system and miscommunication of the instrumentation system, caused the operators of the reactor to take actions which led to loss of coolant. This resulted in the partial melting of the reactor core[40]. There were no fatalities in the TMI accident because no radioactive substances were released into the environment. This is due to the presence of a containment structure (Figure 4.5) over the reactor, which by design, is to prevent the release of radioactive substances into the environment in case of an accident. In addition, the containment structure is designed to withstand the crash of heavy objects including large aircraft.

The Chernobyl accident occurred when the reactor was subjected to abnormal operational conditions during an experimental run, leading to an extreme power rise far above the designed power limit. This caused a steam explosion, rapture of the reactor vessel and the release of large amount of radioactive substances into the environment. Post-accident investigations indicated that design flaws, relating to reactor stability, reactor shutdown and control systems led to the accident. Worst of it all, the reactor had no containment structure over it to prevent the release of radioactive substances in case of an accident[41]. Considering the significant difference between the Chernobyl reactor that was of out-dated Soviet design and that of the Western type of reactors, it can be concluded that the severity of the Chernobyl accident is unique to the type of reactor in question[14,42]. Since that accident, the Chernobyl type of reactors has been phased out. Also, the few existing ones have been retrofitted to improve their safety. Russia has also come out with new designs with improved safety features, conforming to Western standards. The accident claimed 31 fatalities that were plant workers (most of them were the fire fighters) within the first months[14,43]. In 2005, almost two decades after the accident, the estimated number of radiation related deaths had increased to almost 50.

The Fukushima accident was caused by destruction of the emergency power supply and reactor cooling systems by a tsunami, which flooded the reactor site after a severe earthquake. The earthquake shook the Eastern part of Japan including the Fukushima Daichi plant site where 6 nuclear power plants were located with 3 of them in operation. In response to the earthquake, all the reactors shut down automatically and were all physically and mechanically intact. There was however loss of grid power to the plants because the earthquake destroyed the grid network. As a result of this, the reactors had to depend on emergency generators for cooling of the reactor core[44]. Cooling of reactors after shutdown is very essential because reactor cores heat up as a result of radioactive decay. About 45 minutes after the earthquake, a 15 m tsunami wave, triggered by the earthquake, swept through the site. Being higher than the 5.7m sea defence wall of the plant site, it completely inundated the site destroying the emergency power supply and

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[40] US Nuclear Regulatory Commission, *Backgrounder on the Three Mile Accident*. https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html

[41] World Nuclear Association, *Chernobyl Accident*

[42] Hirschberg, S. and Srupsczweski, A., *Comparison of Accident Risks in Different Energy Systems-How Acceptable?*, IAEA Bulletin Vol. 41-1 March 1999, pp. 29.https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull41-1/41102782530.pdf.

[43] Wagemaker et al, *Clinically Observed Effects in Individuals Exposed to Radiation as Result of the Chernobyl Accident,* Proceedings International Conference, "One Decade After Chernobyl" Vienna, 8 -12 April 1996, pp. 175

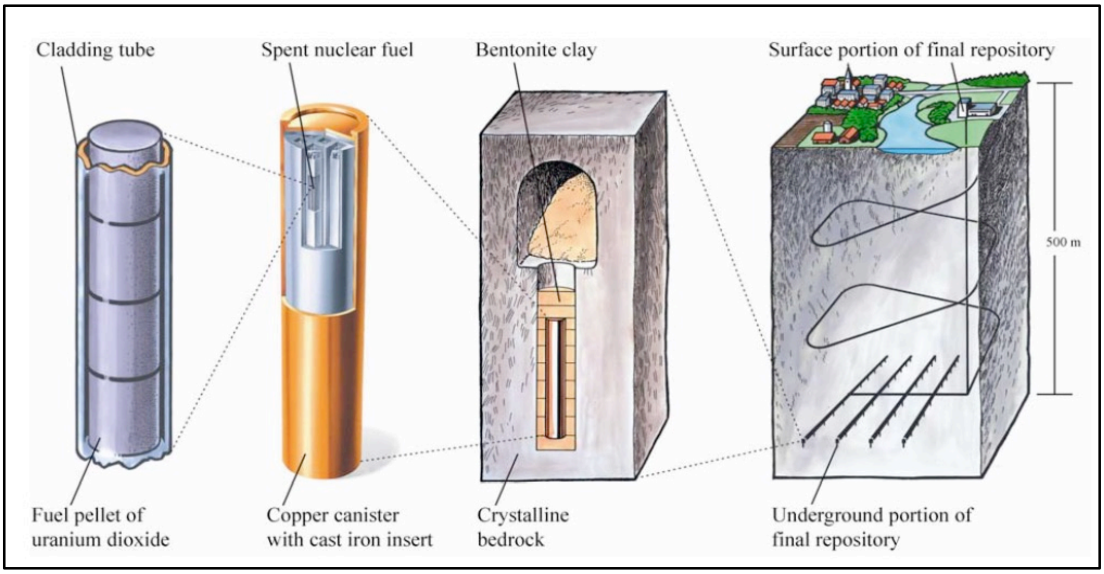
[44] World Nuclear Association *Fukushima Accident* http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/fukushima- accident.aspx

cooling systems. This led to the overheating of the core of the 3 operating reactors resulting in the partial melting of their core. The venting of gas by the operators to prevent pressure build up in the reactor facilities as well as the discharge of contaminated coolant water into the sea, caused the released of radioactive substances into the environment. To date no fatalities have occurred as a result of the accident. According to post-accident investigations, the amount of radiation received by the emergency workers and the public is too low to cause any discernible increase in radiation related health effects to the members of the public and their descendants[45].

It is worth noting that all the reactors in the 3 major accidents were not of modern design. They were designed in the 1960s and therefore susceptible to the kind of accidents which occurred. On the contrary, modern reactors have improved safety features. These include passive cooling and passive control systems which employ the force of gravity for control during emergencies as well as natural convection for coolant flow, instead of active systems like pumps, motors, human intervention.

In addition to nuclear power plant safety, disposal of nuclear waste is a major public concern. Managing nuclear waste is less of a problem because the quantities of waste involved are remarkably small relative to the energy produced. The small quantities permit a "confinement" strategy for the radioactive material, beginning with the nuclear fission process and through to waste disposal, essentially isolated from the environment. Disposal techniques exist and the hazard decreases with time owing to radioactive decay. The main disposal options are engineered structures, mined cavities, and deep geological repositories (Figure 4.5)[46]. However, disposal is blocked not by technical, but by political obstacles as a result of the "Not in my backyard" (NIMBY) syndrome. The public concern about nuclear waste should therefore be addressed through education.

Figure 4.5: Nuclear Waste Disposal Concept



Source: GAEC

[45] United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), A 68/64, p11, UN New York, 2013. http://www.unscear.org/docs/GAreports/A-68-46_e_V1385727.pdf

[46] International Atomic Energy Agency, *Nuclear Power and Sustainable Development*, 2006, p. 18.

Proliferation of nuclear weapons is another public concern to be addressed when going in for the nuclear option. The major proliferation concern is risk associated with the fuel cycle, particularly fuel enrichment, fabrication and reprocessing, in which a part of the nuclear material may be diverted to, or stolen for non-peaceful uses. The US ATOMS FOR PEACE policy announced in 1953 promoted a policy of international nuclear co-operation based on the condition that nuclear technology transfer would be used exclusively for peaceful purposes. The 1970 Treaty on the Non-Proliferation of Nuclear Treaty also binds signatory countries from engaging in nuclear weapon manufacture and deployment activities. The IAEA has also introduced binding safeguards protocols, which involve on-site inspections of nuclear facilities. Ghana is a signatory to the Non-Proliferation Treaty and IAEA safeguard protocols.

Ghana nuclear power programme may not involve fuel enrichment and fabrication of uranium or the reprocessing of spent fuel. It is possible to seek reliable fuel supply and reprocessing arrangements through bilateral or international agreements, such as the Global Nuclear Energy Partnership (GNEP) or as part of contractual arrangement with the vendor country. It is worth noting that similar arrangement was made for the supply of fresh fuel and the return of the spent fuel to the supplier of Ghana's Research Reactor 1, which has been operated successfully since 1995. This reactor is one of the nuclear facilities in Ghana that are regularly subjected to necessary inspections and monitoring by IAEA inspectors to ensure safety and also that there is no diversion of nuclear material.

It is clear that public apprehension against the nuclear power option is due to their misconceptions about the technology. Studies have shown that the nuclear option has a relatively low health and environmental impact. In addition, the accounts on nuclear accidents indicate that the occurrence of catastrophic events in the use of nuclear power technology is virtually impossible particularly in modern advance reactors.

4.2.3 What Makes Nuclear Power Unique

i. Long-term Government commitment – '100 years +';
ii. Public perception/acceptance and public trust;
iii. Start-up phase is significant in length and effort, some 5-15 years before the shovel hits the ground;
iv. Highest level of safety and security. Without nuclear safety, there cannot be safe production of nuclear energy. Without nuclear fuel, there cannot be production of nuclear energy;
v. Safety and security are always a work in progress (continuous improvement). Highest level of safety and security required;
vi. Safety, Security and Safeguards are national responsibilities, but the consequences of a nuclear accident or of a terrorist act are global;
vii. Capital intensive investment;
viii. Well trained human resources;
ix. Control of nuclear materials;
x. Long-term nuclear waste management;
xi. No quick fix solution in developing a nuclear power programme;
xii. Nuclear power's characteristics require special attention;

xiii. Strong national leadership to ensure coordination and broad political and popular support;
xiv. Leadership and commitment are important to ensure both the required funds and the coordinated effort needed for success;
xv. The penalties of interruptions and restarts are significant.

4.2.4 Addressing Public Concern about Nuclear Power Operation

The fear of radiation health effects, particularly from severe accidents and radioactive waste, is central to public concerns about nuclear power activities. Major issues of concern to government and the public are nuclear safety, radioactive waste management, human resource capacity and public perception/acceptance. There is also proliferation of nuclear materials into unauthorised hands, which has been addressed under Section 4.2.2.

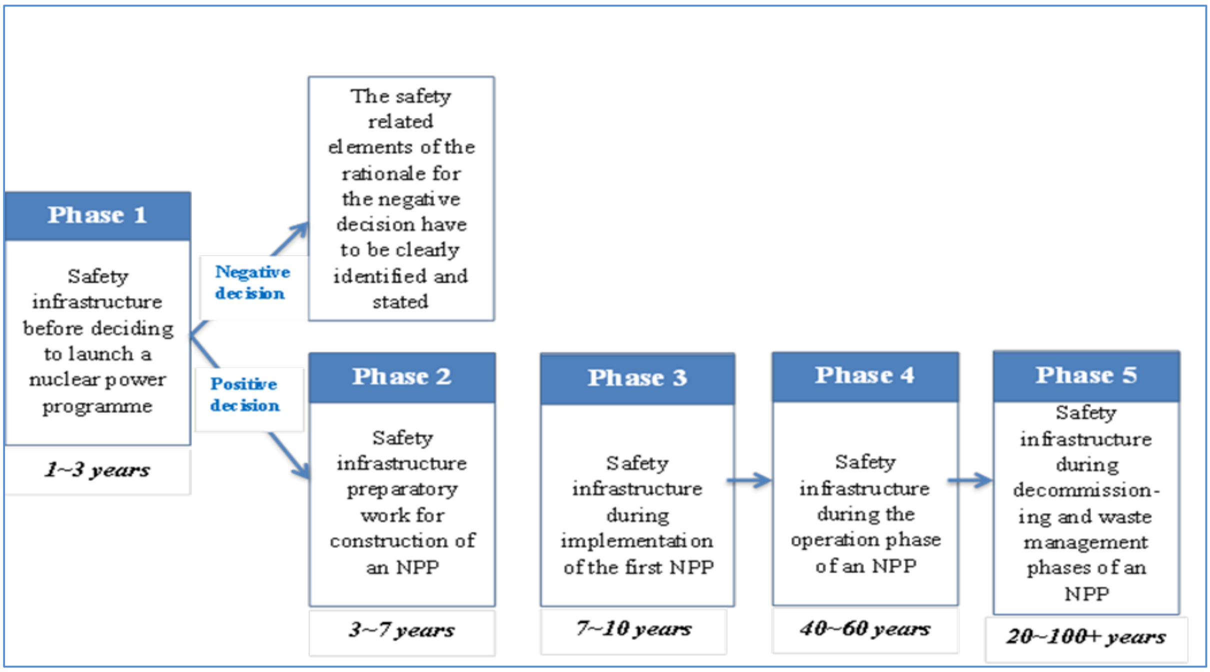
Nuclear Safety

Notwithstanding the Chernobyl and Fukushima accidents (both discussed in Section 4.2.2), nuclear power plant still remains a safe means of generating electricity. Nuclear reactors are designed with appropriate thermal and radiological shields to ensure that the operating personnel, the general public and the environment are not exposed to unsafe levels of nuclear radiation from operation of nuclear power plant. Safety improvements at nuclear power plants have, over the years, been made by identifying and applying lessons learned from nuclear accidents, improving the effectiveness of defence-in-depth, strengthening emergency preparedness and response capabilities, enhancing capacity building through thorough and comprehensive training of operators and staff, and protecting people and the environment from ionising radiation.

Developing the necessary nuclear safety infrastructure is the key to ensuring safety in the lifetime of a nuclear power plant. Nuclear safety infrastructure is a set of institutional, organisational and technical elements and conditions that a country establishes to provide a sound basis and foundation for ensuring a sustainable high level nuclear safety throughout the stages of nuclear programme development. From nuclear safety standpoint, the lifetime of a nuclear power plant is divided into five Phases based on INSAG-22[47] with indicative average durations for each Phase as presented in Figure 4.6. Ghana is in Phase 1 of the nuclear power programme and development of safety infrastructure has been central to all the activities in this Phase.

[47] INTERNATIONAL NUCLEAR SAFETY GROUP, Nuclear Safety Infrastructure for a National Nuclear Power Programme Supported by the IAEA Fundamental Safety Principles, INSAG-22, IAEA, Vienna (2008).

Figure 4.6: Main phases of safety infrastructure development over the lifetime of a nuclear power plant



Source: GAEC

Radioactive Waste Management and Decommissioning

Nuclear wastes are a significant part of the nuclear power picture, and need to be managed and disposed of properly. Nuclear wastes are not difficult to manage. Safe methods for the management and final disposal of high-level radioactive waste are technically proven. The amount of radioactive wastes is very small relative to wastes produced by fossil fuel electricity generation. It should be mentioned that in more than 5 decades of civil nuclear power experience, nuclear waste has not caused any serious health or environmental problems, nor posed any real risks to people.

Several power reactors have been completely decommissioned and dismantled, with the sites released for unconditional use. The options for decommissioning nuclear power plants range from returning the site outright to a greenfield state through to entombing the structures for a hundred years or more in order to allow substantial decay of radioactive materials. The option chosen will depend on regulatory requirements, public and political opinion, and safety and economic considerations.

Nuclear power is the only large-scale energy-producing technology which takes full responsibility for all its wastes including decommissioning and fully costs this into the product. The cost of managing and disposing of nuclear power plant wastes represents about 5% of the total cost of the electricity generated. Most nuclear utilities are required by governments to put aside a levy (e.g. 0.1 cents per kilowatt hour in the USA, 0.14 cent per kilowatt hour in France) to provide for management and disposal of the wastes.

The actual arrangements for paying for waste management and decommissioning also vary. The key objective is however always the same: to ensure that sufficient funds are available when they are needed.

Furthermore, the nuclear and radioactive waste management industries work to well-established safety standards for the management of radioactive waste. International and regional organisations such as the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), the European Commission (EC) and the International Commission on Radiological Protection (ICRP) develop standards, guidelines and recommendations under a framework of co-operation to assist countries in establishing and maintaining national standards. National policies, legislation and regulations are all developed from these internationally agreed standards, guidelines and recommendations. Amongst others, these standards aim to ensure the protection of the public and the environment, both now and into the future.

Human Resource Capacity

Human Resource Development and Technology support will be needed to sustain the introduction and development of nuclear power plant in Ghana. The sustainability of the programme requires developing our own technical capabilities. This can be achieved over a period, with contractual arrangements for education and training programmes with the vendor country. This has been the practice worldwide where vendor countries through contractual arrangements establish on-site integrated training centre(s) in the recipient country and offer both on the job and specific training support both locally and in the vendor country. The establishment of the training centre(s) is essential for performing tasks.

Public Perception/Acceptance

Nuclear safety and issues of management of radioactive waste – both related to environmental values – shape public perception and concerns about nuclear power plant operation. The way to allay the fears of the general public is to focus more on relationship building, engaging in organised dialogue with stakeholders and concerned citizens at the local level, framing messages that speak to the background and social identity of key audience segments, using respected third parties and opinion leaders to build trust, and using Web sites and other social media tools that enhance transparency and two way dialogue with audiences. It is worth noting that the NPI, the main technical body championing the development of the necessary nuclear infrastructure has two centres dedicated to public communication, sensitisation, education and information on the nuclear power programme. Together, the centres have prepared a communication strategy document, developed a website and other social media platforms, organised series of stakeholder engagement meetings (this will continue throughout the programme lifetime), prepared questionnaires aimed at collecting data on public perception and receptiveness of nuclear power (this is yet to be administered due to lack of funds), publication of monthly newsletter aimed at educating, providing information and status of the nuclear infrastructure development.

4.3 The Milestone Approach and Ghana Nuclear Power Roadmap

4.3.1 The Milestone Approach

A successful nuclear power programme requires a national commitment of at least 100 years. Creating the infrastructure and building the first nuclear power plant will take at least 10–15 years[48]. This requires strong national leadership to ensure coordination and broad political and popular support. Nuclear safety, nuclear security and non-proliferation have to be ensured and seen to be ensured. Thus, the highest standards of safety, security and safeguards must be applied. It should be emphasised that a country pursuing a nuclear power programme remains responsible for the safe, secure, peaceful and efficient use of nuclear power. This requires the country to have an owner/operator with prime responsibility for safety, and a competent independent regulatory body to oversee the programme. A nuclear power programme cannot simply be bought.

Nuclear power plants have long lifetimes, relatively low running costs but high capital cost resulting in financing characteristics that are different from other major projects. Developing successful financing and contracting is a major challenge and requires significant government involvement. Decommissioning and the management of radioactive waste will require resources after the power plant has been retired. Therefore arrangements need to be in place to accumulate adequate funds.

The milestone approach[21] for a nuclear power programme is holistic and considers the development of 19 specific infrastructure issues. The framework is divided into three phases and milestones, with the duration of each Phase dependent on the degree of commitment and resources applied to the programme. These different phases are:

i. Phase 1: Considerations before a decision to launch a nuclear power programme is taken;
ii. Phase 2: Preparatory work for the contracting and construction of a nuclear power plant after a policy decision has been taken;
iii. Phase 3: Activities to implement a first nuclear power plant.

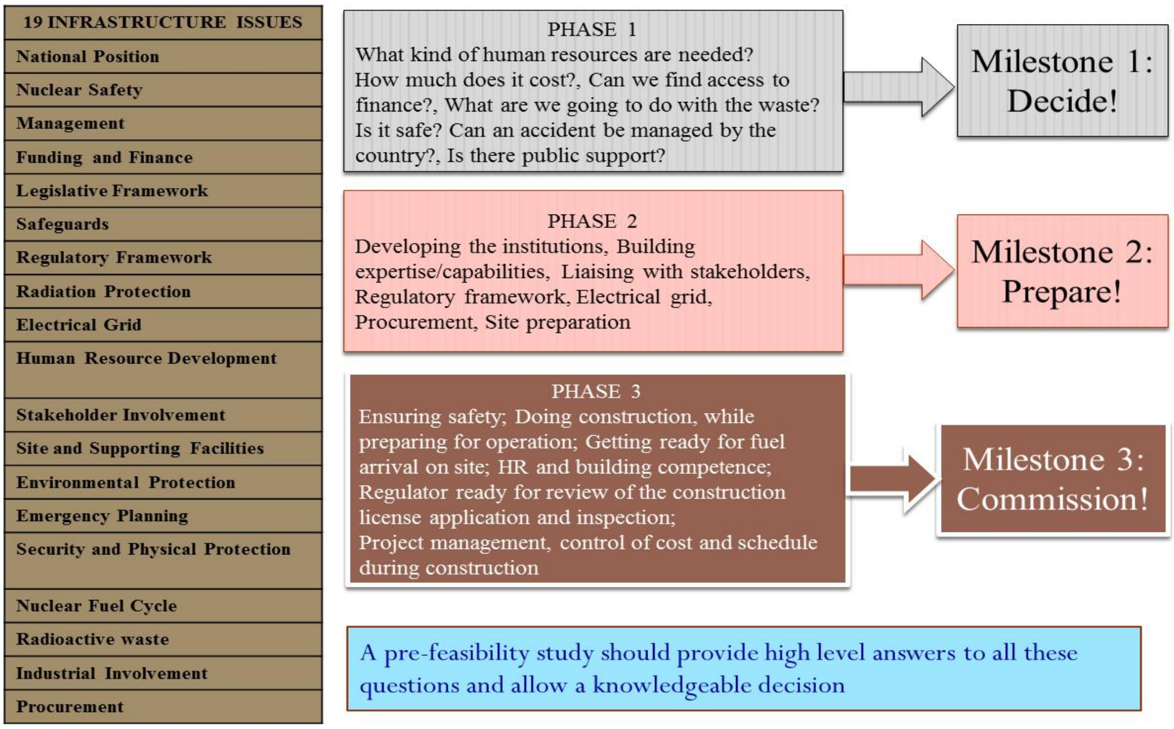
The completion of each Phase is marked by a specific Milestone at which the progress of the development effort can be assessed and a decision made to move on to the next Phase. These milestones are:

i. Milestone 1 (at the end of Phase 1): Ready to make a knowledgeable commitment/decision to a nuclear power programme;
ii. Milestone 2 (at the end of Phase 2): Ready to invite bids for the first nuclear power plant;
iii. Milestone 3 (at the end of Phase 3): Ready to commission and operate the first nuclear power plant.

[48] IAEA NG-G-3.1, Milestones in the Development of a National Infrastructure for Nuclear Power, IAEA Nuclear Energy Series Publication, Vienna, 2007

Key considerations and challenges faced by newcomer countries such as Ghana in developing the 19 infrastructure issues have been summarised in Figure 4.7 for each of the phases.

Figure 4.7: Newcomer Challenges in developing nuclear infrastructure for introduction of nuclear energy



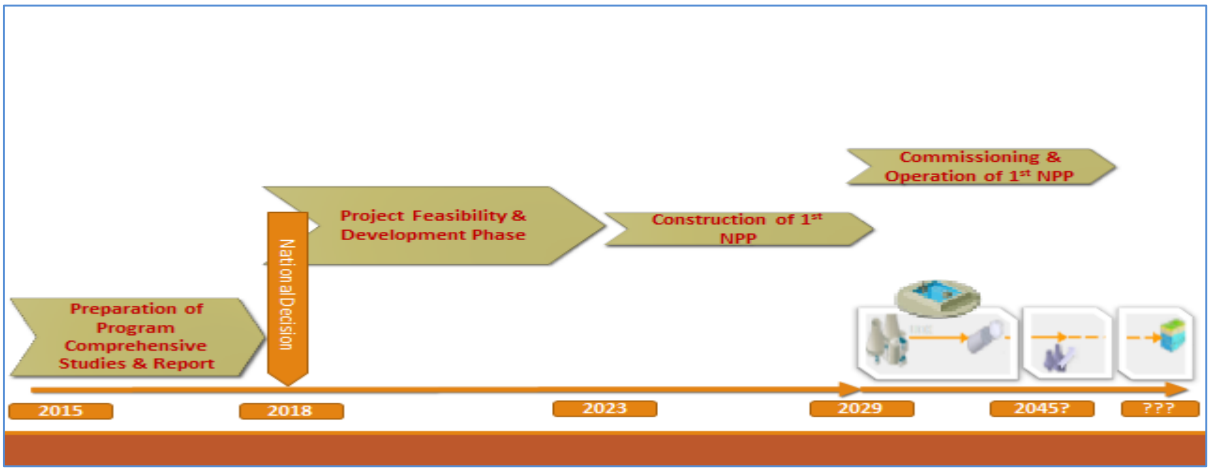
Source: GAEC

4.3.2 Ghana Nuclear Power Roadmap

The draft roadmap[49] (Figure 4.8) for Ghana's nuclear power programme identifies actions for each of the 19 infrastructure issues spanning across the three Phases. Appropriate Structures/Agencies have been identified to be responsible for the various infrastructure actions in the roadmap. An overall time frame of 14 years has been proposed from programme initiation to plant commissioning. This is strongly predicated on strong government commitment and dedicated funding for activities. Phase 1 and 2, which sum up the developmental phase is scheduled for eight years, whereas Phase 3, the construction phase, is scheduled for six years.

[49] The roadmap for Ghana nuclear power programme, NPID-120000-STG-001, January 2016

Figure 4.8: Roadmap for Ghana's Nuclear Power Programme



Source: GAEC-NPP, 2015

Key Assumptions to Achieve Targets

i. Strong evidence of Government supports by providing sufficient oversight, logistics and fund commitment;
ii. Active participation of all key stakeholders;
iii. Functional role appointment (and competence development programme) of the regulatory authority;
iv. Consistent following of roadmap and effective demanding and reporting of progress at top governmental level;
v. Strong GNPPO with regarded authority and needed flexibility to effectively manage and coordinate the programme development;
vi. Strategic Inter-Governmental Agreements and Consultancy engagement;
vii. One unit envisaged to be constructed under the programme;
viii. Turnkey (EPC) type of contract for the construction of the NPP;
ix. A 1 – 3 years transition period for transfer of operation of NPP from EPC contractor to Ghanaian operator;
x. Full scope of Ghanaian operating personnel to be ready at least a year before commencement of commissioning of NPP.

4.3.3 Key Organisations

Three key organisations are involved in developing the national nuclear infrastructure with each having a specific role to play and with responsibilities changing as the programme advances.

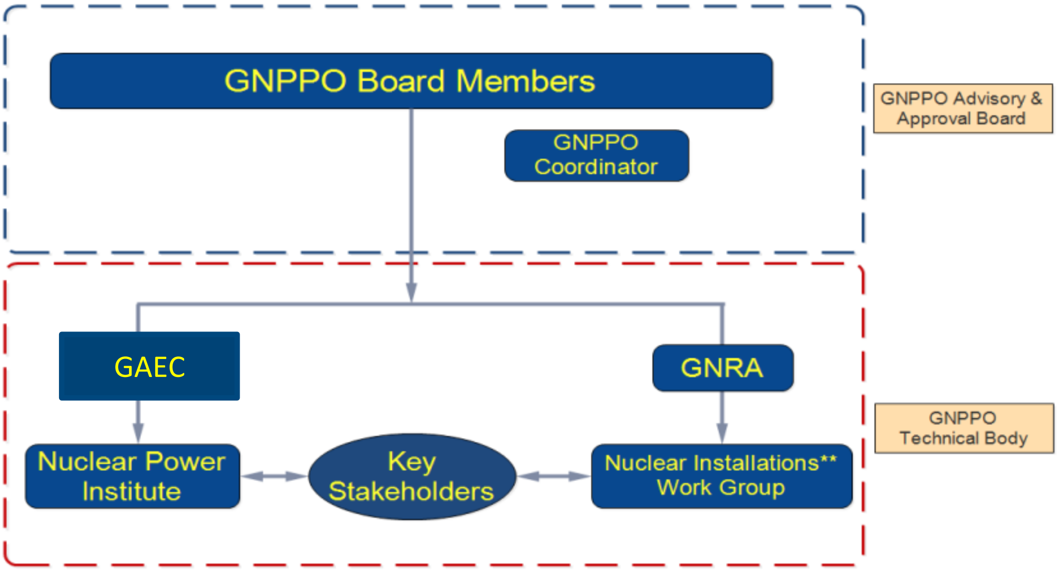
Ghana Nuclear Power Programme Organisation (GNPPO)

Following the presidential commission report, cabinet took a decision to include nuclear energy into the energy mix in 2008 and subsequently nuclear energy was included in the national energy policy and strategy in 2010. The government of Ghana declared its intention to pursue a nuclear power programme for peaceful purposes through a letter submitted to the International Atomic Energy Agency in 2012. The Ghana Nuclear Power

Programme Organisation (GNPPO) was established to see to the implementation of the programme and the development of the necessary nuclear infrastructure for successful introduction of nuclear energy into the energy mix. Currently, the GNPPO is under the Ministry of Power and is to be custodian of the national nuclear energy programme.

In order to accelerate the development of the necessary nuclear infrastructure, the Ghana Atomic Energy Commission acting on behalf of the government of Ghana and the GNPPO, established the Nuclear Power Institute (NPI) to provide technical support to the GNPPO. The NPI has been working to promote the cause of the development of the required nuclear infrastructure for Ghana’s Nuclear Power Programme. The GNPPO has advisory and technical bodies as presented below (Figure 4.9).

Figure 4.9: Involvement of Key Organisations



Source: GAEC-NPP, 2015

Legislative Framework and Independent Nuclear Regulatory Authority

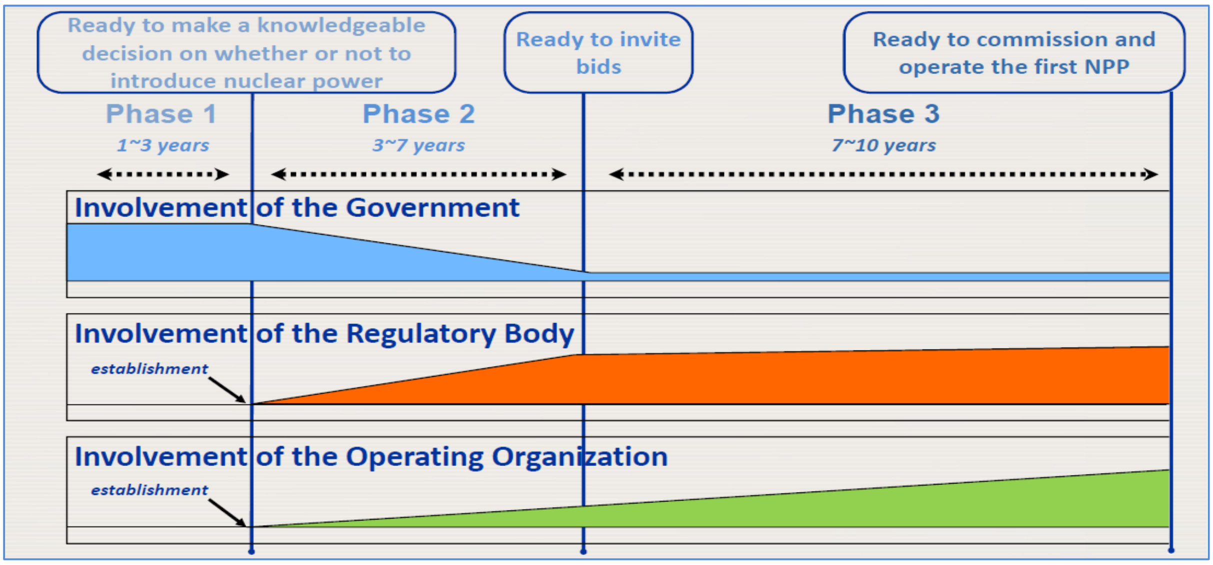
Developing a nuclear power programme requires Ghana to have a comprehensive nuclear law and to ratify international treaties and conventions. Ghana has so far ratified most of the international treaties and conventions necessary for a nuclear power programme, with the exception of three outstanding conventions. The Office of Legal Affairs, GAEC (OLA-GAEC) is working to ensure that Ghana ratifies the remaining conventions. In addition, the OLA-GAEC with support from other stakeholder institutions is conducting legal gap analysis to determine laws and legislations that need amendment or enactment to meet the requirements of the nuclear power programme.

In August 2015, Parliament of Ghana passed a comprehensive nuclear law, NRA Act, 2015 (Act 895) that establishes an independent Nuclear Regulatory Authority (NRA) to ensure an effective regulatory regime with respect to nuclear safety, security and safeguards. The NRA is mandated to facilitate the development of national policies and the regulation and management of activities associated with the handling and utilisation of all radioactive and ionising radiation sources in Ghana.

Owner/Operator

The owner/operator is the outstanding organisation yet to be established. Discussions have been ongoing as to how to settle on the owner/operator organisation. This is being supported by the development of owner/operator document that will address the function, role, and structure of the organisation. It is expected that decision on the establishment of the owner/operator would be finalised by the end of the year. The involvement of these three key organisations changes depending on the Phase as illustrated in Figure 4.10.

Figure 4.10: Involvement of Key Organisations



Source: GAEC-NPP, 2015

4.3.4 Nuclear Energy Policy

A Nuclear energy policy document is to be prepared within the framework of the national energy policy. The document seeks to place nuclear energy within the right national context in regards to developing a sustainable energy mix for the country. The basis of the nuclear energy policy is to:

i. Prepare for the development of manpower and promote plans for the introduction of nuclear power for electricity in the country;
ii. Attain energy independence and security of electricity supply;
iii. Enhance strategies for the realisation of aspirations envisaged in Ghana's national objective of attaining a middle income status and beyond.

4.4 Some Critical Areas Requiring Attention

4.4.1 Industrial Involvement

Developing local or national industrial involvement/participation[50] for a nuclear power programme involves the arrangement or rearrangement of a number of industries in the country for services, materials supply, fabrication and construction, as part of the integrated supply chain that should be established for the programme. Though for the first nuclear power plant, the most common scheme is a turnkey EPC contract for both the nuclear island and the balance of plant (BOP), the EPC contractor will engage subcontractors and suppliers to engineer, design, construct and commission the nuclear power plant units which typically is a mix of local industrial organisations and international suppliers. Again, the owner/operator organisation will take on projects that are related to the turnkey project with the EPC contractor (e.g. grid upgrades, roads, training centres and administrative facilities) and will enter into contracts with local industrial organisations to support these projects. Therefore, there is the need to do the following:

i. Develop/prepare/conduct national/local industries' capacity surveys;
ii. Establish policies and identify target areas;
iii. Establish industrial standards and quality assurance mechanisms;
iv. Build capacity and provide incentives for national R&D programme, establishing partnership with experienced companies, providing official long-term and low-interest loan for capital investment.

During Phase 1 of the programme, the management body of the programme (GNPPO) should assess national and local industrial capabilities, interest of business/industrial leaders in participating in the NPP project considering the special requirements necessary, necessary investment for intended upgrading of industrial facilities and develop short and long term policies on the level of local participation that is practical and desired.

During Phase 3 of the programme, the GNPPO should continuously coordinate and implement industrial involvement policy (capacity building, incentives) and reassessment of the sources of supply to support operation.

4.4.2 National Position

The national position[51] is the outcome of a deliberative process and study that establishes the governmental strategy and commitment to develop, implement and maintain a safe, secure and sustainable nuclear power programme known as knowledgeable decision. It should be noted that an intention to develop a nuclear power programme is not a decision to embark on a nuclear power programme. According to the current roadmap for nuclear power development, a comprehensive report which will present an assessment of the 19 infrastructure issues including a complete prefeasibility for an implementation of a nuclear program will be prepared at the end of Phase 1 (expected date, December 2017). This report will be the technical basis for a national decision to be taken by government that would clearly communicate Ghana's readiness

[50] IAEA NE series No. NG-T-3.4: Industrial involvement to support a national nuclear power programme, Vienna, 2016
[51] IAEA NE series No. NG-T-3.14: Building a national position for a new nuclear power programme, Vienna, 2016.

and commitment to proceed with the programme or otherwise according to the international (and national) norms, standards and obligations of the Country. The comprehensive report would consider among others[52]:

i. Thorough analysis and development of scenarios of the country's energy demand and supply alternatives;
ii. Macro-economic study on the impact of introducing a nuclear power programme;
iii. Considerations of nuclear safety, including the recognition of the non-zero possibility of a severe accident;
iv. Initial analysis of the domestic and international legal requirements and agreements required to proceed;
v. Preliminary evaluation of the potential sites capable of hosting a nuclear power plant;
vi. Analysis of the government funding necessary to support the development of the appropriate infrastructure, especially the regulatory oversight;
vii. Strategy for the development of the necessary human resources;
viii. Strategy and funding approach to provide for decommissioning, management of spent fuel and nuclear waste and environmental remediation;
ix. Plan for effectively engaging stakeholders and the public throughout the process.

4.4.3 Human Resource Development

One of central challenges in undertaking a nuclear power programme and deploying a first nuclear power plant (NPP) for newcomer countries is to attain and maintain the competence and qualification of NPP personnel, which includes management staff, operations, maintenance personnel, engineering and technical support personnel and training staff as well as the regulatory body. Staffing of a first NPP is a comprehensive and long-term project and the success of it requires the successful completion of a number of sub-projects. These sub-projects include the development of certain elements of nuclear power programme infrastructure; the development of national and NPP training systems; and attracting, selection, training, qualification and authorisation of NPP personnel. A failure to perform any of these projects may result in a failure of the entire project to provide adequate numbers of qualified and motivated personnel for the first NPP.

One of the important factors for the successful staffing of the first NPP is multi-aspect cooperation with the NPP vendor for acquiring necessary support in the training system development, training of personnel, and ensuring that competent personnel are available for the commissioning and especially for the first years of NPP operation, when national staff is gaining necessary experience and growing its competence.

[52] Requirements for an effective national position on nuclear energy, NPID-305100-STG-001, July 2014

Chapter 5 Petroleum

5.1 Introduction

The term Petroleum literally means oil from rock and comes from two Greek words *petra* and *oleum*, meaning rock and oil respectively. This definition was based on the first sighting of liquid hydrocarbon seeping from rocks in ancient Greece. Over the years, however, the definition has been extended to cover both gaseous and liquid hydrocarbons. For the purposes of this report, petroleum will refer to both natural gas and crude oil and their respective derivatives. The infrastructure plan for crude oil and its derivatives will be treated separately from that of natural gas and its derivatives. The gas value chain is described in terms of three broad categories of activities: upstream, midstream and downstream, while the oil value chain has two categories: upstream and downstream. It is worth noting, however, that the upstream activities (i.e. exploration and production) are considered the same for both the oil and gas value chains. Supply and demand forecasts, which are at opposite ends of the value chains, are the key drivers of the infrastructure plans linking the supply to the market. Both supply and demand projections are presented for oil and gas.

The goals of the petroleum sub-sector according to the Petroleum Sector policy are to:

i. Ensure the sustainable exploration, development and production of the country's oil and gas resources;
i. Foster the judicious management of the oil and gas revenue for the overall benefit and welfare of all Ghanaians.
ii. Promote the indigenisation of related knowledge, expertise and technology.

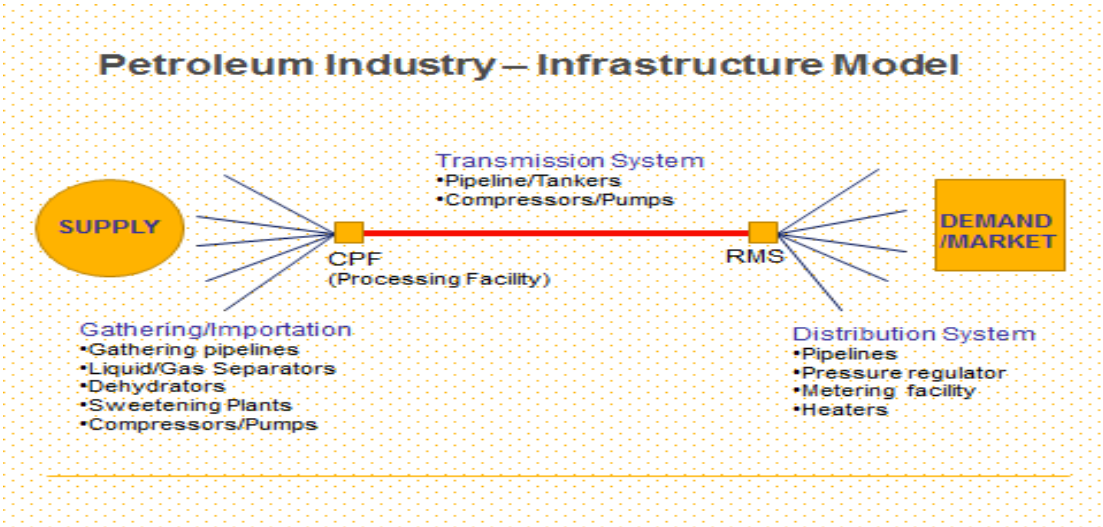
The major challenges regarding the sector, especially the upstream petroleum sub-sector, include how to sustainably develop the oil and gas industry and judiciously manage the revenue received.

In view of these goals and challenges, the policy focuses on the regulation of the petroleum industry with respect to licensing and operation of the oil and gas companies; improving Ghana's institutional and human resource capacity; enhancing local content; and fiscal incentives that will ensure maximum benefits to the people of Ghana. The policy seeks also to ensure transparency in the use and distribution of the oil revenue.

5.2 Petroleum Sector Infrastructure Plan

The petroleum sector infrastructure model is indicated in Figure 5.1 below.

Figure 5.1: Petroleum Sector Infrastructure Model



Source: Gas Master Plan, 2015

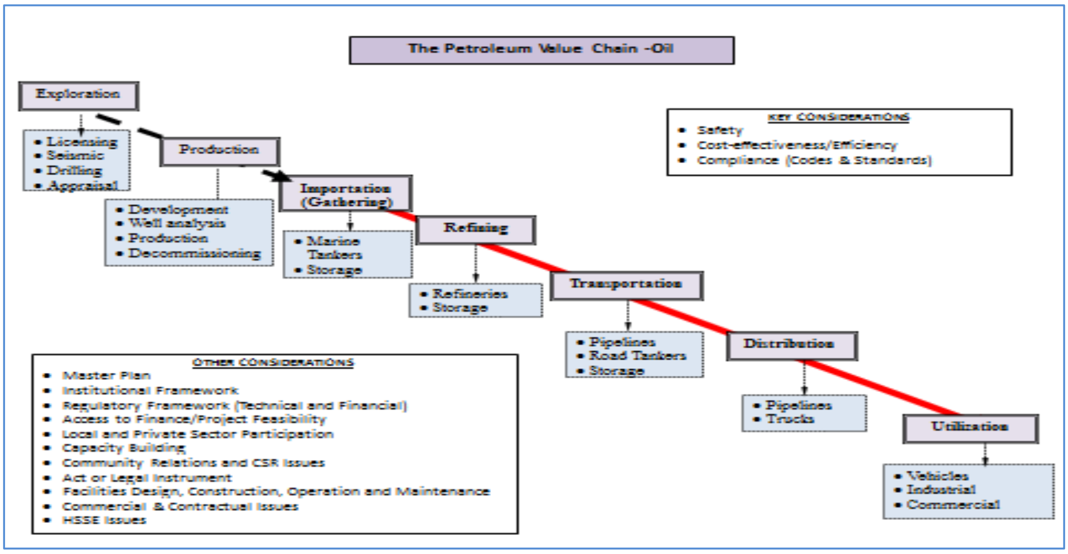
5.3 The Oil Infrastructure Plan

The oil supply value chain is indicated in Figure 5.2. The activities are divided into upstream and downstream activities. The upstream activities are as discussed in Section 5.3.1. The downstream activities are presented below.

5.3.1 Upstream Activities

Upstream activities involve six key stages in the oil and gas value chain. These include licensing, exploration, appraisal, development, production and de-commissioning. These activities are typically capital intensive and currently, in Ghana's situation, have minimal local participation.

Figure 5.2: Oil Value Chain



Source: Gas Master Plan, 2015

5.3.2 Downstream Activities

The downstream petroleum industry, which has significant local participation, currently consists of activities such as importation, refining, storage, transportation, distribution and utilisation.

Importation of Crude Oil/ Petroleum Products

The crude oil processed by the Tema Oil Refinery (TOR) are imported. There are 4 main discharge/loading facilities for crude oil and refined products in the country. These are the All Berth Buoy (ABB), the Single Point Mooring (SPM), Tema Oil Jetty and Takoradi Oil Jetty. Tema Offshore Mooring Limited (TOM) as per their license was mandated to operate and maintain the SPM and the ABB in a Build Operate and Transfer (BOT) agreement between the Government of Ghana and Trafigura. The Ghana Ports and Harbours Authority (GPHA) is responsible for the operations and maintenance of the Tema and Takoradi Oil Jetties.

Single Point Mooring (SPM)

This is an offshore facility used for the offloading of crude oil from tanker vessels of capacities up to 155,000 tonnes (dead weight). Its related accessories include a 36-inch crude pipeline (7.3 km offshore and 4.9 km onshore) from the SPM to Tema Oil Refinery (TOR) crude oil tanks. The SPM is expected to receive about 120,000 Mt of crude per month, but is operating significantly under capacity due to challenges with the refinery's operations and also challenges with raising LCs to procure the crude oil.

All Berth Buoy (ABB)

The ABB is an offshore facility used to receive imported refined petroleum products, mainly gasoil (diesel) and gasoline (petrol). The facility has a tanker mooring capacity of up to 50,000 tonnes (dead weight) and offloading capacity of about 970Mt per hour. The

ABB is connected through an 18″ refined product pipeline (4.0 km offshore and 5.1 km onshore) to the Tema Oil Refinery tank farm at a landfall at the Sege Beach east of the Gao lagoon, at approximately 5°40.2′N, 0°02.65′E and 3.5 km east of Tema Port. The ABB is linked to a booster station which is managed and operated by the Kpone Marine Services Limited and currently consists of one 2,500m^3 gasoline tank, a 400m^3 interface tank, a metering station, import booster pumps and a fire water tank and station. The ABB is linked via a network of pipelines to TOR and other private depots. The ABB records an average throughput of approximately 250,000MT of refined products per month.

Tema Oil Jetty

This is an onshore import/export facility managed by the Ghana Ports and Harbour Authority (GPHA). It is designed to receive vessels of up to 9.6m draft and a maximum length of 260m. The jetty is linked via a network of pipelines to TOR and private storage depots. The Tema oil jetty especially also serves as the gateway for the TOR's naphtha and cracked fuel oil exports, and records an average throughput of approximately 77,000MT per month.

Takoradi Oil Jetty

This is also an onshore import facility managed by GPHA at Takoradi. However, unlike the Tema oil jetty, it has no loading arms. It has only pipes, which are connected directly to the vessels to discharge. The draft of the Takoradi jetty is 8.4m and the maximum length of vessels it can receive is 120m. The jetty is linked to a network of pipelines that connect into private depots owned or operated by Cirrus Oil Limited and Chase Petroleum Limited. The Takoradi jetty is also currently being used to discharge LPG straight from Ocean Vessels into BRVs. This is done as a temporary measure to decentralize the lifting of LPG from Tema alone, and records an average throughput of approximately 25,000MT per month. It is expected that in the future, indigenous crude oil would be gathered and transported to the refinery for processing via the jetty. This would be part of the medium-to-long term infrastructure plan.

Refining

The Tema Oil Refinery is the only refinery in the country and has a capacity of approximately 45,000 barrels per day, which is about 60% of the nation's current demand. Crude oil used by the refinery is currently sourced from Nigeria and other African countries including Equatorial Guinea, Cameroon, Gabon and Angola. The refinery is linked to the Tema oil jetty, the Single Point Mooring (SPM) and the Conventional Buoy Mooring (CBM) facilities at the Tema port by pipelines of various diameters for the transfer of crude oil and refined petroleum products. The main refinery products are gasoline, fuel oil, LPGs, diesel, and kerosene/jet fuel. The infrastructure plan considered the existing and planned refinery capacity and made recommendations for appropriate expansion.

Storage

The overall domestic storage capacity for crude oil and refined petroleum products is estimated at 1,057,700 MT of liquid products, 17,200 MT of LPG and 300,000 MT of crude oil. The Bulk Oil Storage and Transportation Company (BOST) and TOR collectively own about 80 percent of the total storage capacity while private depot operators own the remaining 20 percent. Currently, BOST owns storage facilities at six locations within the country, namely Accra Plains, Akosombo, Mami Water, Kumasi, Buipe and Bolgatanga.

Transportation

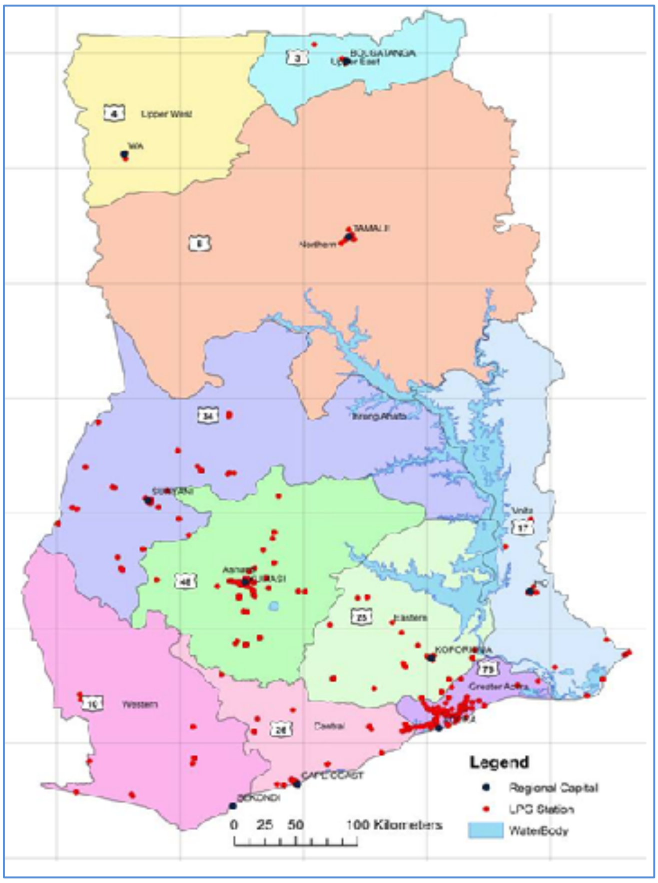
The general means of transporting petroleum products is through pipelines, barges and by road. A network of pipelines connects the coastal depots across the country from SPM, ABB or oil jetties. To transport petroleum products using barges, the Volta Lake serves as the main transport route specifically from the BOST tanks in Akosombo to the BOST tanks in Buipe. Bulk Road Vehicles (BRVs) usually transport petroleum products from TOR or Accra Plains Depots (APD) to Kumasi and Buipe. In addition, the BRVs transport products from depots to service stations and customer locations around the country.

Distribution

The Tema Oil Refinery currently supplies petroleum products to only Bulk Distribution Companies (BDCs) such as Cirrus, Chase, and Fueltrade Ltd. These BDCs sell the products to the oil marketing companies, including Shell, GOIL, Total, Galaxy and ENGEN, which distribute and retail the products to consumers.

Nationwide distribution of petroleum products is done via over 3,000 retail outlets round the country. The regional distribution of these retail outlets is shown in Figure 5.3. The highest number is found in the Greater Accra region which unsurprisingly also has the highest consumption of petroleum products. The least number of stations is found in the Upper West Region.

Figure 5.3: Location of LPG retail stations across Ghana



Source: TEC/EUEI-PDF Study, 2011

Utilisation

Petroleum products are mainly used is for vehicular transport, power generation and heating. The infrastructure plan is driven by the demand and supply plans and these are presented in the following sections.

5.4 Oil Demand Plan

This section looks at the various utilisation options for oil and its derivatives as well as the associated demand profiles for both power and non-power applications for the next thirty (30) years.

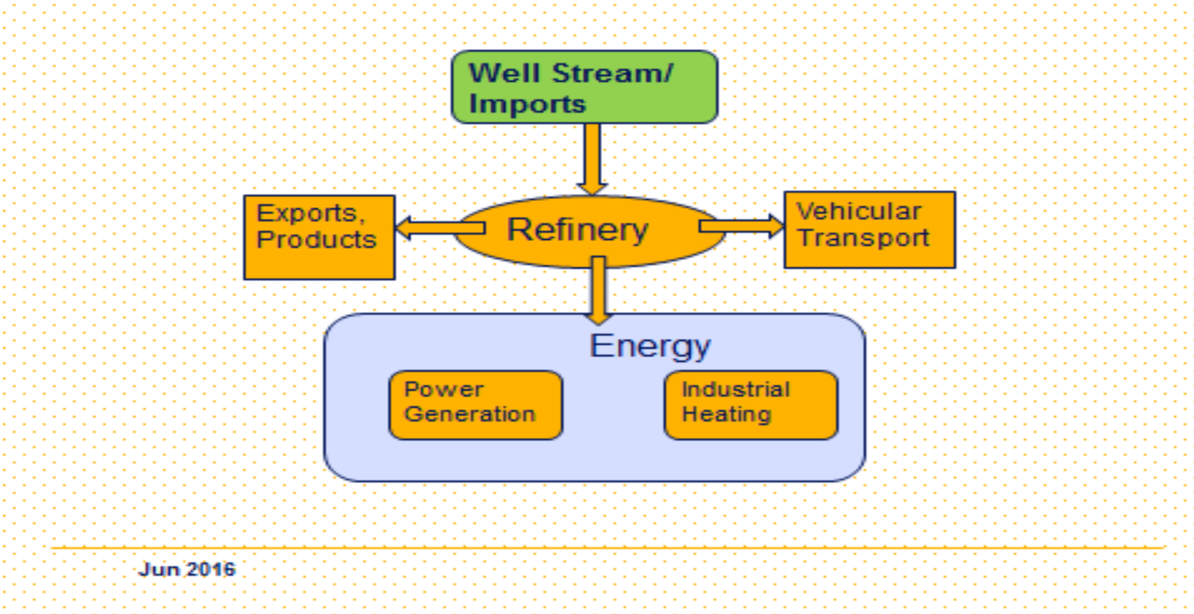
5.4.1 Oil Utilisation Plan

The main products derived from refining crude oil are gasoline, fuel oil, LPGs, diesel, and kerosene/jet fuel. The utilisation options include the following:

i. Power Generation;
ii. Vehicular Transport;
iii. Industrial Heating.

These options are summarised in Figure 5.4.

Figure 5.4: Utilisation Options for Oil



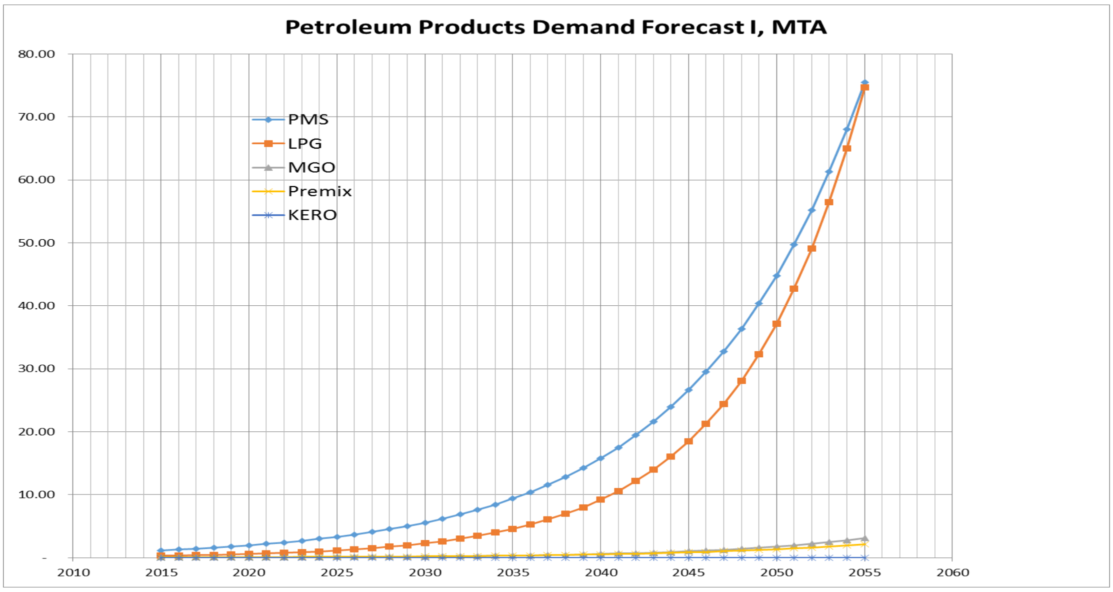
Source: Gas Master Plan, 2015

The power sector constitutes the largest share of demand at an average of 88% of total demand over the period 2015 to 2040.

5.4.2 Demand Forecast for Crude Oil and Petroleum Products

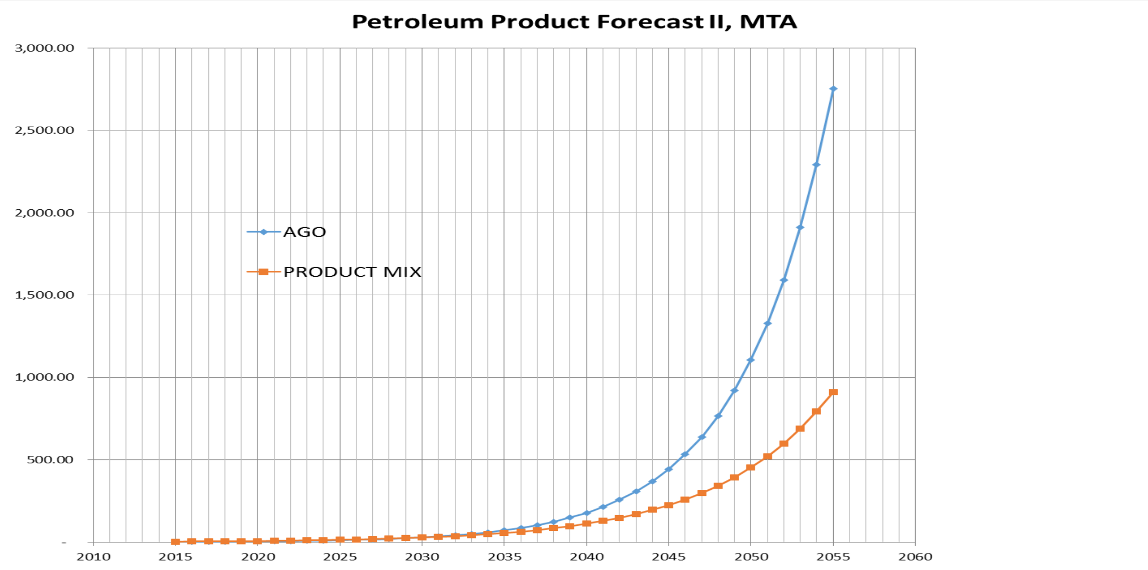
The demand profile for crude and the various petroleum products are presented in Figures 5.5 and 5.6 respectively.

Figure 5.5: Annual Petroleum Product Demand Forecast, Million-Tonnes/Year



Source: Author's Construct, 2017

Figure 5.6: Annual Petroleum Product Demand Forecast, Million-Tonnes/Year



Source: Author's Construct, 2017

5.5 Oil Supply Plan

5.5.1 Supply Forecast for Imported Oil

This section covers two broad categories of oil supply sources:

- Domestic production based on domestic gas reserves and resources; and
- Oil imports

Domestic oil supplies are based on the reserves from the Jubilee, TEN, MTA (Mahogany, Teak and Akasa), and the Sankofa fields. Furthermore, the Paradise field discovered by Hess is an oil and gas condensate discovery while the Hickory field, also by Hess, is a gas condensate discovery. There are also likely to be more resources (both non-associated gas and associated) from undrilled blocks. The following sections discuss each resource based on current information about the status and development of the fields and prospects.

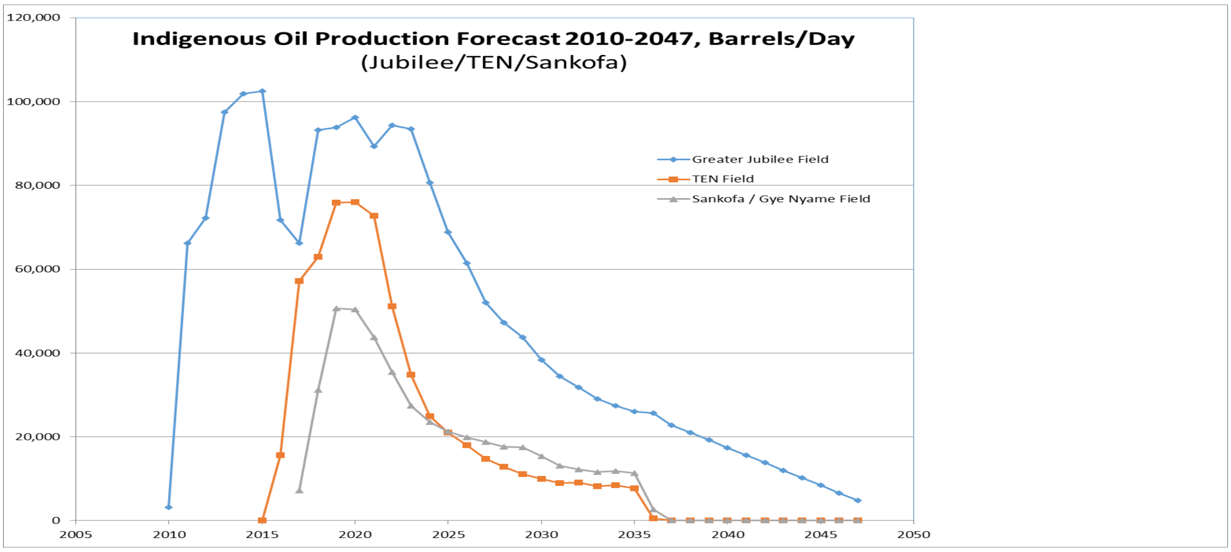
5.5.2 Production Forecast for Indigenous Oil

Jubilee Production Potential

There are significant quantities of gas associated with the Jubilee field's oil reserves, which came into production at the end of 2010. The Jubilee oil is light crude with Gas to Oil Ratio (GOR) in excess of 1,000 standard cubic feet per barrel.

The field is being developed in phases and further wells are to be drilled. This would increase the oil and gas production and extend the plateau of production profiles. Figure 5.7 reflects the expected indigenous production forecast.

Figure 5.7: Oil Production Forecast, 2010 – 2047, Barrels/Day

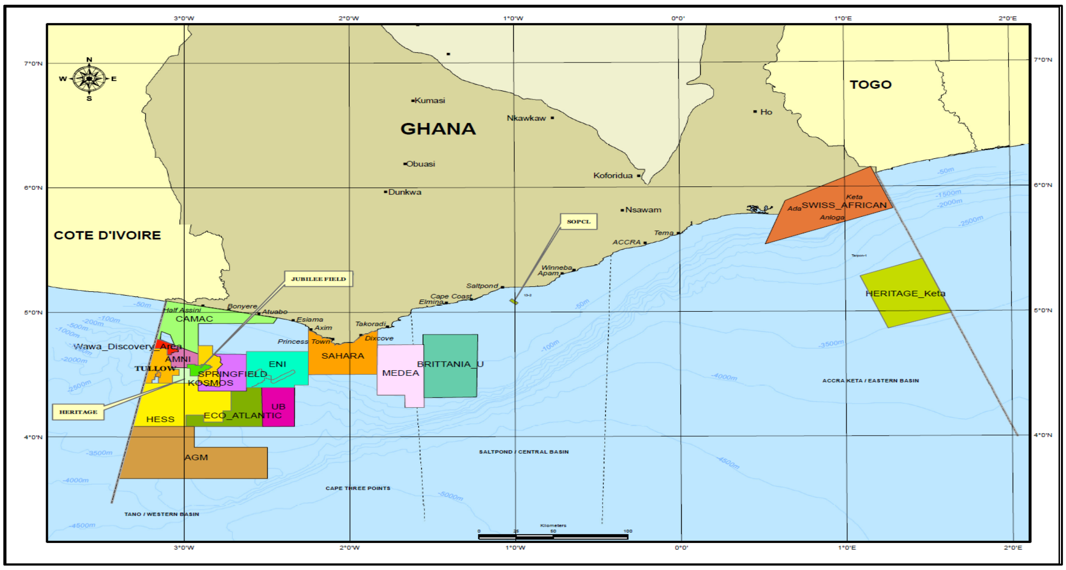


Source: Author's Construct, 2017

5.5.3 Reserves Potential for Indigenous Oil Resources

An offshore activity map is shown in Figure 5.8. The Jubilee oil field is currently in production. The Tullow block which covers the TEN fields is shown to the west of the Jubilee oil field, adjacent to the border with Cote d'Ivoire.

Figure 5.8: Ghana's Offshore Activity Map



Source: Gas Master Plan, 2015

Table 5.1: Supply Plan – Reserves Potential for Indigenous Oil

Reserves Statement (As at 30th June 2016)			
	Ultimate Reserves	**Recoverable Reserves**	
		Gross	**Net Carried and Participating Interest (GNPC/State)**
Crude Oil & Condensates (MMBO)			
Saltpond*	5.6	0.35	0.15
Jubilee	628	455	58.7
Mahogany	31	31	3.7
Teak	0	0	0
TEN	239	239	34.1
Sankofa & Gye Nyame (OCTP)	204	204	37.7
Total Oil and Condensates (MMBO)	**1108**	**929**	**134**

Source: Gas Master Plan, 2015, *Saltpond field has been shut in since December, 2015

To the east of the Jubilee field is the Kosmos Block, which contains the MTA fields. These fields will be developed and produced using the Jubilee FPSO. The Greater Jubilee Full Field Development Plan sets out the integrated development of the Jubilee field, and the Mahogany and Teak discoveries (together known as the "Greater Jubilee"). Mahogany and Teak will be tied back to and produced through the existing Jubilee Floating Production Storage and Offloading (FPSO) vessel. To the south of the Jubilee field is the Hess Block which contains seven separate discoveries. The ENI Block is to the east of the Jubilee field.

The offshore area is generally prospective and has attracted the attention of numerous international oil companies. There are also potentially significant resources onshore in the Voltaian basin, though the exploration and development of these is a long term proposition.

5.6 Infrastructure Plan – Refinery, Products Storage, Pipelines

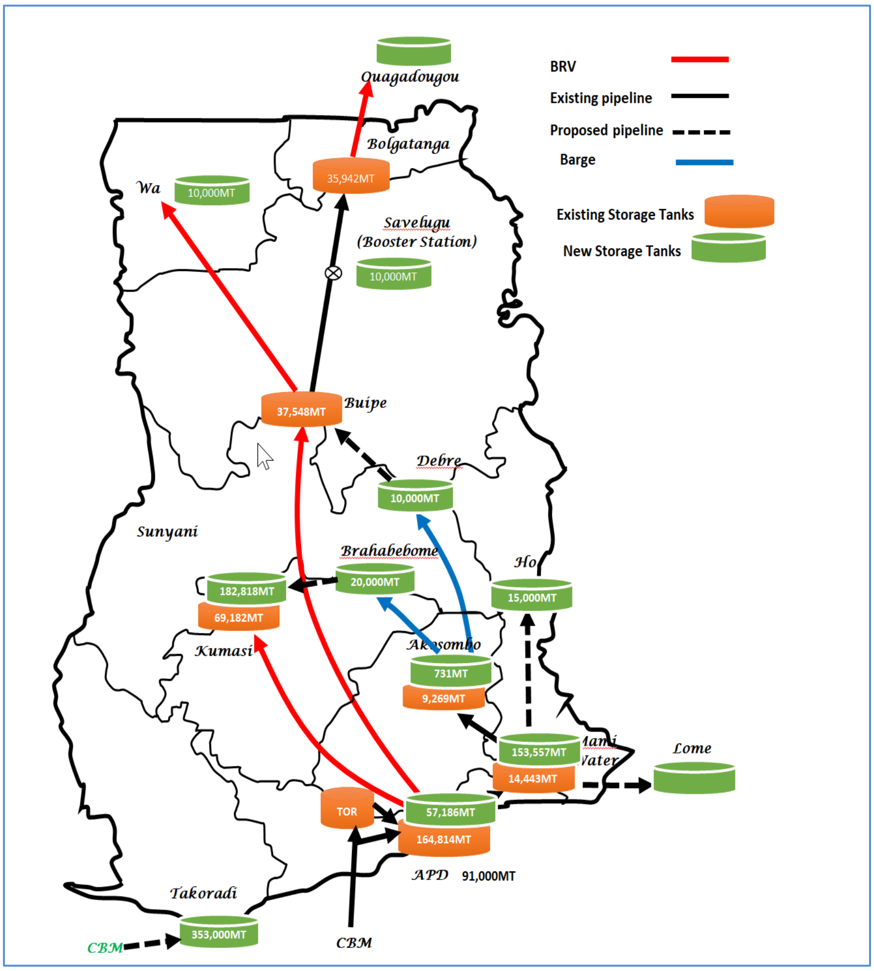
5.6.1 Refinery

The capacity of the Tema Oil Refinery will be increased from the current 45,000 bpd to 60,000 bpd by 2025. Besides that, a totally new refinery is planned in the Western Region to handle processing of the indigenous oil finds in the offshore basins.

5.6.2 Transportation

The transport of crude and finished products between the supply source and the market will remain by pipeline, road or marine vessels. Pipelines (and/or vessels) will also be used to transport Ghana's indigenous oil production for processing at the Tema Oil Refinery and the planned new refinery. The existing and proposed storage and pipeline infrastructure for petroleum products are shown in Figure 5.9

Figure 5.9: Existing and Proposed Petroleum Products Infrastructure



Source: Gas Master Plan, 2015

5.7 The Gas Infrastructure Plan

The use of natural gas in Ghana started with imports of gas from Nigeria through the West Africa Gas Pipeline (WAGP) for use in the power generation sector. The WAGP supplies have been unreliable, subject to major interruptions and supply shortfalls consistently below agreed supply volumes. With significant domestic associated and non-associated gas reserves discovered recently, the gas supply dynamic in Ghana has changed. Likely near-term production from the most advanced reserves are concentrated in three large offshore gas fields: the Jubilee field with associated gas reserves estimated at 335 billion cubic feet (bcf), the TEN fields with associated gas reserve of 353 bcf and the Sankofa field with non-associated gas reserves of 1,168 bcf.

A comprehensive Ghana Gas Master Plan Model (GMPM) has been developed to examine alternative scenarios, covering the following main aspects:

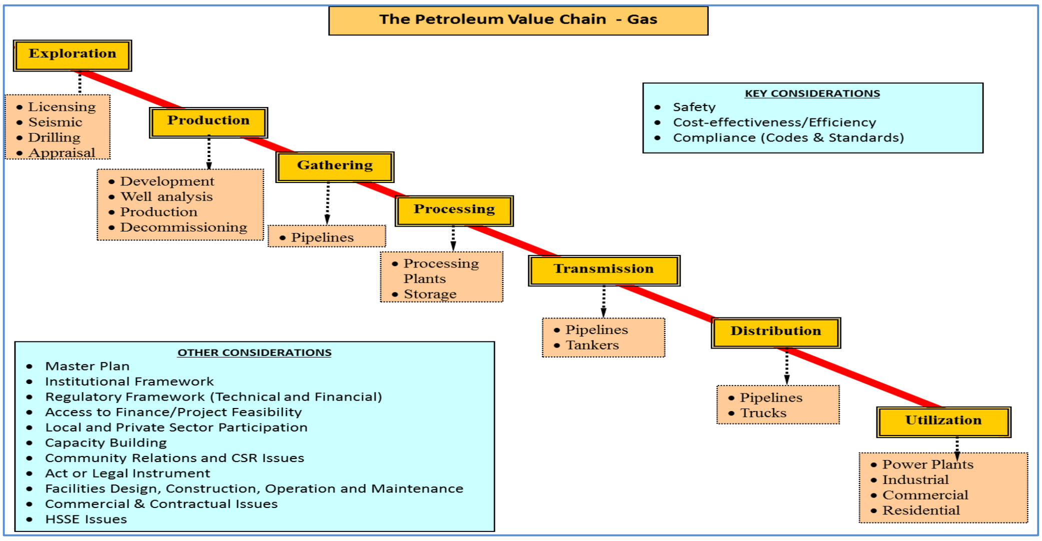
i. Estimates of the demand for gas in Ghana up to 2040 on the basis of a power dispatch model and netback prices for the most likely non-power offtakers.
ii. Calculations of the national annual gas supply and demand balance in Ghana, as well as the regional balances.
iii. The weighted average cost of gas resulting from the supply mix.

iv. Determination of the location, capacity, costs and timing of new infrastructure: transmission pipelines and LNG terminals.
v. The economic value of different gas utilisation scenarios.

The GMPM model enables different scenarios to be examined and compared. A training course has been provided for stakeholders so that future scenarios can be examined after the GMP study.

The gas value chain shown in Figure 4.10, unlike the oil value chain, has three categories of activities**:** upstream, midstream and downstream. The upstream activities cover exploration and production while midstream activities cover gathering, processing and transmission. The downstream activities are limited to distribution and utilisation.

Figure 5.10: The Gas Value Chain



Source: Author's Construct

The requisite infrastructure plan along the value chain would cover each of these stages of activities. The current Gas Master Plan (GMP) presents a road map for most of the activities along the chain.

5.7.1 Midstream Gas Activities

The midstream industry consists of activities such as gathering of the resources, processing of the raw gas, and transmission of the processed gas.

Gathering

The gathering of the aggregated gas is normally done with high-pressure pipelines, which link the supply sources to the processing plant. It is important that any plan for the gathering or transfer facilities consider the magnitude and projected life of the recoverable reserves.

Processing

Raw gas conditioning and processing typically requires expansion of the gas, either across a valve or a turbine. The process results in a significant temperature drop accompanying the pressure drop. The processing plants are typically referred to as Joule Thompson (JT) plants or Turboexpander plants. The current plant at Atuabo is a JT plant. The main products from the processing are lean gas, LPGs, and condensates.

Transmission and Storage

The mode of transmission and/or storage of natural gas usually depends on its state. Gaseous natural gas is normally transmitted through large diameter pipelines at high pressure; while natural gas liquids including LNG and LPG are typically transported and stored under controlled conditions of temperature and pressure in smaller diameter pipelines. Storage of gaseous natural gas is done in salt caverns or depleted reservoirs and not in tanks like the liquefied derivatives. Transmission of gaseous natural gas usually has compressors providing the motive force, whiles pumps are used for the liquids.

5.7.2 Downstream Gas Activities

Distribution

Gas distribution is normally performed by Local Distribution Companies (LDCs) that take custody of the gas at the city gate and transport it to the battery limits of the end-users.

Utilisation

The main usage for natural gas is for power generation, petrochemical industries – such as methanol, fertilizer, urea, etc., as well as for vehicular transport (CNG) and heating.
The gas infrastructure plan is driven by the demand and supply plans and these are presented below.

5.8 Gas Demand Plan

This section looks at the various utilisation options for natural gas as well as the associated demand profiles for both power and non-power applications for the next thirty (30) years. The transport of natural gas between the supply source and the market is typically by pipeline or by storage tanks or cylinders (on marine vessels or trucks or rail) as LNG or CNG.

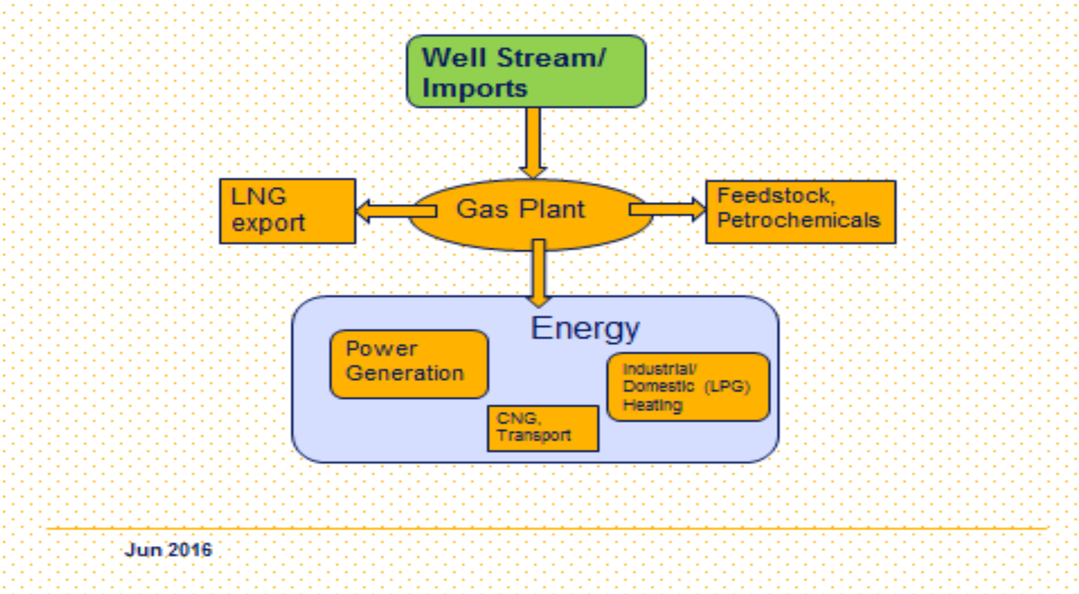
5.8.1 Gas Utilisation

Utilisation is the various ways that the gas could be used. This is mainly as an energy source or as feedstock for various industrial applications. Usually the utilisation option drives the type of processing and mode of transportation.

The main products from processing of raw or wet gas, are Lean Gas and Natural Gas Liquids (NGLs) (which includes liquefied petroleum gas (LPG) and condensates). The

NGLs are removed from the gas stream and marketed separately. The lean or dry gas is utilised primarily as fuel for power generation, but could also be used as a fuel source for industrial applications, or as a feedstock for certain petrochemicals. The utilisation options are summarised in Figure 5.11.

Figure 5.11: Gas Utilisation Options



Source: Gas Master Plan, 2015

Gas for Power Generation

Gas for power generation is the priority for utilisation in the country. Due to periodic gas supply shortfalls from Nigeria and the Jubilee field, thermal generation plants frequently use Light Crude Oil (LCO) and Diesel. These are relatively higher cost fuels and environmentally more unfriendly.

Non-Power Uses of Natural Gas

The non-power utilisation options are:

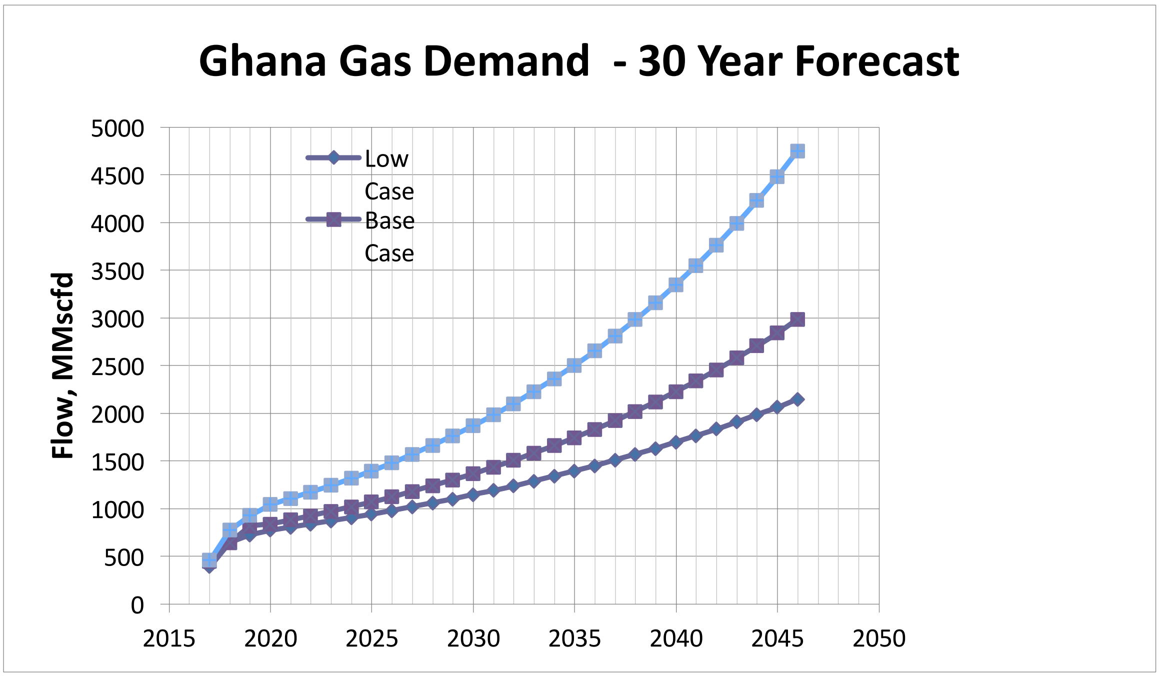
i. Industrial Heat
ii. Residential and Commericial for heating and as cooking fuel
iii. CNG for transportation
iv. Fertilizer/Urea
v. Methanol
vi. Dimethyl Ether - a derivative of methanol)
vii. Ammonia/Ammonium Nitrate
viii. Petrochemicals

5.8.2 Gas Demand Forecast for Power and Non-Power Loads

Given the uncertainties over future gas supplies, the development of new power and gas infrastructure and the demand for power, we have considered three alternative scenarios for gas demand projection:

i. Low case – assumes gas requirement for existing thermal plants with a growth of 4% annually;
ii. Base case – assumes gas requirement for existing thermal plants with a growth of 5% annually;
iii. High case – assumes gas requirement for existing thermal plants with a growth of 6% annually.

Figure 5.12: Gas Demand Profile



Source: Author's Construct

5.9 Gas Supply Plan

This section covers three broad categories of gas supply sources:

- Domestic gas reserves and production;
- Regional gas imports;
- LNG imports.

5.9.1 Domestic Gas Reserves and Supply

Domestic gas reserves are based on the supply of associated gas from the Jubilee field, the TEN field, the MTA field (Mahogany, Teak and Akasa); and the non-associated gas discovery, the Sankofa field. Furthermore, the Paradise field discovered by Hess is an oil and gas condensate discovery while the Hickory field, also owned by Hess, is a gas condensate discovery. More resources (both non-associated gas and associated) are also likely to be discovered from concessions that are yet to be drilled. Apart from gas supplied from Ghana's indigenous fields, gas additional gas can be sourced from Nigeria through the WAGP besides the potential for LNG imports.

Three scenarios have been prepared based on the above summary of reserves and resources:

i. Base supply scenario
ii. Low supply scenario
iii. High supply scenario

Table 5.2: Scenarios for Gas Reserves and Resource, *Bcf*

Field	Low Supply	Base Supply	High Supply
Jubilee*	256	490	591
TEN	209	363	402
Sankofa and GyeNyame	929	1,107	1,191
MTA*	3	128	173
Hess		177	177
Shallow Tano			193
Other Non-associated gas			1,000
Other Associated gas			1,000
Total	**1,397**	**2,265**	**4,730**

Source: Gas Master Plan, 2015
* NB: *Estimates from Greater Jubilee Full Field Development Plan, 2015*

To obtain a realistic picture of future production volumes, yet-to-find oil and gas fields are included in the analysis. Exploration in Ghana is continuing at a rapid pace and further discoveries are likely to be made. However, these possible further discoveries have only been taken into account in the high supply scenario forecast. The timetable for the start of supply for the yet-to-find fields is only indicative.

Table 5.3: Summary Data for Gas Exports and Pricing Scenarios

Field	Production Year (earliest)	Daily Sales peak (mmscfd)	Indicative cost (US$/mmbtu)
Jubilee	2015	60-120	2.98-4.20
TEN	2017	30-50	2.98-4.20
Sankofa*	2018	150-180	9.8
MTA	2019	50-120	4.20
Hess	2021	50	2.98-4.20
Shallow Tano	2025	50	2.98-4.20
Other Non-associated gas	2020	140	4.20
Other Associated gas	2019	140	2.98

Source: Gas Master Plan, 2015
** This negotiated price of US$9.8 /mmbtu, by prevailing global gas prices, is excessive*

5.9.2 Regional Gas Imports (Nigerian Gas via WAGP)

The WAGP currently has a capacity of 170 mmscfd without additional compression. However, with additional compression, the capacity can be increased to 470 mmscfd at a maximum operating pressure of 150 bar. The Volta River Authority (VRA) has contracted a capacity of 123 mmscfd. It should be noted that to date, the WAGP has failed to deliver the contracted quantity consistently due to a coincidence of factors.

5.9.3 Offshore Gathering Facilities Plan

Jubilee-Atuabo offshore gas gathering pipeline: This is a 12-inch diameter, 58 km offshore pipeline from the Jubilee field's FPSO Kwame Nkrumah to the Atuabo Gas Processing Plant. The deep sea section is 14 km long at depths of up to 1000 m, while the shallow water component is 44 km long at depths of up to 80 m. This pipeline delivers raw gas from the Jubilee field for processing onshore at the Atuabo gas processing plant. Completed in 2014, the pipeline is owned and operated by the GNGC.

5.9.4 Onshore Gathering Facilities Plan

The onshore gathering system is yet to be developed. Currently the Voltaian basin is the only onshore field with production potential.

5.10 Processing Infrastructure Plan

Processing involves the processes and infrastructure required to transform the raw gas from its "crude" state to a saleable or consumable state. While refineries are used to process crude oil, gas plants are used to process raw gas.

Sweetening Plant (Sour Gas Removal)

The process of removal of the sour (and acidic) components of raw gas (H_2S and CO_2) is called sweetening. These components of the gas stream maybe removed with an amine column, using, for example, monoethanol amine (MEA) or diethanol amine (DEA) or monodiethyl amine (MDEA).

Dehydration and Dew-point Control (Water & Hydrocarbon)

Gas from the sweetening plant may still contain some water and heavy hydrocarbons. These must be reduced so that the gas product stays above both the dew-points of water and the hydrocarbons. This can be accomplished in several ways:

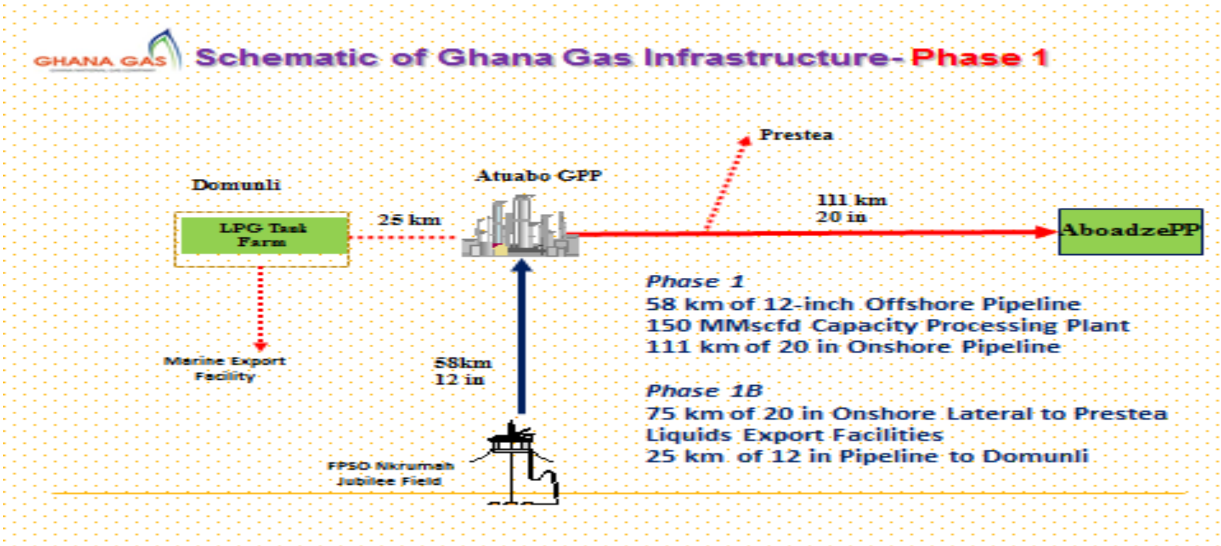
Hydrocarbon (HC) Liquids Recovery

The liquid HC from both the separators and the dew-point controller are sent to a fractionating column for separation of the individual components. This is essentially by distillation, utilising the different boiling points of the components. Hydrocarbon liquids recovery from raw natural gas can range from the use of a simple dew point controller to deep extraction processes.

Sulphur Recovery

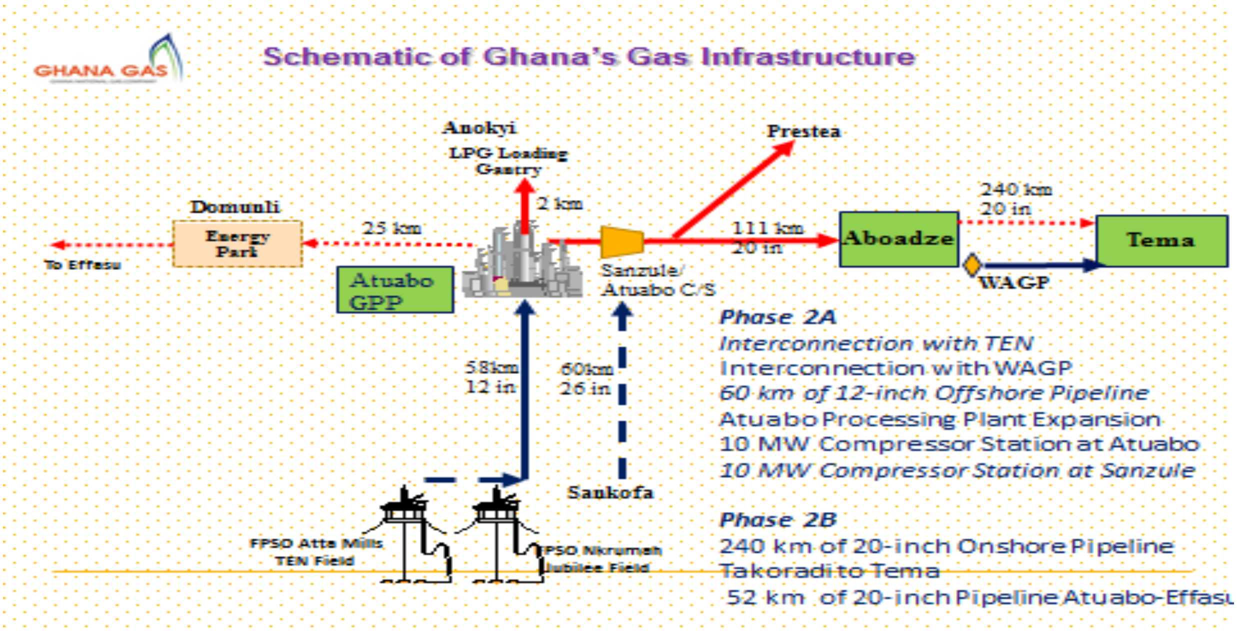
The acid gases (H_2S and CO_2) from the sweetening plant could be sent to a sulphur recovery plant where the H_2S is reacted with O_2 to produce elemental sulphur. The residual SO_2 and CO_2 are rejected to the atmosphere depending on environmental regulations. Figures 5.13 and 5.14 represent the current and proposed infrastructure plan for the gas system.

Figure 5.13: Ghana Gas Infrastructure Phase 1



Source: Gas Master Plan, 2015

Figure 5.14: Ghana Gas Infrastructure Phase 2

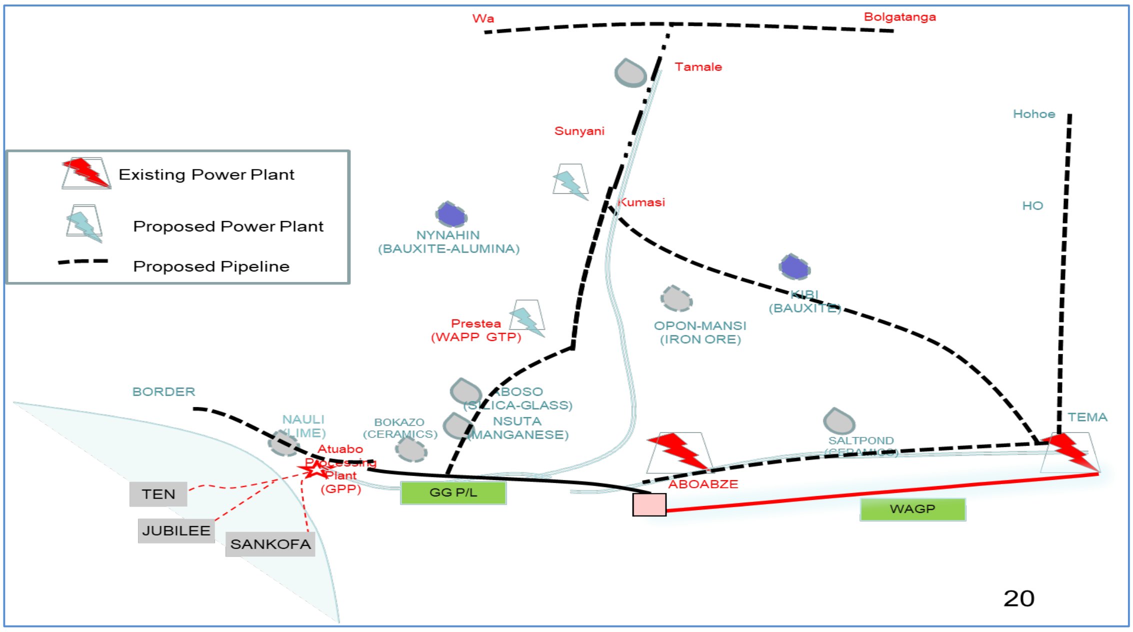


Source: Gas Master Plan, 2015

5.11 Transmission Facilities Plan

Based on technical parameters adopted, the following national transmission pipeline network will be developed.

Figure 5.15: Ghana Gas Transmission System



Source: Gas Master Plan, 2015

5.11.1 Western Corridor Gas Pipeline System

The proposed Western Corridor pipeline covers the Takoradi-Elubo border along the western coastline and takes off inland via the Essiama-Prestea lateral to Kumasi and ends at Sunyani at the cost of US$563 million.

5.11.2 Eastern Corridor Gas Pipeline System,

The proposed Eastern Corridor pipeline starts from Takoradi to Tema and has a dual path: one towards the Volta Region and the other to the Eastern Region terminating in Kumasi in the Ashanti Region at a total cost of US$675 million.

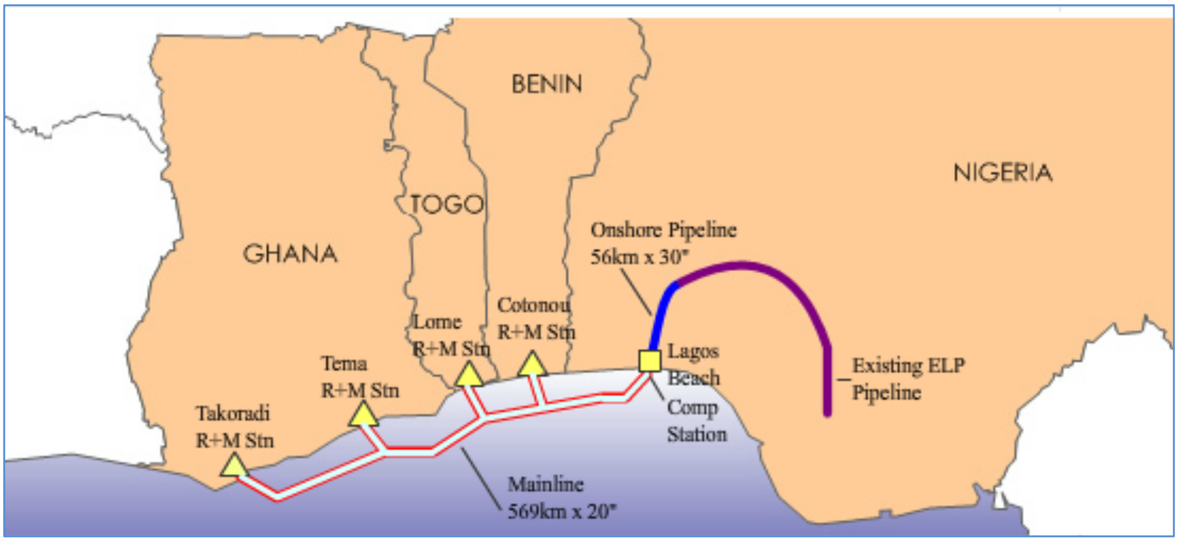
5.11.3 Northern System

Connections from Kumasi via Sunyani, Tamale, Bolgatanga and Wa were proposed. The northern pipeline section is costly and viability of the system is questionable. These are in effect three pipeline segments with a length of 300 km (Sunyani-Tamale) and 150 km (Tamale-Upper Junction, the approximate midpoint between Wa and Bolgatanga) with extensions to Wa and Bolgatanga totalling about 600 km at a cost of US$468 million. Very low throughput volume and high capital cost means that the postage stamp transmission tariff would be high.

5.12 West African Gas Pipeline (WAGP)

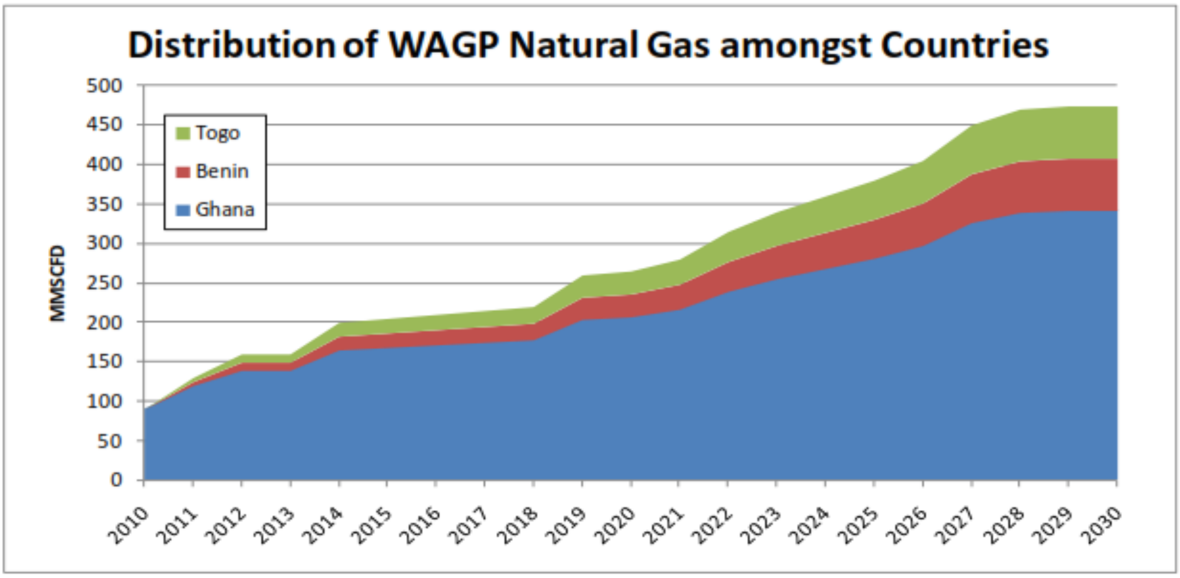
The WAGP is a 691 km long offshore pipeline starting from Nigeria and ending in Ghana, with landing points in Cotonou (Benin), Lome (Togo), Tema and Takoradi. At full capacity and without compression, the pipeline can deliver 170 mmscfd. The maximum deliverability, requiring additional compression, is 474 mmscfd. While the contracted capacity for Ghana is 123 mmscfd, it should be noted that to date the WAGP has failed to deliver the contracted quantity consistently. The flow of Nigerian gas has practically been restricted to Tema, with the Tema-Takoradi section of the WAGP remaining largely unutilised. This has opened the possibility of using this section of the WAGP to reverse flow surplus gas in Western Corridor to feed the Eastern Corridor demand centres.
The distribution of natural gas from the pipeline to Benin, Ghana and Togo is shown in Figures 5.16 and 5.17.

Figure 5.16: The West Africa Gas Pipeline connecting Nigeria, Benin, Togo and Ghana



Source: Gas Master Plan, 2015

Figure 5.17: Distribution of Natural Gas from WAGP amongst Countries



Source: Ghana National Petroleum Corporation, 2011

5.13 Enablers for Implementation of Oil and Gas Infrastructure Plans

The petroleum infrastructure plan considers all the elements that influence the long-term life-cycle of the facility including design, construction, operation and maintenance. The enabling environment that drives the plans is critically important, with structures such as institutional and regulatory frameworks (both technical and financial), capacity building, community relations and corporate social responsibility in project affected areas, with local and private entity participation as well as access to finance. The institutional framework will reflect a clear and unambiguous delineation of sector agency roles to ensure sustainable growth of the industry.

5.13.1 Local Content

The promotion of "local content" in the petroleum industry in Ghana will necessarily be under the umbrella of the private sector. Local content would have to be unambiguously defined both in the context of individuals and corporations. Appropriate safeguards need to be in place to ensure that the implementation of any local content policy does not prove counter-productive. In selected cases, the government can also assist in providing access to capital to qualified "locals".

5.13.2 Capacity Building

Building the necessary local human capacity to meet the challenges of a relatively new petroleum industry in any country will require dedicated government and private investment. Both the academic institutions and the local industry have to be key stakeholders in this venture. Training in the principles and application of the relevant technologies need to be offered at home and abroad to both students and industry personnel. Cross-functional training should also be encouraged to sustain the intellectual capacity and versatility of the work force.

5.13.3 No Gas Flaring Policy

Ghana has a "No Gas Flaring" policy meaning that any produced gas will have to be:

a. Re-injected back into the reservoir or
b. Developed for utilisation.

Option (a) enhances oil production rates particularly in the later years of the reservoir's life. Option (b) is a more costly option in terms of facility requirements, but the development option will result in tremendous revenue potential as well as significant job creation.

Either of the two options will mean less atmospheric emission and a good basis for application for emission credits.

5.14 Gas Pricing Policy

5.14.1 Existing Pricing Policy

The Natural Gas Pricing Policy (NGPP) was published by the then Ministry of Energy (MoE) in May 2012 and sets out the gas pricing principles. The 2012 document envisaged import parity pricing for gas, resulting in expected surplus revenue being accumulated in a Gas Rent Fund. This would, among others, be used to resolve investment deficits in the power sector, and, when resources permit, cross-subsidise the fertiliser industry and other strategic sectors.

5.15 Recommendations

Policy and Regulations

To promote sustainable growth in the oil and gas industry, the government will develop enabling policies across the petroleum value chain. These policies will achieve the following benefits:

i. Reflect fair returns to all stakeholders, including government, investors and end-users.
ii. Be transparent, predictable, clearly defined and open to all investors that meet specified criteria.
iii. Be simple to administer and not impose unnecessary bureaucratic 'red-tape' on private investors.

An enabling Act, in addition to the Petroleum Act 919 (2016), should be developed specifically for the gas sector.

Institutional and Regulatory framework

Clarity of roles needs to be firmly established. A responsibility matrix for the various sector agencies needs to be clearly spelt out. The institutional and regulatory frameworks will reflect a clear and unambiguous delineation of sector agency roles.

Industry Development

The government will actively seek and encourage private sector involvement, with investment promotion and local content participation; and facilitate access to capital. There is a critical need to build local human capacity to meet the challenges of a relatively new petroleum industry including the areas of design, material specification, construction and operation and maintenance. Active promotion of community relations and corporate social responsibility in project affected areas is also recommended.

Oil Demand and Utilisation Plan

The government will develop an oil utilisation plan that clearly spells out an allocation scheme for the various industries including power generation, vehicular transport and industrial heating. Demand for oil and oil products for the uses mentioned above will be considered alongside other sources of fuel or energy forms.

Oil Supply Plan

The development of indigenous oil supply sources (both offshore and onshore) would be strongly encouraged to reduce cost and enhance supply security. The national oil company, GNPC, will initiate its own exploration and production business within the next 5-10 years.

Oil Infrastructure Plan

A dedicated infrastructure plan that links the supply points to the market will be developed and regularly updated. Ghana needs another refinery to augment or replace the existing one at Tema. This should have sufficient capacity to handle both indigenous and imported crude. For petroleum products storage, periodic assessment of available capacity will be conducted. Pipeline infrastructure that transports petroleum products will be expanded to gradually replace road transportation (BRVs).

Gas Demand and Utilisation Plan

The Gas Master Plan, which is the roadmap for the growth of the nascent gas industry, will be updated periodically and reflect the changing industrial needs into the future. Petrochemical and agrochemical industries should be given priority after power generation. Demand for gas and gas derivatives for the uses mentioned above will be considered alongside other sources of fuel or energy forms. A predictable gas pricing methodology (for both commodity and tariffs) will be developed and adhered to.

Gas Supply Plan

The development of indigenous gas supply sources (both offshore and onshore) will be strongly encouraged to reduce cost and enhance supply security. Planned or unplanned disruptions to gas supply can be addressed either by linepack or an LNG source, depending on the duration of the outage or imbalance. Pipelines linking offshore oil supply to a new refinery.

Gas Infrastructure Plan

An appropriate gas infrastructure plan with adequate available capacity will be determined and revised periodically to handle any incremental flows coming onto the system. The requirement for an additional train for gas processing should be assessed based on projected production of raw gas from the fields.

Chapter 6 Road Transport

6.1 Introduction

The level of social and economic development of any country is directly linked with the quality and extent of its transport infrastructure. Economic growth and social development depend in part on increasing the capacity and utilisation of transport infrastructure to move goods and people. Transportation is a major necessity, facilitating the production and consumption of goods and services at different locations, and allowing for increased trade and a more even population spread.

Ghana can boast of five (5) main modes of transport, namely: road, railway, sea, air, lake and rivers. Each mode is currently developing and expanding to meet current demand and future opportunities that exist in the socio-economic environment without any recourse to integration.

The predominant mode of transport in the country is by road – with an estimated market share of over 95% and 90% of passenger and cargo traffic respectively. The main challenge to road transportation is the inconsistencies in the road surface of the classified networks. There are national roads which are unpaved. In cases where they are paved, some sections are usually in poor condition, making their use unreliable and expensive in terms of vehicle operating cost. Allowing the status quo to prevail will have a devastating effect on Ghana's ultimate vision of becoming a high-income country.

6.1.1 Vision

The vision of the road transport sector is "to provide an integrated, efficient, cost-effective and sustainable transportation system responsive to the needs of society, supporting growth and poverty reduction and capable of establishing and maintaining Ghana as transportation hub of West Africa."[53]

6.2 Policy and Main Institutions in the Road Transport Sector

6.2.1 National Transport Policy

An appropriate National Transport Policy (NTP) guides the development and operation of the transport systems. It aims to help reduce transport costs for internal distribution of goods and services as well as keep the country's exports competitive in the world market. It is also aimed at providing safe and reliable transport services to the population.

[53] Ghana Highway Authority, Draft Strategic Plan, 2015 - 2017

Strategic Goals and Objectives

The NTP of 2008 defines strategic goals and objectives of the transport sector. These underpin the Transport Infrastructure Plan component of the GIP. Development priorities under the GIP are as follows:

i. Establish Ghana as a transportation hub for the West African sub-region;
ii. Create a sustainable, accessible, affordable, reliable, effective, efficient, safe and secure transport system that meets user needs;
iii. Integrate land use, transport planning, development planning and service provision;
iv. Create a vibrant investment and performance-based management environment that maximises benefits for public and private sector investors;
v. Develop and implement a comprehensive and integrated policy, governance and institutional framework;
vi. Ensure sustainable development in the transport sector;
vii. Develop adequate human resources and apply new technology.

The GIP is the anchor for a series of detailed, medium-term, transport sector strategic plans over the 30-year investment period. It also guides the development of inter-modal transport system, combining road, rail, aviation and maritime and water transport in an integrated system.

6.2.2 Main Institutions within the Road Transport Sector

The Ghana Highway Authority (GHA) is responsible for the trunk roads in the country. Trunk roads connect the various regions of the country to the national capital, and the country to its neighbours. They also link areas of socio-economic activities and major production centres and markets.

The Department of Feeder Roads (DFR) is responsible for feeder roads. The feeder system is next in the road hierarchy to trunk roads. It is a key transport mode in rural areas and also feeds the trunk roads with traffic from the farm gates and rural communities. The feeder road network is extensive but mainly made up of gravel and earth.

The Department of Urban Roads (DUR) is responsible for the urban roads. The urban road system is third in the roads hierarchy and used mainly for distribution of goods and services in urban centres.

6.3 Current State of the Road Transport Sector

6.3.1 Demographic and Poverty Statistics

A demographic analysis was undertaken to look at the inequalities in the distribution and delivery of transport infrastructure in Ghana. The regional population figures as well as the incidence of poverty information were obtained from the Ghana Statistical Service (GSS). This information and the transport distribution data were used to establish the accessibility indices, road density etc. Tables 6.1 and 6.2 present the findings.

Table 6.1: Regional Road Accessibility

Region	Area (sq. km)	Population	Total Length of Roads km	Accessibility*	Road Density
Upper East	8,842	1,031,478	3,518	293	0.40
Upper West	18,376	677,763	4,697	144	0.26
Northern	70,384	2,468,557	9,901	249	0.14
Brong Ahafo	39,557	2,282,128	10,776	212	0.27
Ashanti	24,389	4,725,046	9,861	479	0.40
Volta	20,570	2,099,869	5,671	370	0.28
Eastern	19,323	2,596,013	5,866	442	0.30
Greater Accra	3,245	3,909,764	8,650	452	2.67
Central	9,826	2,107,209	5,492	384	0.56
Western	23,921	2,323,597	5,671	410	0.24

*See Table 6.3 below
Source: Author's Construct

Table 6.2: Road Condition and Poverty Distribution

Region	Population	% below poverty line	Length in poor condition	% of poor roads
Upper East	1,031,478	74	3,476	35
Upper West	677,763	41	4,059	74
Northern	2468,557	35	1,231	41
Brong Ahafo	2,282,128	38	2,155	51
Ashanti	4,725,046	51	5,496	43
Volta	2,099,869	30	1,760	38
Eastern	2,596,013	40	2,268	30
Greater Accra	3,909,764	43	4,240	56
Central	2,107,209	40	2,197	40
Western	2,323,597	56	4,844	40

Source: Author's Construct

6.3.2 Effects of Poor Road Condition on Socio-Economic Activities

A survey by the Ministry of Roads and Highways in 2013 evaluated the effects of poor roads on the socio-economic activities in the areas of accessibility, mobility and welfare. Table 6.3 gives the indices used for the evaluation.

Table 6.3: Road Condition on Socio-Economic Indices

Measure of Accessibility	Measure of Mobility	Measure of Welfare
Transport tariffs to nearest markets	Frequency of long-distance trips for all modes of transport out of settlements	Transport inaccessibility as cause of produce loss
Travel time to major markets	Transport waiting times	Frequency of trips to health facility
Proportion of the populace accessing health, schools and social services	Proportion of households with direct access to a mode of transport	Percentage of school-age children at school
% of the year when no access to transport	Total traffic passing through communities	Average monthly household income
Farm gate prices of major produce	Reliability of passenger transport	Average monthly household expenditure

Source: Transport Survey Report by Statistical Services for Ministry of Roads and Highways, 2013

Road Quality and Education

Almost 31% of those going to school faced some difficulties. On a regional basis, Upper East (53%), Volta (43%) and Greater Accra (40%) regions reported relatively high proportions of students who had some difficulty getting to school (Table 6.4).

Table 0.4: Distribution of Access to Education, 2013 (%)

Region	Yes	No	Total
Western	25	75	100
Central	15	85	100
Gt. Accra	40	60	100
Volta	43	57	100
Eastern	28	72	100
Ashanti	35	66	100
Brong Ahafo	23	77	100
Northern	15	85	100
Upper East	53	47	100
Upper West	35	65	100
GHANA	**31**	**69**	**100**

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

The three main difficulties faced in getting to school were bad roads during the rainy season (37%), followed by bad roads in all seasons (23%) and long distances to school (11%).

Table 6.5: Main Difficulties Faced in Going to School, 2013 (%)

Type of difficulties	Percentages
No access road	6
Bad roads (wet season)	37
Bad roads (dry season)	1
Bad roads (all seasons)	23
Difficulty getting vehicle	7
Long waiting time	4
Heavy traffic on road	6
Distance too long	11
Frequent breakdowns of vehicles	0
No money for transport	4
Other	1
TOTAL	**100**

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

Road Quality and Health

The main obstacles encountered in visiting health facilities assigned by respondents are given in Table 6.6 below. Nineteen percent (19%) of the respondents cited long distance as the main obstacle encountered while visiting a health facility. Of those who complained about distance, Upper East Region had the highest percentage (32%) and the Greater Accra Region recorded the lowest percentage (10%). This is consistent with the accessibility indices given in Table 6.6.

Table 66.6: Main obstacle encountered in visiting a health facility, 2013 (%)

Region	Main obstacle being faced								
	No access road	Bad roads	Difficulty getting vehicle	Long waiting time	Heavy traffic on the road	Distance too long	No money for transport	Other	Total
Western	1	11	40	12	5	28	1	2	100
Central	3	17	20	30	2	18	10	0	100
Gt. Accra	2	21	12	19	28	10	3	5	100
Volta	1	21	29	18	1	16	8	6	100
Eastern	0	20	37	11	3	24	2	3	100
Ashanti	1	16	40	13	10	15	5	0	100
Brong Ahafo	0	10	64	9	0	16	1	0	100
Northern	5	32	22	4	0	27	10	0	100
Upper East	1	24	34	0	0	32	9	0	100
Upper West	1	20	50	3	0	20	6	0	100
GHANA	**2**	**19**	**33**	**13**	**7**	**19**	**5**	**2**	**100**

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

Bad roads account for 19% of the main obstacles they face visiting a health facility. The Northern Region had more than a quarter (32%) of the respondents who mentioned bad roads while the Brong Ahafo Region had 10%. Only 2% of the population mentioned no access road as the main obstacle faced visiting a health facility.

Road Quality and Agriculture

One of the main challenges to the growth of agriculture in Ghana is access to markets. Table 6.7 gives details on distance travelled to the nearest markets on a regional basis. It has also been established through research that about 50%–70% of food prices in urban centres is due to transport-related costs. Therefore, better accessibility can help to reduce consumer prices of agricultural products.

Table 6.7: Distance travelled to the nearest mark, 2013 (%)

Region	Distance (Km)					
	0-1	1.1-2	2.1-3	3.1-6	6.1-10	Total
Western	55	20	12	13	0	100
Central	42	21	16	21	0	100
Greater Accra	27	21	6	43	3	100
Volta	24	19	17	40	0	100
Eastern	29	19	21	31	0	100
Ashanti	30	19	18	33	0	100
Brong Ahafo	31	19	13	37	0	100
Northern	23	19	20	38	0	100
Upper East	22	24	28	26	0	100
Upper West	1	11	24	64	0	100
GHANA	**32**	**19**	**17**	**32**	**0**	**100**

Source: Transport Survey Report by Statistical Services for Ministry of Roads and Highways, 2013

One of the main difficulties in agricultural development is marketing of farm produce. Fifty-nine percent (59%) of farmers had difficulty marketing their farm produce due to bad roads. Some 16% have no access roads to enable them travel to market their farm produce, while 12% lacked any means of transport to market their produce. Table 6.8 depicts the various difficulties.

Table 6.8: Difficulties faced in marketing farm produce due to road quality, 2013 (%)

Region	Difficulty faced							
	No Access Road	Bad Road	No Means of Transport	High Transport Cost	Transport Not Reliable	Other	Not Applicable	Total
Western	24	41	14	11	10	0	0	100
Central	46	31	11	5	7	0	0	100
Greater Accra	23	54	15	4	4	0	0	100
Volta	24	53	3	7	8	4	1	100
Eastern	17	68	10	2	3	0	0	100
Ashanti	14	69	8	3	5	1	0	100
Brong Ahafo	10	82	1	3	4	0	0	100
Northern	11	40	25	12	12	0	0	100
Upper East	2	48	42	5	3	0	0	100
Upper West	1	59	23	1	16	0	0	100
GHANA	**16**	**59**	**12**	**5**	**7**	**1**	**0**	**100**

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

General Road Transport Services

General road transport services are unsatisfactory due to long delays (53%) and unpredictable schedules (46%). In the Western Region, 70% of the poor service is due to long delays. In the Northern Region, the major problem is unpredictable schedules, which constituted about 57% of the reasons for the unsatisfactory road transport services. Table 6.9 gives the breakdown per region.

Table 6.9: Reasons for non-satisfaction with transport availability, 2013 (%)

Region	Long delays	Unpredictable schedule	Other	Total
Western	70	28	2	100
Central	58	42	0	100
Greater Accra	53	44	3	100
Volta	33	65	2	100
Eastern	63	36	1	100
Ashanti	54	44	2	100
Brong Ahafo	44	54	2	100
Northern	41	57	2	100
Upper East	56	44	0	100
Upper West	60	40	0	100
GHANA	**53**	**46**	**1**	**100**

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

Table 6.10: Means of transport from residence to workplace of the employed by sex and locality, 2013 (%)

Means of travel	Urban			Rural			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	GHANA
Public (taxi shared)	12	12	**12**	4	4	**4**	7	6	**7**
Public (taxi-individual)	3	3	**3**	1	1	**1**	2	2	**1**
Vehicle (*trotro*)	22	16	**19**	6	5	**6**	11	9	**10**
Bus (Metro Mass)	0	0	**0**	0	0	**0**	0	0	**0**
Bus (public)	1	1	**1**	0	0	**0**	0	0	**0**
Train	0	0	**0**	0	0	**0**	0	0	**0**
Company car/vehicle	0	0	**0**	2	1	**1**	2	0	**1**
Boat/ferry/canoe	4	1	**2**	1	0	**1**	2	0	**1**
Private car	8	4	**6**	1	0	**0**	4	2	**3**
Motorcycle	7	1	**4**	3	1	**2**	4	2	**3**
On foot	36	59	**48**	66	82	**74**	55	74	**65**
Bicycle	7	3	**5**	16	6	**11**	13	5	**9**
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

About 44.0% of workers got vehicular transport to their workplace within fifteen minutes while 65% of the workforce commuted to their workplace on foot. This confirms the poor state of the current public transport available to production and service centres.

About 52% of workers cited bad roads as the main challenge faced in getting to their workplace. About half of respondents (51%) engaged in agricultural production were producing food crops for both the domestic market and own consumption.

Table 6.11: Main difficulties faced by the employed going to work by region, 2013 (%)

Region	No access road	Bad roads	Difficulty getting vehicle	Long waiting time	Heavy traffic on road	Distance too long	No money for transport	Other	Total
Western	20	54	6	3	9	8	0	0	100
Central	22	22	10	11	12	22	1	0	100
Greater Accra	2	51	6	8	27	3	3	0	100
Volta	29	45	2	1	1	17	2	3	100
Eastern	33	56	1	2	4	3	0	1	100
Ashanti	12	46	11	6	14	10	1	0	100
Brong Ahafo	17	71	4	3	0	3	1	1	100
Northern	35	46	2	0	0	15	2	0	100
Upper East	6	54	3	1	1	35	0	0	100
Upper West	1	69	1	0	1	27	1	0	100
Male	19	50	5	4	10	10	1	1	100
Female	18	54	6	3	6	12	1	0	100
GHANA	**19**	**51**	**5**	**4**	**8**	**11**	**1**	**1**	**100**

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

Eleven percent of the national workforce travel long distances to their workplaces, with 35% of workers in the Upper East and 27% in Upper West regions being the worst affected.

Congestion due to heavy traffic on the road was cited as the next challenge faced by workers in Greater Accra (27%) and Ashanti Regions (14%) regions, while Northern (35%), Eastern (33%) and Volta (29%) regions complained about not having access roads to their work place. Table 6.12 gives a summary of the effect of bad roads on Ghana's socio-economic activities.

Table 6.12: Effect of Bad Roads on Access to Socio-Economic Services and Activities, 2013 (%)

Region	Socio-Economic Services and Activities				% of Poor Roads
	Health	Education	Markets	Workplace	
Greater Accra	21	40	54	51	56
Ashanti	17	35	69	47	43
Central	17	15	31	22	40
Western	11	25	41	53	40
Eastern	20	28	68	56	30
Brong Ahafo	10	23	82	71	51
Volta	21	43	53	45	38
Upper East	24	53	48	54	35
Northern	32	15	40	46	41
Upper West	20	35	59	69	74

Source: Transport Survey Report by Ghana Statistical Service for Ministry of Roads and Highways, 2013

Overall supply of road transport services in Ghana is characterised by long delays and unpredictable travel schedules. The road infrastructure is currently made up of 72,405 km (inclusive of unclassified roads). Of the total, 40% is in good condition, 31% is in fair condition and 29% is in poor condition. The total national vehicle fleet, all categories combined, was 1,952,564 as of 2015. The road transport system is bedeviled by insufficient road maintenance and dilapidated condition of most of the fleet.

6.3.3 Ghana's Road Network

Existing Condition

Table 6.13 below gives the state of the road network by surface type as of 2015. Only 23% of the road network is paved and the remaining 77% is unpaved.

Table 6.13: Road Network by Surface Type by Length, 2015 (km)

Road Agency	Rigid	Asphaltic Concrete	Surface Treated	Gravel	Earth	Total Paved	Total Unpaved
GHA	39	2,356	6,672	5807	-	9,066	5,807
DFR	-	-	1,928	27,231	12,886	1,928	40,117
DUR	3	956	5,044	5,226	4,232	6,004	9,458
Total	42	3312	13,644	38,264	17,118	16,998	55,382
% Percentage	0.06	5	19	53	23	23	77

Source: Ministry of Roads and Highways

Table 6.14 shows the condition mix per region from which the national condition mix is given as 40% Good; 31% Fair; 29% Poor.

Table 6.14: National Road Condition Mix by Region, 2015

Region	Good		Fair		Poor		Total	
	(km)	(%)	(km)	(%)	(km)	(%)	(%)	(km)
Greater Accra	3,588	41	1,797	21	3,264	38	100	8,649
Upper West	2,320	49	1,438	31	939	20	100	4,697
Ashanti	4,050	41	3,005	30	2,806	28	100	9,861
Brong Ahafo	3,405	32	2,885	27	4,486	41	100	10,776
Central	1,753	32	2,255	41	1,485	27	100	5,493
Northern	3,875	39	3,654	37	2,372	24	100	9,901
Upper East	2,113	60	591	17	814	23	100	3,518
Volta	2,673	47	1,740	31	1,257	22	100	5,670
Western	3,194	40	2,735	34	2,045	26	100	7,974
Eastern	2,007	34	2,106	36	1,753	30	100	5,866
Total	28,978	40	22,206	31	21,221	29	100	72,405

Source: Ministry of Roads and Highways

The road condition from 2012-2015 is given in Table 6.15 below. Of the total road network, 60% is in fair to poor condition. This segment of the road network is due for periodic maintenance, rehabilitation and reconstruction investments. The segment in good condition has dropped from 42% in 2012 to 40% in 2015.

The maintenance backlog increased from 19,059 km in 2012 to 22,206 km in 2015, leading to an inefficient road infrastructure to support transportation of goods and services (Table 6.15).

Table 6.15: Road Network Size and Condition, 2012-2015

Indicator/ Year	2012		2013		2014		2015	
Road condition mix:	**Condition**	**Length (km)**	**Condition**	**Length (km)**	**Condition**	**Length (km)**	**Condition**	**Length (km)**
Good	42%	28,588	45%	31,978	35%	25,014	40%	28,978
Fair	28%	19,059	25%	17,766	33%	23,558	31%	22,206
Poor	30%	20,420	30%	21,319	32%	22,847	29%	21,221

Source: Ministry of Roads and Highways

Road Network Size

The classified network size increased by 3,566 km from 67,853 km in 2011 to 71,419 km in 2014. The details are given in Table 6.16.

Table 6.16: Classified Size of Road Network from 2011 - 2014

Year /Indicator	2011	2012		2013		2014	
	Total length (km)	Total length (km)	Annual km increase	Total length (km)	Annual km increase	Total length (km)	Annual km increase
Trunk Roads	13,263	13,477	214	14,873	1,396	14,874	1
Urban Roads	12,400	12,400	0	14,000	1,600	14,500	500
Feeder Roads	42,190	42,190	0	42,190	0	42,045	-145
Total Network	**67,853**	**68,067**	**214**	**71,063**	**2,996**	**71,419**	**356**

Source: Ministry of Roads and Highways

National Vehicle Fleet and Operational Issues

The total national vehicle fleet in all categories is 1,952,564 as of end-2015. A total of 861,039 vehicles (44.1%) are roadworthy. The remaining 55.9% of the vehicle fleet are not fit to be used on the road network (Table 6.17). The Driver and Vehicle Licensing Authority (DVLA) is embarking on re-registration of all roadworthy vehicles for all categories from 2017 to enable a correct estimation of the vehicular fleet in the country. This will also enable proper estimation of the fatality indices.

Table 6.17: Vehicle Fleet and Driver Information, 2010 - 2015

Year	Driver Licensing (In-Traffic Test)			Driver Licensing (Written and Theory Test)			Road Worthy		
	No. Tested	% Passed	% Failed	No. Tested	No. Passed	No. Failed	No. Vehicles Registered	Cumulative No. Registered Vehicles	No. Road Worthy
2010	110,877	79	21	104,975	69,685	35,290	102,330	1,230,468	748,219
2011	127,827	75	25	125,957	77,440	48,517	141,819	1,372,287	839,767
2012	126,935	71	29	124,252	69,956	54,296	159,793	1,532,080	931,690
2013	97,383	70	30	109,899	57,461	52,438	176,878	1,708,958	1,003,673
2014	66,160	69	31	113,183	49,537	63,646	132,014	1,840,972	886,269
2015	25,515	71	29	85,129	45,774	39,355	111,592	1,952,564	861,039

Source: Driver and Vehicle Licensing Authority

Most of the vehicles in the country are 'used vehicles' imported from mainly European countries. The average age of these imported vehicles is 10–20 years. The high rate of emission and accidents experienced on the roads are mainly due to the high proportion of vehicles that are not roadworthy, coupled with the poor road condition.

6.4 Ghana's Road Infrastructure Indices

6.4.1 Overview

Table 6.18 presents some indices used to establish the road infrastructure deficit.

Table 6.18: Comparison of Current Road Infrastructure Indices with some Upper Middle- and High-Income Countries, 2015

Country	Population x1,000,000	Land Size Area (Sq.km)	Classified Road Network Size (km)	Road Density	Total Length of Paved Road (km)	Ratio - Paved Road To Network	Rural Accessibility Index (RAI) - %
Australia	23.13	7,692,000	823,217	0.107	356,343	0.43	Not Available
Denmark	5.614	42,925	73,929	1.722	73,929	1	99
Qatar	2.169	1,157	9,830	0.849	9,830	1	81
Singapore	5.399	719.1	3,425	4.76	3,425	1	Not Available
South Korea	50.22	100,210	106,414	1.06	83,000	0.78	89
Saudi Arabia	28.83	2,150,000	221,374	0.102	47529	0.21	75
China	1,327	9,597,000	4,500,000	0.463	3453890	0.77	97
Trinidad & Tobago	1.341	5,131	8,320	1.621	4,068	0.66	91
Oman	3.632	309,501	69,783	0.225	29,685	0.43	81
U.K.	64.1	242,900	394,428	1.624	394,428	1	96
Ghana – Existing	**25.9**	**238,535**	**71,419**	**0.299**	**16,998**	**0.23**	**61**
Ghana – Proposed 2057	**57**	**238,535**	**285,000**	**1.2**	**256,000**	**0.9**	**90**
Ghana Deficit	**31.1**	**-**	**213,581**	**0.9**	**239,000**	**0.67**	**23.4**

Source: Author's construct based on World Bank, World Development Indicators, 2015

The deficit in Ghana's road infrastructure compared to some upper middle-income and high-income countries is seen in the last row of Table 6.18. Taking the case of South Korea, its road density is 1.06 but its land area is 40% of Ghana, and its population is almost twice that of Ghana.

Road density is the ratio of the length of the country's total road network to the country's land area. The road network includes all roads in the country: motorways, highways, main or national roads, secondary or regional roads, and other urban and rural roads.

Considering Ghana's population density, land size and the fact that every part of the country is habitable and in active economic use, the desired road density to enable the country to attain high-income status is 1.2. This means that for the next 40 years, the road network size needs to increase from almost 72,000 km to 285,000 km. The paved segment of the network will increase to 256,000 km and the Rural Accessibility Index (RAI) should increase from current level of 61% percent to 90%.

Comparing the 40-year target of 285,000 km with other countries

The road density based on a network size of 285,000 km is almost like the current average for upper middle-income countries. For example, according to the World Bank, in 2009, the total length of roads in Ghana was 962 km per 1,000 km^2 of land area with 158.1 km (16%) paved and the remaining 804 km unpaved. The middle-income country (MIC) equivalent was 1,545.7 km per 1,000 km^2 of lands of which 507.4 km (33%) was paved and the remaining 1,038.3 km not paved. If Ghana aims for the MIC average of 1,545.7km/1,000km^2 by 2057 then the country's total road network should be 368,536 km. Similarly, the United Kingdom has the same land area as Ghana and more than twice the population, and has a paved road length of 394,428km.

If Ghana reverses the current urban sprawl, adopts dense and compact settlement systems, and leaves a large part of its rural area for agriculture, the country should be able to suffice with 285,000km of roads transiting into the high-income bracket. With this number, most of the Ghanaian roads that are outside the classification system would be brought to the formal classification system, paved and tolled wherever possible.

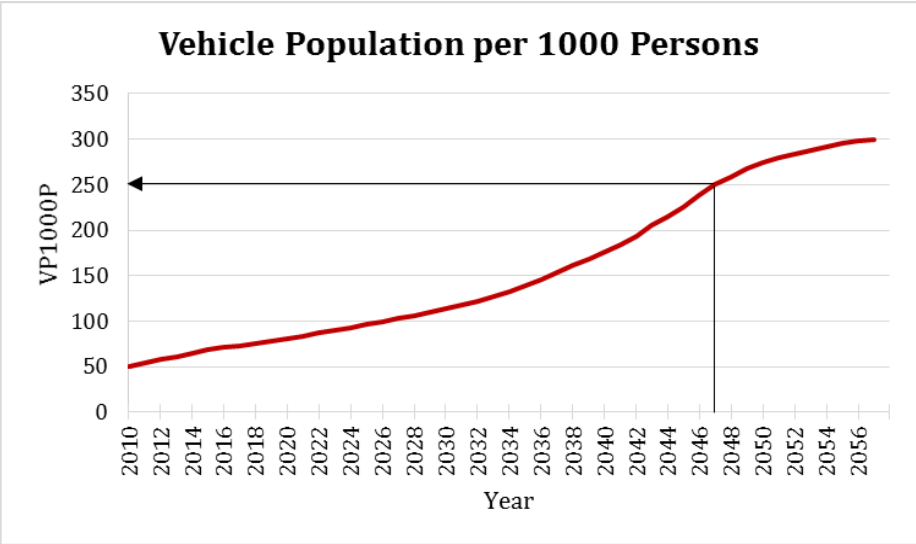
6.4.2 Vehicle Population per 1000 Persons (VP1000P)

The vehicle population in 2014 was 1.885 million for all categories of vehicles. The vehicle population per 1,000 persons (VP1000P) is one of the indicators used to determine the standard of living of the populace. The population of Ghana as of 2014 was 26.5 million, with a vehicle population of 1.885 million. The VP1000P was therefore 71.13 (i.e. 1,885,000/26,500 = 71.13) as of 2014. This meant that for every 1,000 people, 71 vehicles were available to them. Vehicle refers to cars, light, medium and heavy-duty trucks, and buses but does not include off-road vehicles or heavy construction equipment.

In 2014, the average number of vehicles available for every 1,000 people in high-income countries was about 600. It is expected that by 2057, Ghana will use more mass transport and therefore the country will adopt the decision to achieve a VP1000P of 300, which is half of the current average for high-income countries.

The GIP horizon is up to 2047. Ghana's population is projected at 50.7 million by 2047. It is expected that by 2047, Ghana VP1000P will be 250, meaning the vehicular population will be equivalent to a quarter of the population. Figure 6.1 gives the targeted VP1000P by 2047.

Figure 6.1: VP1000P Projections for Ghana



Source: Author's construct

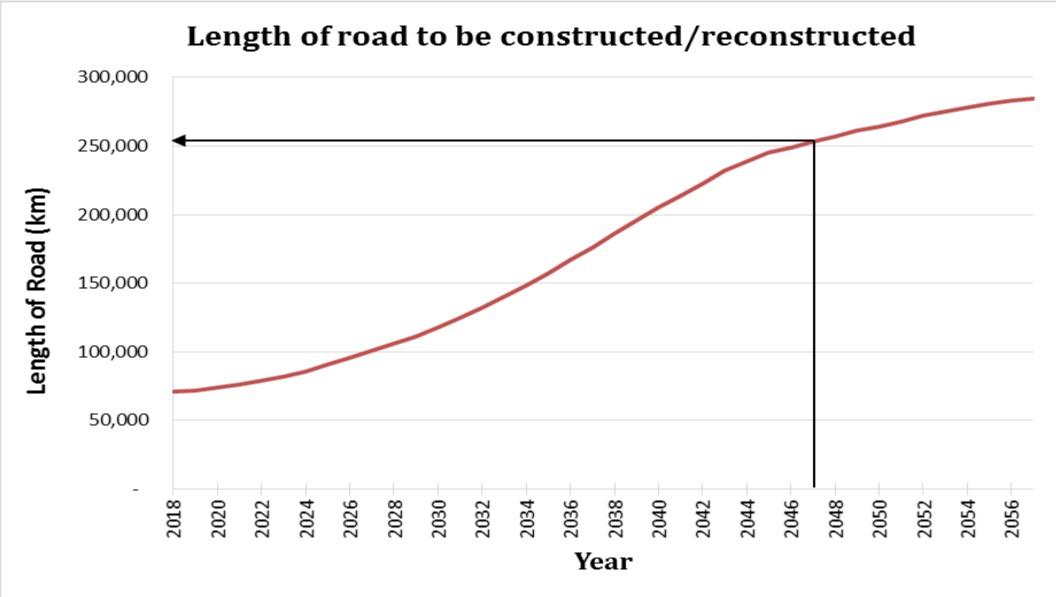
Ghana should also enter the automobile manufacturing industry, which is expected to boom in the coming years. US automobile industry research estimates that as of 2010, there were 1.015 billion motor vehicles in use in the world. The world vehicle population passed the 500 million-unit mark in 1986, from 250 million motor vehicles in 1970. Between 1950 and 1970, the vehicle population doubled roughly every 10 years. Two US researchers estimate that the world's fleet will reach 2 billion motor vehicles by 2020, with cars representing at least 50% of all vehicles. By 2047, the number of vehicles globally will exceed 4 billion, and Ghana should by then have developed the capacity to manufacture some of these vehicles.

6.4.3 Projected Road Network Size by 2047

From the foregoing, if the size of the network in 2057 is 285,000 km then the size of the network by 2047 should exceed 253,000 km.

It will include a combination of various levels of roads, motorway (expressway), high - speed dual carriageways, four-lane roads, and two-lane roads. The road network will be expanded from 72,000 km to 253,000 km in 30 years (Figure 6.2) further broken down in Table 6.19. Basically, about 177,000 km of new roads will be constructed or reconstructed during the development phase. This does not include roads under maintenance or rehabilitation.

Figure 6.2: Cumulative Length of Roads to be Constructed or Reconstructed



Source: GIP Team

Table 6.19: Breakdown of Roads by Type for the Plan Period

Road Type	Motorway/ Expressway	High Speed Way (4-Lane)	4-Lane	2-Lane (High Standard)	2-Lane	Total
Trunk Roads						
Paved (km)	2,240	8,288	9,432	20,720	-	40,680
Unpaved (km)	-	-	-	-	15,920	15,920
Sub-Total (km)	**2,240**	**8,288**	**9,432**	**20,720**	**15,920**	**56,600**
Feeder Roads						
Paved (km)	-	-	-	101,540	-	101,540
Unpaved (km)	-	-	-	-	55,160	55,160
Sub-Total (km)	**-**	**-**	**-**	**101,540**	**55,160**	**156,700**
Urban Roads						
Paved (km)	285	3,298	10,449	20,748	-	34,780
Unpaved (km)	-	-	-	-	4,920	4,920
Sub-Total (km)	**285**	**3,298**	**10,449**	**20,748**	**4,920**	**39,700**
Total Network						
Paved (km)	2,525	11,587	19,880	143,008	-	177,000
Unpaved (km)	-	-	-	-	76,000	76,000
Grand Total Length of Roads (km)	**2,525**	**11,587**	**19,880**	**143,008**	**76,000**	**253,000**

Source: Author’s construct

Table 6.20 below shows the regional distribution of roads. In arriving at this breakdown, weighted scores were apportioned to each region based on its population density, coverage area, length of roads in poor condition and the percentage of population below poverty line. In order to ensure uniformity, the weighted score for the population density was higher (45%), followed by coverage area (25%), the length of roads in poor condition (20%) and lastly, the percentage of population below poverty line (10%). The total length of roads for each region by 2047 is the product of the average weighted score for each region and the total road network expected to be in place by 2047 (253,000 km), slightly modified to ensure equity in distribution.

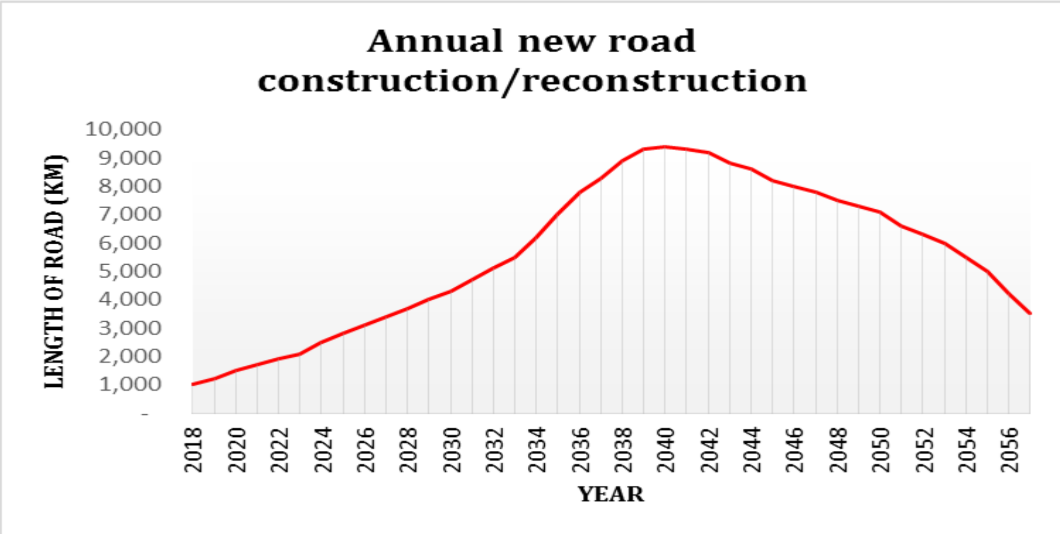
Table 6.20: Regional Breakdown of Total Length of Road Network by 2047

Region	Area (sq.km)	Population (2010)	Population Density	Total Length of Roads, 2015 (km)	Length of roads in poor condition, 2015 (km)	Road Density	Percentage of Population below poverty line	Total Length of Roads by 2047 (km)
Greater Accra	3,245	4,010,054	1,236	8,650	4,677	2.67	43	30,170
Central	9,826	2,201,863	224	5,492	2,460	0.56	40	19,389
Ashanti	24,389	4,780,380	196	9,861	6,198	0.40	51	36,203
Eastern	19,323	2,633,154	136	5,866	3,650	0.30	40	26,025
Upper East	8,842	1,046,545	118	3,518	2,585	0.40	71	15,653
Volta	20,570	2,118,252	103	5,671	1,656	0.28	30	20,117
Western	23,921	2,376,021	99	5,671	4,997	0.24	56	27,654
Brong Ahafo	39,557	2,310,983	58	10,776	2,527	0.27	38	26,871
Upper West	18,376	702,110	38	4,697	4,852	0.26	41	16,811
Northern	70,384	2,479,461	35	9,901	1,356	0.14	35	34,107
							Total	**253,000**

Source: Author's construct

The estimated length of road to be constructed or reconstructed each year to meet the network size target of 253,000km is shown in Figure 6.3.

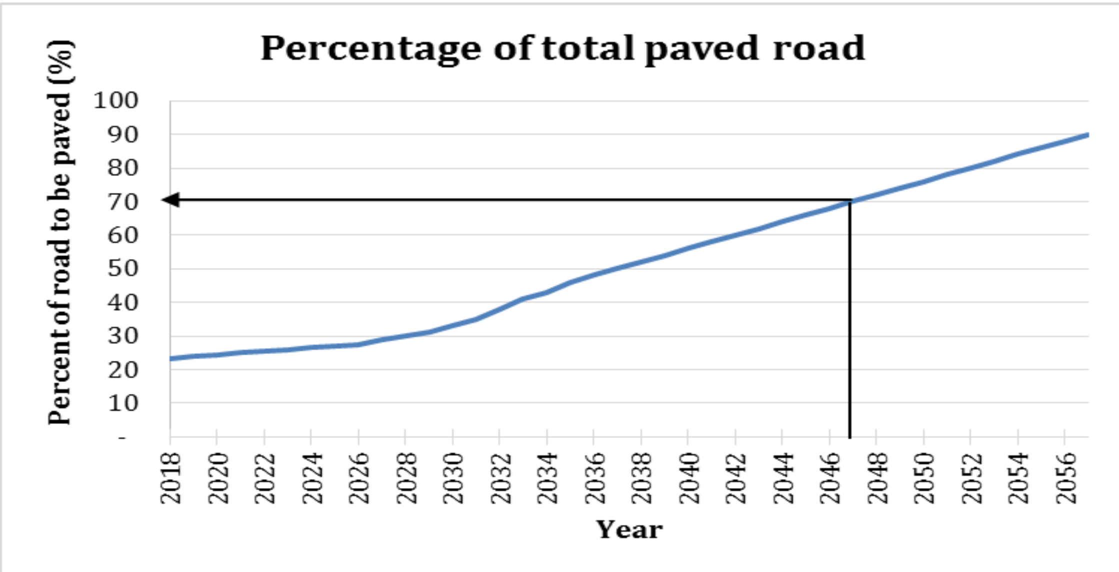
Figure 6.3: Annual New Road Construction or Reconstruction



Source: GIP Team

The percentage of paved roads will increase from the current 16,000 km, being 23% of the network size to 177,000 km, which is 70% of the network by 2047 (Figure 6.4).

Figure 6.4: Percentage of Total Paved Road



Source: GIP Team

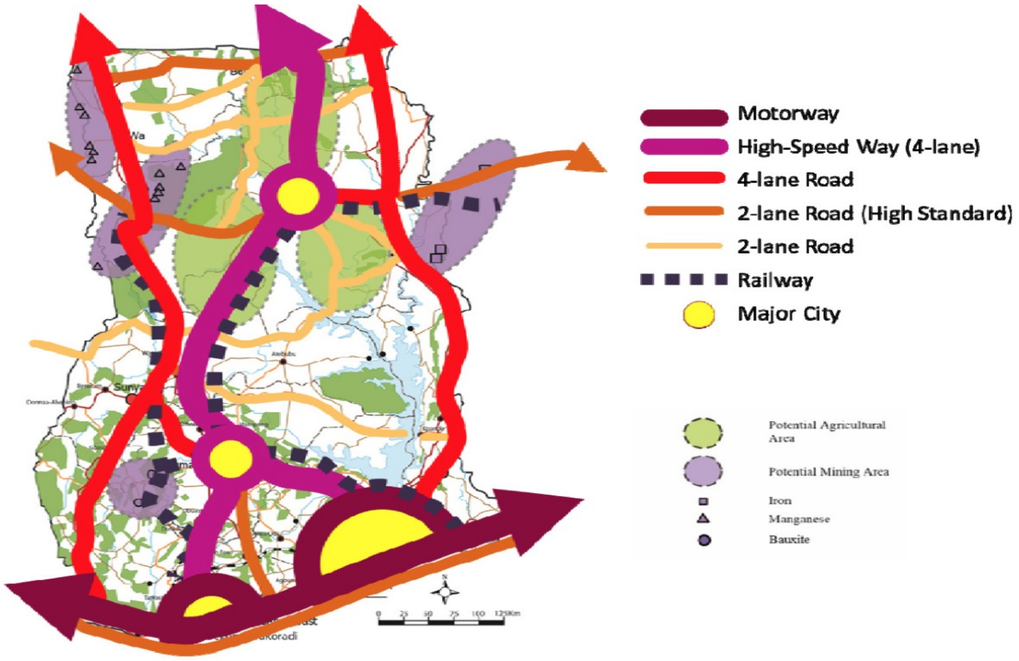
6.4.4 Conceptual Framework of Ghana's Road Development

The conceptual framework of Ghana's road sector is based on the following long-term goals:

i. Establish physical and economic sub-regional integration with neighbours;
ii. Develop diverse economic sectors targeting sub-regional, regional and international markets;
iii. Widen development in the country to improve the living standard of the people;
iv. Secure high-speed transport corridors in order to attract investment in economic sectors.

The conceptual corridor framework for the planning period is shown in Figure 6.5.

Figure 6.5: Spatial Concept of Ghana's Road Development



Source: The Project on Corridor Development for West Africa Growth Ring Master Plan, Draft Final Report, 2017

National and International Expressway System

The National Spatial Development Framework (NSDF) proposes a national expressway system, in addition to the upgrading of highways and new segments. A national expressway system will be beneficial to the economy as it will meet the growing demand for connectivity and mobility, and improve the quality of life of the citizenry. In countries where the expressway system has been implemented, there has been improved productivity and economic efficiency. The highways to be upgraded include the two Trans-African Highways that run from east to west (along the coast) and from north to south.

A number of other segments are proposed, including, *inter alia*:

i. The Accra-Kumasi Expressway (as Phase 1 of the Ghana African Highway Link Accra–Ouagadougou);
ii. The Kumasi-Paga expressway (as the Phase 2 of the Ghana African Highway Link Accra–Ouagadougou);

iii. The Sunyani Loop (Kumasi-Sunyani-Techiman);
iv. The Accra City Region Expressway;
v. ECOWAS Trans-West African Coastal expressway.

There will also be focus on northern Ghana to improve connectivity with current and new trunk roads to:

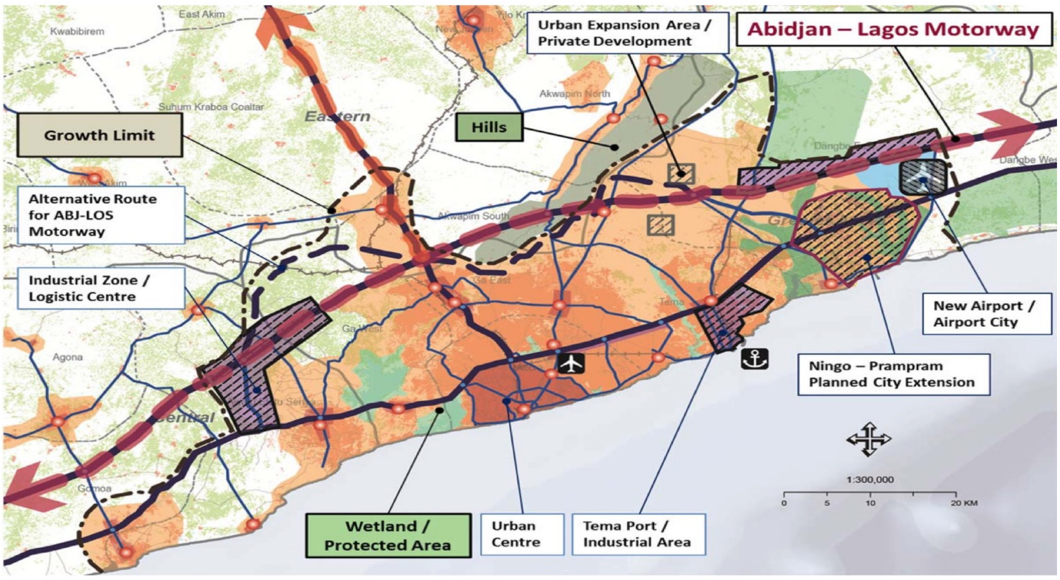
i. Improve SADA trunk road system;
ii. Improve connectivity with new and improved trunk roads;
iii. Create and implement strong urban growth containment policies to ensure dense and compact settlements, and prevent sprawling;
vi. Create new urban settlements at the midpoint of two intersecting trunk roads between Yapei and Tamale.

Conceptual Spatial Structure for Greater Accra

Under the new expressway system, the conceptual spatial structure for Greater Accra is shown in Figure 6.6. The future spatial structure contains the new Abidjan-Accra-Lagos motorway, a new international airport and airport city in Prampram. The new road, the Abidjan-Accra-Lagos motorway will function as part of the outer ring road for Greater Accra and it will be parallel to the Kwame Nkrumah motorway (N1).

A strong connection will be developed between the Abidjan-Accra-Lagos motorway and north-south corridors (Central Corridor and Eastern Corridor). Similarly, a strong link will be established from Tema Port to the north-south corridors (Figure 6.6).

Figure 6.6: Spatial Concept of Greater Accra Region



Source: The Project on Corridor Development for West Africa Growth Ring Master Plan, Draft Final Report, 2017

6.4.5 Developing the Ghanaian Construction Industry

Infrastructure is the lifeblood of prosperity and economic confidence. Successful delivery of well-planned infrastructure investments offers developing economies an opportunity to compete in the global marketplace. Construction is the activity through which infrastructure is delivered. Aside this key role, the construction industry also contributes to the development of nations through forward and backward linkages with other sectors and industries of the economy.

By forward linkages, the output of the construction industry serves as inputs in other industries. For instance, construction output including all types and forms of infrastructure like buildings, roads and dams are used as inputs by the financial, transport, energy and industries sectors. Backward linkages, on the other hand, relate to growth in industries that supply construction inputs – i.e. manufacturing companies – to the growth of the construction industry. In fact, almost every economic activity is linked with the construction industry. Therefore, the growth and development of any economy is directly or indirectly connected with the construction industry.

Concerns about the capacity and capability of Ghana's construction industry in the handling of not only this huge road programme but also other areas of construction are addressed with the establishment of a regulatory body. Issues relating to building the absorptive capacity, equipment and financial capacity, personnel (high-level, middle-level and skilled manpower), construction materials and the regulatory framework are all addressed in the report of the construction industry.

Construction Materials

A huge array of road construction materials will be developed as part of the impending boom. These include limestone, cement, steel, quarrying materials, laterite, and asphalt and bitumen.

- Steel - Ghana has enough iron ore deposits to drive its industrialisation and infrastructure development through to high-income status. Considering the relationship between urbanisation, infrastructure and steel, there is scope for steel production in Ghana. The steel-intensive nature of infrastructure will drive the creation of vast steel production capacity in Ghana.
- Developing Asphalt and Bitumen Plants - Asphalt and bitumen plants will be established throughout the country to advance this ambitious road construction drive.

Building the Capacity of Construction Industry Professionals

High and middle-level Ghanaian professionals will be educated and recruited to lead in the design and construction works, while lower level skilled manpower will be trained and certified to address the skill needs of the sector.

6.5 Trunk Road Development

6.5.1 Overview

The Ghana Highway Authority (GHA) has a long-term vision of producing and maintaining road networks in the country that will contribute to equity and balance in socio-economic development. Through research, the road sector has established a road condition mix of 70% good, 20% fair and 10% poor as the most economical mix that will bring movement of people and freight around the network at the lowest vehicle operating costs.

The main focus is the maintenance of the existing trunk road network (routine and periodic maintenance). The maintenance portfolio will be further assessed to help increase the funding capacity of the Road Fund to meet the road maintenance funding requirement.

Corridor Development

In the area of development works, GHA has prepared the Corridor Programme and prioritised it in Phases 1 and 2. During this period, the missing links of the trunk road network will be constructed.

In this direction, the Authority has carefully selected lateral corridors within the country for development. The other categories of road sections to be developed and maintained are based on traffic volume, cocoa-growing areas and tourist sites. Figure 6.7 shows the GHA Road Plan for the period 2015 to 2035.

Figure 6.7: Ghana Road Plan (2015 – 2035)

Source: GHA Strategic Plan (2015-2035)

Priority Corridors

Some road sections are critical to the socio-economic development of the country. The development of the following priority corridors will facilitate trade and movement of goods and services within the West African Sub-Region.

Table 6.21: Priority Corridors

Corridor	Road Section
Coastal	Noepe–Akatsi–Sogakope–Accra–Takoradi–Elubo
Central	Accra–Kumasi–Techiman–Tamale–Bolga
Eastern	Tema–Asikuma–Hohoe–Kejebi–Yendi–Kulungugu
Western	Western: Elubo–Enchi–Sunyani–Bamboi–Sawla–Wa–Hamile
Northern	Lawra–Lawra-Han–Tumu–Navrongo–Bolga–Bawku–Polimakon

Source: Ghana Highway Authority

New Corridor Programme

The new lateral corridors across Ghana linking Togo to Cote d'Ivoire to be developed based on equity in socio-economic development across the country are the following:

i. Upper East – West
ii. Northern East – West
iii. Central East – West
iv. Lower East – West

Table 6.22: Corridor Development

Road Type	Maintenance	Development (Corridor Projects)	
Trunk Road	Routine	1st Priority	2nd Priority
	Periodic	Coastal corridor: Aflao- Elubo Central corridor: Accra-Kumasi- Paga Eastern corridor: Tema -Yendi-Kulungugu Western corridor: Enchi-Sunyani-Hamile Northern corridor: Lawra-Wa-Bolga-Polmakrom	Upper – East –West Northern–East – West Middle –East –West Lower-East-West

Source: Ghana Highway Authority

Public Private Partnership (PPP) Programme

The following road sections have been registered under a PPP programme in the Plan:

i. Accra – Tema Motorway
ii. Accra – Takoradi
iii. Accra – Kumasi
iv. Tema – Akosombo – Anyirasewase
v. Tema – Sogakope
vi. Kumasi – Sunyani
vii. Kumasi – Anwiankwanta
viii. Takoradi – Agona Junction
ix. Mamfe – Koforidua – Bunso

Missing Links

During this period, GHA will construct all the missing links on the trunk road network. Table 6.23 gives details of all the missing links.

Table 6.23: List of Missing Links on Trunk Road Network

S/No.	Route No.	Road Section	Length (km)
1	N12	Kramokrom – Akontombra	11
		Sub Total	**11**
2	IR7	Ejura – Taylor	22
3	IR7	Kyirenkye -Anyinofi - Sabuso	38
4	IR7	Apapaso – Sabuso	6
5	IR7	Sabuso –Asayanso	40
		Sub Total	**106**
6	IR10	Gbasinkpa - Mankarigu	71
7	IR11	Mishuo – Kunka	71
8	R92	Nawuni – Mankarigu	40
9	R29	Nakpali – Chichagi	70
10	N9	Juanayili - Chambuligu	87
		Sub Total	**339**
11	R34	Begoro – Mpraeso	50
12	R41	Asikuma – Akoroso	41
13	IR7	Asayanso - Donkorkrom	57
		Sub Total	**148**
14	IR9	Jinini - Banda Ahenkro	30
15	R74	Apapaso – Mframa	35
		Sub Total	**65**
		GRAND TOTAL	**670**

Source: Ghana Highway Authority

Heavily Trafficked Roads

The capacities of the roads will be improved during this investment period (Table 6.24).

Table 6.24: Heavily Trafficked Roads Earmarked for Widening

No	Road Sections	Length (Km)	Remarks
1	Aflao-Denu	68	Asphalt surface in good state
2	Akatsi- Ziope	38	Surface dressed in good state
3	Denu-Ho	100	Surface dressed, needs partial reconstruction
4	Dawhenya-Akpablabanya	41	
5	Dawhenya-Afienya-Dodowa	48	Surfaced dressed section awarded
6	Adenta-Dodowa-Kpong	55	Surfaced dressed, needs asphalt dual carriage way to Dodowa
7	Adenta-Mamfe-Koforidua	58	Adenta to Mamfe is in good state. Mamfe to Koforidua is surfaced dressed but needs partial reconstruction
8	Effiduase-Bunso Road	154	Surface dressed, needs partial reconstruction
9	Winneba –Agona Swedru-Akroso	50	Surface dressed, needs resealing
10	Mankessim-Agona Swedru-Adeiso	90	Surface dressed, needs partial reconstruction
11	Nsawam-Adeiso-Asamankese-Kade	82	Surface dressed, needs partial reconstruction
12	Yamoransa-Anwiankwanta	153	Yamoransa-Assin Praso needs an asphalt overlay. Assin Praso to Bekwai is in good state.
13	Bekwai-Ejisu-Effiduase-Kumawu	29	
14	Kumawu-Agogo	28	Surface dressed in good condition
15	Cape Coast-Twifo Praso	71	Surface dressed in poor condition
16	Nkawkaw-Donkawkrom-Ntoaboma	113	
17	Agona Junction-Tarkwa-Bogoso-Asankragwa	59	Agona Jn – Tarkwa -Bogoso (93km) Asphalt Concrete (AC) in good condition under EU support
18	Diaso-Buako	67	
19	Asawinso-Sefwi Bekwai	26	

No	Road Sections	Length (Km)	Remarks
20	Abuakwa-Bibiani	77	AC wearing course completed under EU support 2003
21	Abuakwa-Sunyani	109	Old AC earmarked for rehabilitation
22	Mankraso-Tepa	45	
23	Goaso- Kyeremaso	64	
24	Berekum –Sampa	82	

Source: Ghana Highway Authority

Bypass to ease Traffic

The by-pass routes (Table 6.25) will be constructed during the period of investment.

Table 6.25: By-Pass Development on the Trunk Road Network

S/No	Sections	Remarks
1	Kumasi Bypass	Central Corridor
2	Konongo Bypass	
3	Tamale Bypass	
4	Bolga Bypass	
5	Cape Coast Bypass	Coastal Corridor
6	Takoradi Bypass	

Source: Ghana Highway Authority

6.6 Urban Roads Development

6.6.1 Overview

Investment on the urban road network will be mainly towards arterial development for movement of large volume of traffic in the shortest possible time. This will be complemented with the construction of interchanges to reduce traffic conflicts currently being experienced on the urban arterial network. The urban road investment will address the collector distribution segment of the urban network.

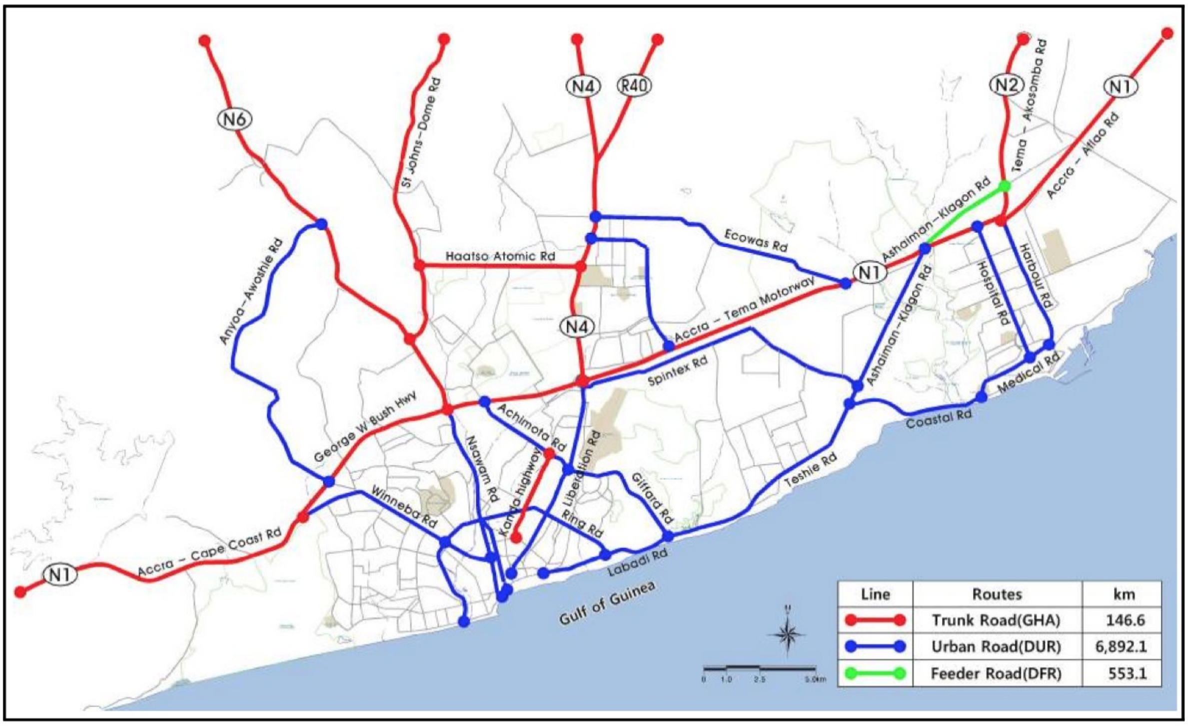
6.6.2 GAMA Road Transport

GAMA's Road Network

Accra, the capital city of Ghana, is considered one of the most populated and fastest growing cities in Africa. It is also the seat of the Greater Accra Metropolitan Area (GAMA). With an urbanisation rate of about 4.41%, GAMA is characterised by high population growth, resulting in a rapid sprawl of settlements and increasing daily inflow and outflow of people due to the commercial and service functions that the metropolis serves

GAMA has road networks consisting of trunk roads (shown in red in Figure 6.8) which connect the various regions, regional capitals and neighbouring countries, and urban roads (shown in blue in Figure 6.8) which link the various suburbs within the region.

Figure 6.8: Current Road Network in GAMA

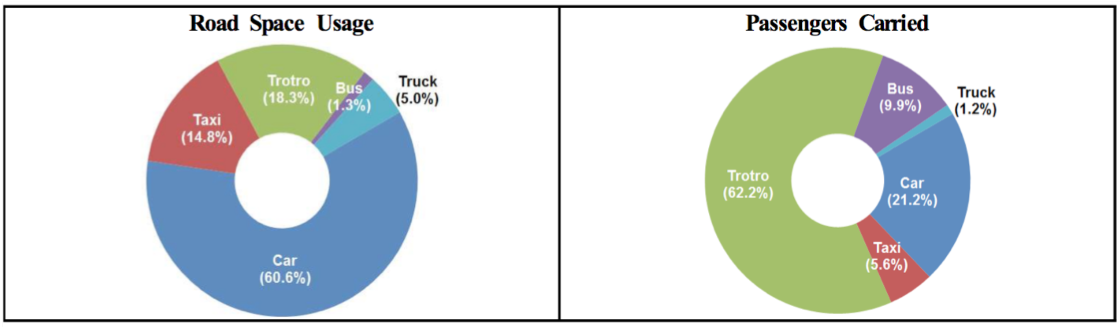


Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

Public Transport System

In GAMA, public transport is operated largely by informal operators with a mix of vehicles and mini-buses with capacities ranging from 15 to 23 passenger seats, popularly known as *trotro*. In GAMA, *trotro* account for the largest modal share of over 62.2%, making it the most patronised mode of transport. Even though the *trotro* mode of transport is the most widespread, *trotro* road space usage is rather low. *Trotro* use just 18.3% of the road space (Figure 6.9).

Figure 6.9: Modal split of vehicles on arterial roads in GAMA

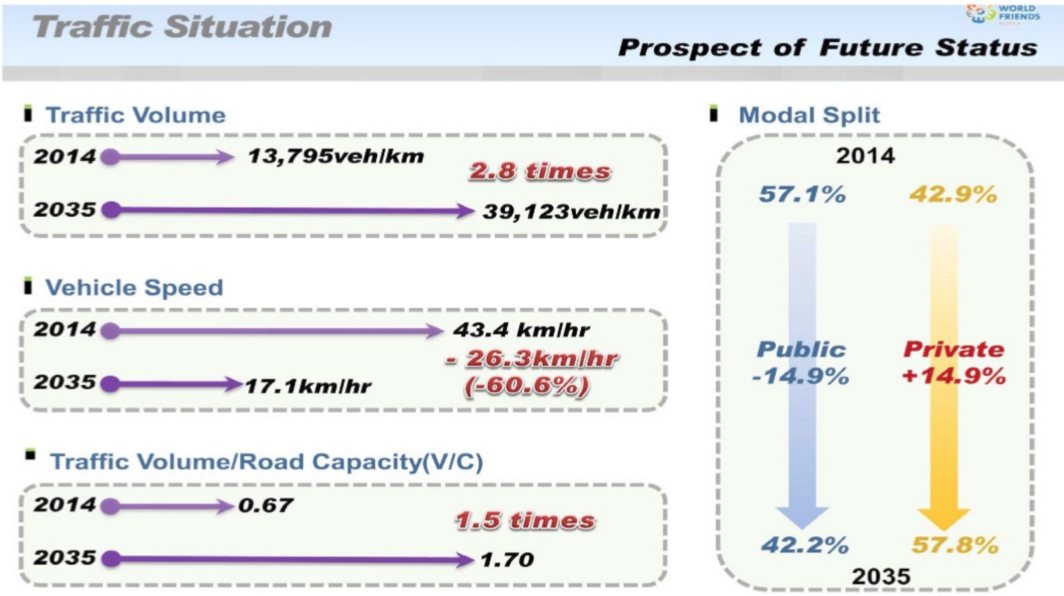


Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

Traffic Situation

Figure 6.10 below shows a volume of about 13,795 vehicles per kilometre, although the total volume of vehicles per day is about 43,962. At a total average growth rate of about 4.5%, the average traffic volume is expected to increase by about 2.5 times by the end of 2035 (from 43,962 vehicles/day in 2014 to 110,745 veh/day in 2035), and the total vehicle per kilometre travel will also increase by about 2.8 times, from 13,795 in 2014 to 39,123 in 2035. The average vehicle travel speed is likely to decrease from 43.4 km/h in 2014 to 17.1 km/h in 2035 within GAMA, and 40.7 km/h in 2014 to 7.3 km/h in 2035 within the capital city itself. In spite of the increasing private ownership of vehicles within the metropolis, a greater percentage of the population still relies on public transport systems owing to low income levels and the absence of alternative modes of transport within the metropolis, and GAMA could capitalise on this to develop a more flexible public transport system.

Figure 6.10: Traffic Situation in GAMA



Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

This increased traffic volume and decreased travel speed will lead to severe traffic congestion on every road within GAMA, resulting in a huge social cost and eventually causing GAMA's competitiveness as a city to dwindle greatly.

It is therefore imperative that road networks be expanded to match the ever-increasing sprawl of the metropolis. With lessons from other megacities from around the world (e.g. Seoul Metropolitan, London, Jakarta, Greater Tokyo, etc.), it will be expedient for GAMA to consider constructing and operating a more competitive public transit system.

Traffic Conditions and Target of GAMA

Table 6.26 shows the prevailing reality against the targets that GAMA desires to attain by the end of the plan period. These targets have been projected in comparison to average public transport performance in some major cities around the world.

Table 6.26: Transport Conditions and Target of GAMA

Class		GAMA's Status	GAMA's Target	Remarks
Public Transport	Road fleet (vehicle)	148 veh (6%)	2,400 veh	Introduce big bus
	Bus Route (km)	0 km (0%)	246 Km	Physical obstacles or real time enforcement bus route
Road Length (km)		7,592 km (42%)	18,592 Km	Major reason of congestion
Urban density (persons/ha)		31.6% (73%)	Transit Oriented Development	Urban structure of low density (Sprawl)
Registered vehicle (vehicles)		0.89 mil (341%)	▼ 0.63 mil	Increasing the public transport usage
Public transport (journeys/persons)		52.1% (49%)	Transit Oriented Development	Hub and Spoke, Improve public transport

Source: The Transport Masterplan Project in Greater Accra, 2016

Hub Terminal and Transfer Facilities

The CBD and its environs tend to experience high transport demand. It is recommended therefore, that approximately 3 arterial bus routes be placed along that corridor. The starting points of any additional routes will serve as the hub of the surrounding areas. Therefore, the hubs at the outskirts and the CBD's hub will serve as the terminals, while points of interchange between *trotro* routes could serve as transfer facilities. With this in mind, GAMA has identified 13 hub terminals and 11 transfer facilities within the metropolis (Figure 6.11).

It is envisioned that a hub terminal should have the appropriate amenities (suitable transfer facilities, sufficient bus garage space etc.). These hub terminals will be built as complexes, with shopping malls, hotels, offices and so on, using PPPs.

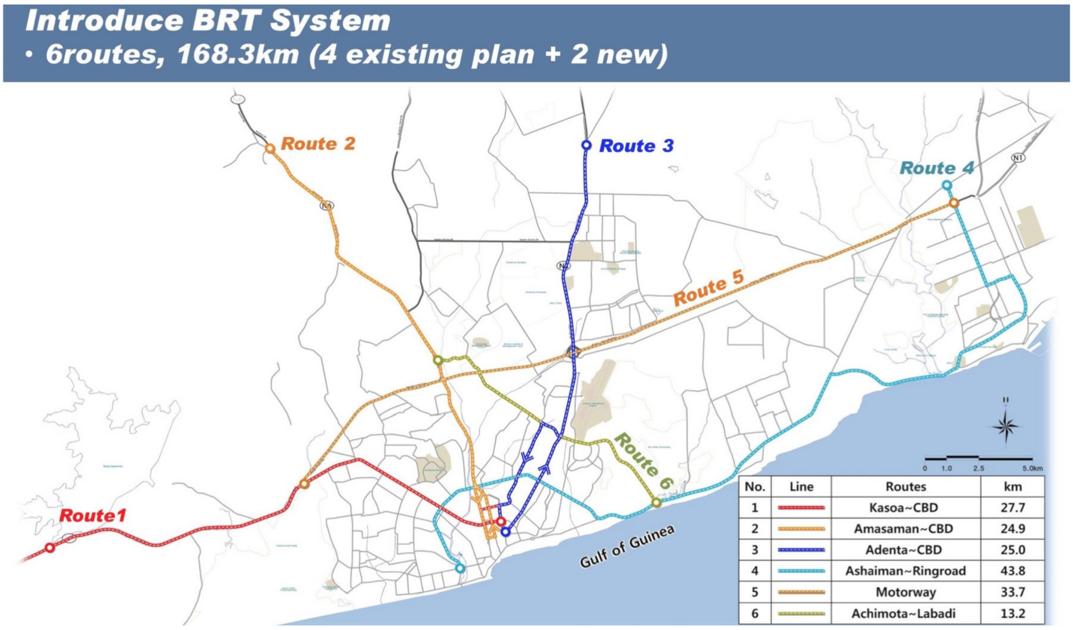
Figure 6.11: Hub Terminals and Transfer Units

Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

Bus Rapid Transit (BRT) System

The introduction of the BRT system is to increase users of public transport systems within GAMA, by making travel by bus efficient enough to dissuade users from switching to private vehicles. Given that private vehicles provide door-to-door trips to vehicle owners, the BRT should therefore be competitive enough to retain its users. In order to achieve this objective, the main factor to consider in developing BRT systems is to ensure that bus journey times are comparable to those of private vehicles.

Figure 6.12: BRT System



Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

The prospect of introducing a BRT system in GAMA has been considered for many years. However, due to many constraints, full implementation has been delayed. Six (6) major routes have been identified:

- Route 1: Amasaman to Tudu in the CBD;
- Route 2: Aburi Road through Independence Ave. to CBD;
- Route 3: Tema Community 1 through Teshie-Nungua, Kwame Nkrumah Circle to CBD;
- Route 4: Winneba Road to UTC;
- Route 5: Sowutuom, Santa Maria to CBD;
- Route 6: Awoshie to Kwame Nkrumah Circle.

However, the absence of exclusive bus lanes has also greatly constrained the full implementation of BRT systems within the city.

Improvement of Bus Systems

In the quest to improve the quality of life of the citizens of GAMA, as well as enhance the competitiveness of the metropolis, the city needs to adopt the *"hub and spokes"* system, where major *trotro*/bus terminals function as hubs, while small terminals along roads or in residential areas serve as the spokes that link passengers to these hubs.

Table 6.27: Improvement for Public Transport

Improvement for Public Transport ***• BRT + Arterial Bus + Hub Terminal + Transfer Facility***					
Improvement Item		***Short-term***	Mid-term I	Mid-term II	Total
BRT (length)		***Adenta~CBD, Amasaman~CBD***	Motorway Kasoa~CBD	Ashaiman~Ringroad Achimota~Labadi	6 routes
		49.9km(24.9km)	61.4km	56.7km	168.3km(24.9km)
Arterial Bus (length/bus)		***Line 2-1, 2-2 Line 3-1, 3-2***	Line 1, 2-3 Line 4-1, 4-2	Line 4-3, C-1, C-2, Line C-3	12 lines
		71.5km / 158(85)	122.6km / 177	98.3km / 146	292.4 / 478(85)
Hub Terminal		***(Amasaman, Ofankor) Adenta, Madina, 37Lorry***	Kasoa, Sowutuom Community1, Sakaman	Ashaiman, Circle, Kaneshie, 37Lorry (Achimota)	13 hub terminals (3)
Transfer Facility		***5 facilities***	3 facilities	3 facilities	11 transfer Facilities

( ) Existing Facilities or Vehicles

Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

In order to achieve this, some reforms need to be made in order to make the public transport system within the city more competitive. Such reforms include the creation of a total of 12 arterial bus networks, to serve as major public transit networks. Big arterial buses will therefore be commissioned to ply the arterial roads, while the *trotro* connect routes from residential areas to these arterial roads.

The short-term investment for the GAMA project is about US$94 million. The cost breakdown is given in Table 6.28.

Table 6.28: Funding Required for Short-Term Investment

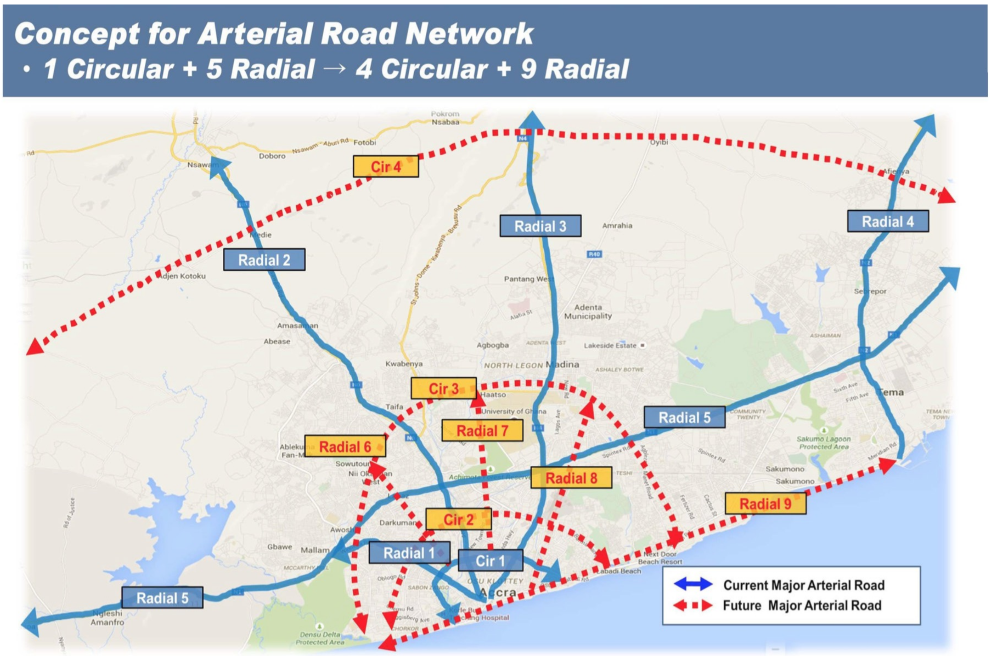
Category		**Unit**	**No. of items**	**Cost (1,000 USD)**	**Remarks**
BRT	Exclusive lane & station	Km	25	54,642.90	MRH
	Transfer Facility	Spot	4	3,099.50	
	Plan & Design	Set	1set	2,887.10	
	Total			60,629.40	
Hub Terminal	Adenta Terminal	ml	4,723	4,567.80	
	Madina Terminal	m2	4,006	3,874.30	
	Plan & Design	Set	1set	422.1	
	Total			8,864.18	
TSM	Traffic Signal Light I Controller	Spot	29	4,018.50	MRH
	Plan & Design	Set	1	200.9	
	Total			4,219.50	
ITS	BIMS	Set	1set	3,957.70	GAPTE
	TSCS	Set	1set	1,860.00	
	Plan & Design	Set	1set	290.9	
	Total			6,108.60	
	Purchase Cost of Vehicle	Fleet	66	13,750.00	MOT
TOTAL				**93,571.70**	

Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

Development of Additional Circular and Radial Roads

Currently, there are five radial arterial roads and one circular road in GAMA. These are absolutely inadequate for the metropolis, considering growth in population and vehicular ownership, especially given the prospects in the long term. The vision, therefore, is to create four circular roads and nine radial arterial roads to serve the metropolis as shown in Figure 6.13.

Figure 6.13: Proposed Arterial Road Network



Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

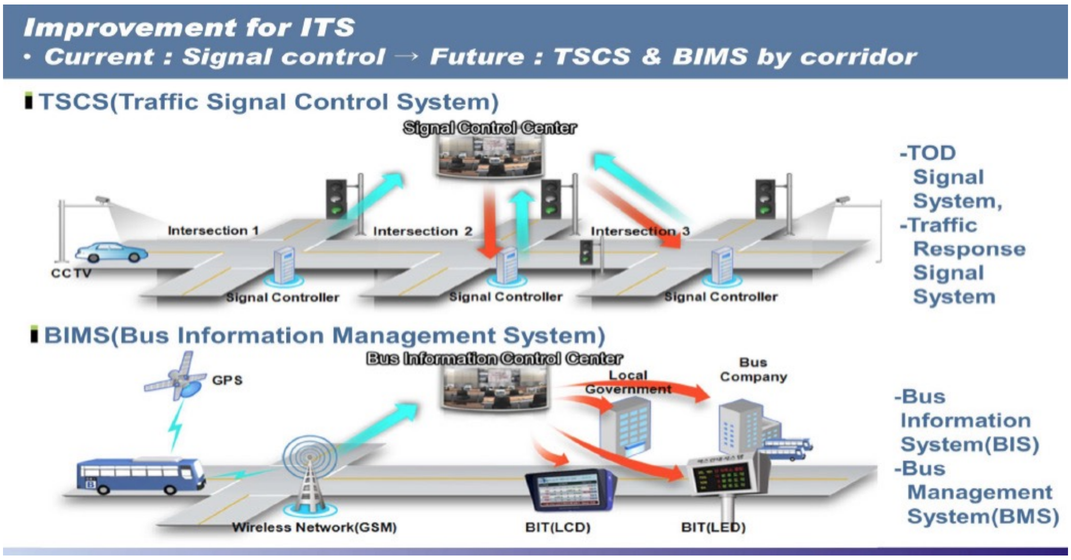
Establishment of Intelligent Transport System

Installing Intelligent Transport Systems (ITS) in GAMA will ensure that passengers can get information about bus routes, estimated waiting and arrival times, different stops etc. With the proper public transport systems in place, making the system smart by using advanced technology to provide such information will make public transport more attractive to current and prospective users, thereby decreasing the reliance on private vehicles and reducing congestion as well as the other current transport challenges in the metropolis.

Establishment of Traffic Signal Control System

A Traffic Signal Control System (TSCS) using modern technology such as closed circuit television (CCTV) will enable monitoring of traffic situations such that authorities can respond promptly to changes in traffic conditions by regulating traffic signals from a remote, even distant, location. The establishment of this system, which should comprise a Traffic Information Centre and field equipment will help with the collection and management of traffic data (using CCTV and Video Display System), which helps in the design of traffic signal control strategies and in managing traffic signal control facilities.

Figure 6.14: Improvement of ITS in GAMA



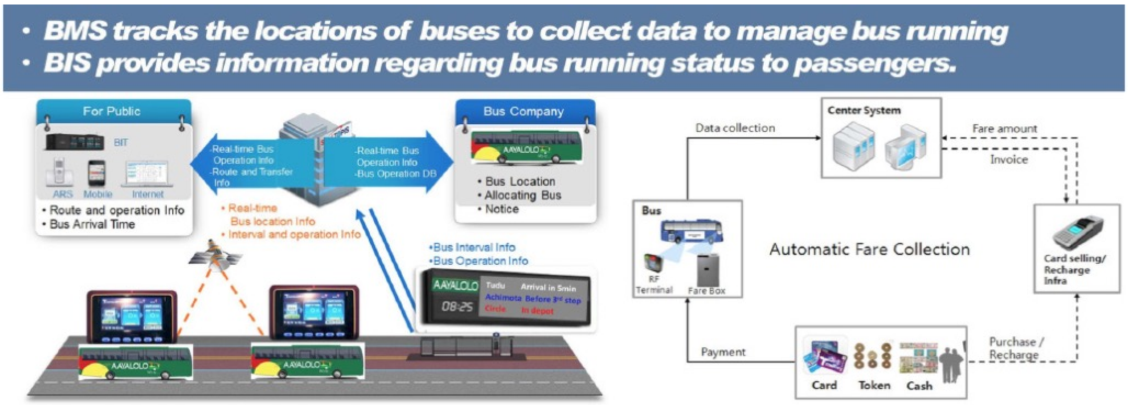
Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

Establishment of Bus Information and Management System

A Bus Information and Management System (BIMS) will enable monitoring of the operating status of each bus, and therefore aid authorities to feed passengers with accurate information such as estimated waiting or arrival time. This will greatly enhance bus transport services and lead to increased patronage, and decrease traffic congestion in the process.

The installation of the BIMS will also aid in the generation, management and communication of bus information, as well as supervision and adjustment of bus operations.

Figure 6.15: BIMS Installation Concept



Application of ITS system

Category		No. of Items
BIMS	Center system	1 set
	Software	1 set
	Bus information terminal	114 spots
	Transmitter(Bus)	66 set
	Transmitter(Passenger)	66 set

Category		No. of Items
TSCS	Center system	1 set
	Software	1 set
	CCTV	15 spots
	VES	15 spots

Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

6.6.3 GKMA Road Transport

Strategy for GKMA Road Network Development

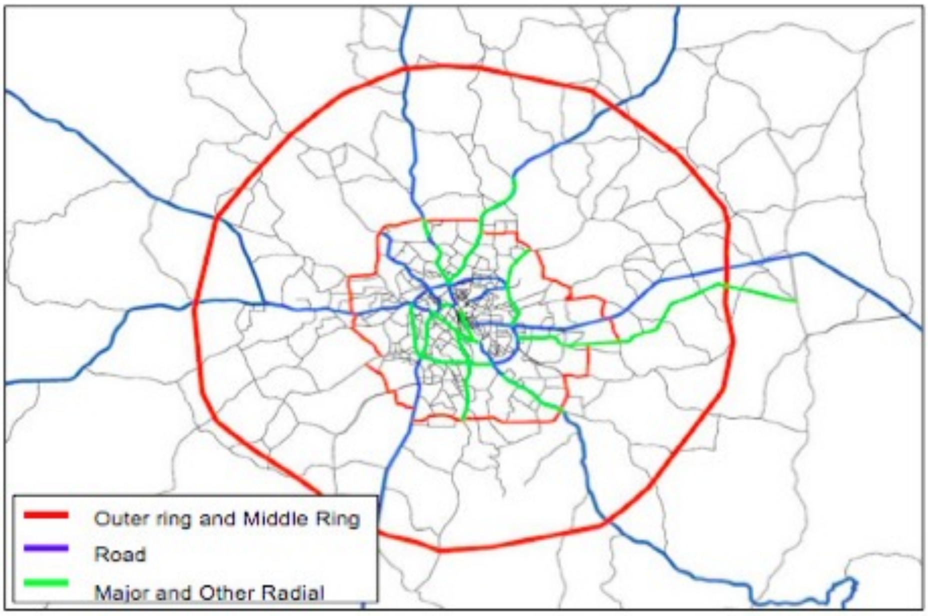
Portions of the road network in the Greater Kumasi Metropolitan Area (GKMA) are greatly strained due to their decreasing capacity to support the increasing volume of road users. It is therefore necessary for the capacity of these roads to be expanded to accommodate the needs of road users. City authorities have identified the following strategies to address this need:

i. Define the hierarchy of roads within the GKMA by:
- Identifying the "urban arterial roads";
- Upgrading minor local roads to regional roads to serve as connections between major radial roads and the city centre;
- Identifying collectors/distributors among small roads.

ii. Develop mass transport network infrastructure and widen the following corridors to at least a two-lane per direction: Mampong road, Offinso road, Sunyani road, Bekwai road, Lake road, Accra road, Antoa road, Abrepo road, old Bekwai and the inner ring road;

iii. Construct the first section of the Outer Ring Road between Ejisu and Kodie to divert traffic away from the city centre, and to promote development in Mampongteng and Kodie as shown in Figure 6.16;

Figure 6.16: Proposed Urban Arterial Roads for KMA



Source: The Study of Comprehensive Urban Development Plan for Greater Kumasi, Draft Final Report, 2013

iv. Upgrade roads that form the middle ring road and encourage its use to improve traffic circulation;

v. Construct a new arterial road as an alternative route to connect Ejisu and Kumasi;

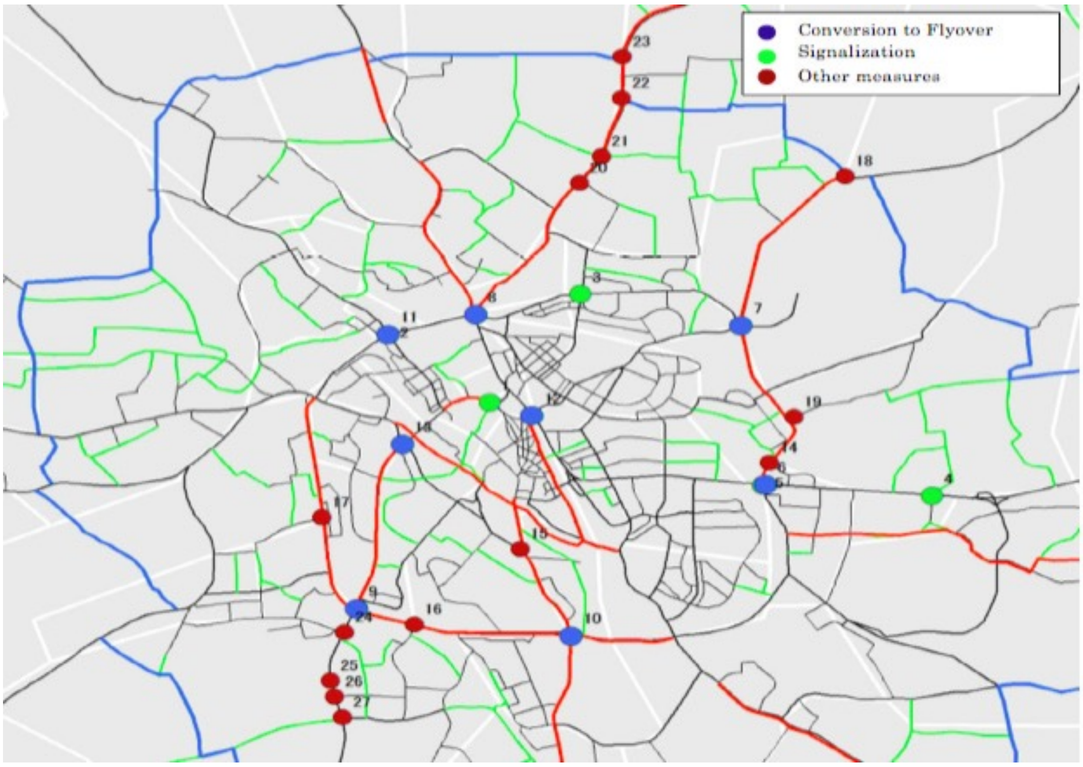
vi. Expand the capacity of the Western bypass, Southern bypass, Lake road, Mampong road, Harper road, New Bekwai road and Antoa road and construct the missing links to connect the Lake road to the Century Hall Road and Old Bekwai to New Bekwai, etc.

Strategy for Intersection and Signalisation Improvement

Traffic conflicts often occur at intersections. GKMA recognises this and will therefore apply the following strategies to address such traffic conflicts:

i. Establish a traffic signal control system and synchronise traffic signals on the entire road network in the metropolis to enable authorities to respond promptly to changes in traffic conditions;
ii. Optimise the use of traffic signals to clear traffic conflicts at major intersections (e.g. Suame, Abrepo, Sofoline, Anloga, Bekwai, etc.) as well as minor ones;
iii. Undertake signalisation and grade separation measures as illustrated in Figure 6.17 below;
iv. Ensure that traffic measures at critical intersections are strictly enforced.

Figure 6.17: Projects under Signalisation and Intersection Improvement



Source: The Study of Comprehensive Urban Development Plan for Greater Kumasi, Draft Final Report, 2013

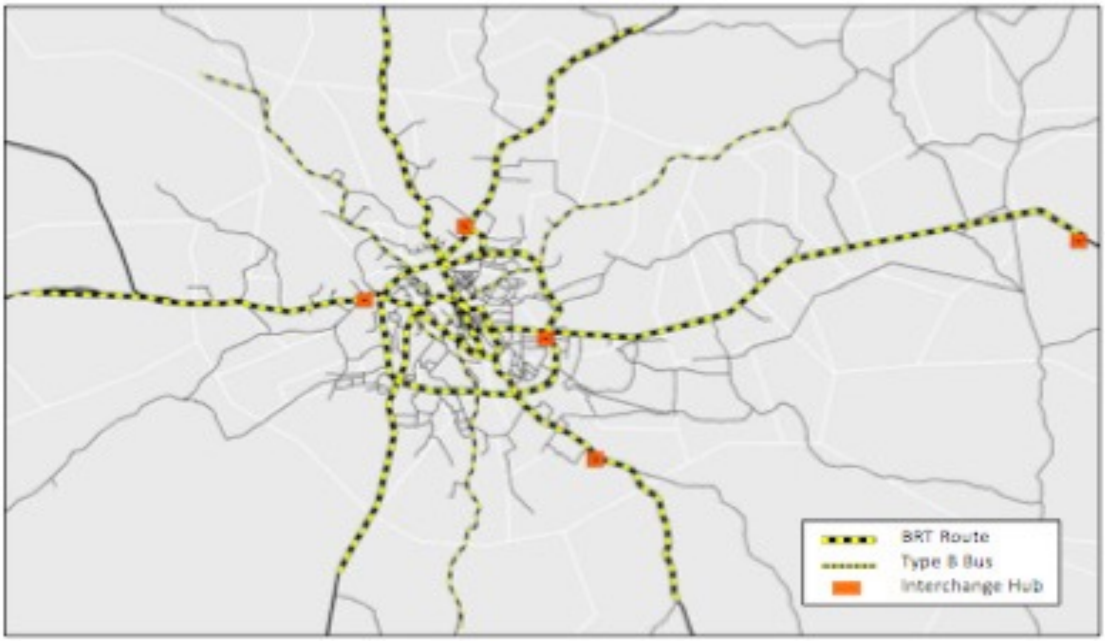
Strategy for Public Transport Development

Most road users in GKMA rely on public transport. It is therefore not only pertinent to enhance the system, but to also make it more attractive to prospective users. The following strategies are thus critical:

i. Transitioning from a low capacity (*trotro*) to a high capacity transport system by introducing large buses;
ii. Creation of BRT routes to cover the nine radial roads and the inner ring road (Figure 6.18);
iii. Develop transfer points at Tafo, Anloga, Kwadaso, Abinkyi, Ejisu and other areas, where long-distance journeys usually end, and have another mode of transport

then move passengers from these transfer points to their final destinations (Figure 6.18).

Figure 6.18: BRT routes and interchange hubs



Source: The Study of Comprehensive Urban Development Plan for Greater Kumasi, Draft Final Report, 2013

Strategy for Traffic Control in the CBD

The main strategy to control traffic in the CBD (Adum and Central Market), has been to provide paid parking services to reduce illegal parking and to foster traffic flow. However, measures proposed to further enhance traffic flow in the CBD are as follows:

i. Enforce laws to reclaim pedestrian space from vendors;
ii. Create walkways and cycle lanes to enhance pedestrian mobility;
iii. Expand the on/off street paid parking system to other areas of the CBD;
iv. Develop a multistorey car parking area in the CBD;
v. Apply vehicle access restrictions (e.g. one-way restrictions) in high-density areas in the CBD, particularly in Adum and Central Market.

Local authorities will be encouraged to integrate the provision of parking facilities in their local plans, as well as develop a framework for private sector engagement in the provision of parking services.

Strategy for Transportation Demand Management

Transportation Demand Management (TDM) measures play an important role in containing traffic demand and the GKMA intends to apply the following strategies to control the demand for transportation particularly in Kumasi:

i. Incorporate public transport services and make public transport provision a priority over private transport provision (e.g. ensuring proper coordination between BRT and feeder services, and providing priority lanes to enhance BRT);
ii. Explore the possibility of implementing flexible working hours to spread out traffic demand;

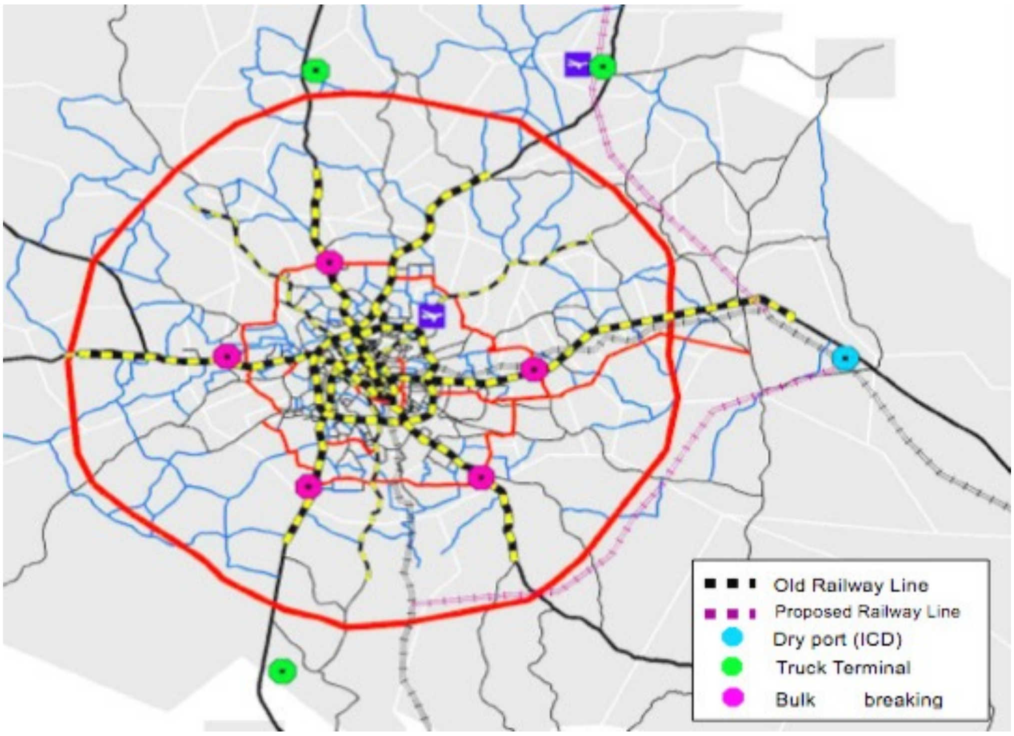
iii. Explore and implement measures that discourage the use of private vehicles and encourage the use of public transport facilities instead.

Strategy for Freight Transport Management

Kumasi lies along a major corridor for the transportation of freight and logistics across the country. The freight industry in the metropolis is however fraught with several challenges including traffic congestion, inadequate parking spaces particularly in the city centre, and the lack of terminals. Implementing the following strategies will improve the services provided by the industry in the contexts of the sub-region:

i. Freight distribution especially within the CBD should be reorganised;
ii. Cooperation among stakeholders in the freight industry should be strengthened;
iii. Create bulk breaking points on the middle ring road to reduce the risk of having large trucks on the middle ring road (Figure 6.19);
iv. Construct truck terminals to serve as bulk breaking points. This will also cut down the number of trips by large trucks at the fringes of the city.

Figure 6.19: Proposed Truck Terminals, Breaking Points and Railway Line



Source: The Study of Comprehensive Urban Development Plan for Greater Kumasi, Draft Final Report, 2013

Priority Projects

Priority projects for improving the transportation sector and the provision of transport infrastructure in GKMA are:

i. A detailed GKMA Transport Master plan to be prepared by 2020 to identify the multimodal dimensions of the network, highlighting the location and area of the new airport, railway capacity and routes systems, urban transport and traffic systems;
ii. The construction of the outer ring road bypassing Kumasi and stimulating the development of sub-urban residential areas within its catchment area;

iii. The improvement of the middle ring road, also as a catalyst for development in its immediate environs;
iv. The creation of BRT routes to serve the GKMA.

6.6.4 Developing the Road Grid System to Accommodate Electric Vehicles

Ghana will develop the necessary infrastructure and create nationwide charger networks in the cities and the countryside. Electric vehicles (EVs) will increase Ghana's electricity demand, which has already been catered for under the GIP. Linking chargers to the internet will facilitate web-based payments, software upgrades, remote troubleshooting, and contribute to a smarter grid. This also calls for nationwide internet connectivity.

The impacts of developing road grid systems will include:

i. Increased availability of EV charging stations;
ii. Increased viability of EV public transportation;
iii. Faster EV charging times;
iv. Easier payment and back-office systems for charger providers;
v. Reduced maintenance of charging units.

Figure 6.20: Electric Vehicle Charging Station for Buses

Source: Google Images

Electric vehicles bring community benefits, such as lower or no emissions. However, for every promise of how electric vehicles will revolutionise transportation, there is a matching practical challenge. If electric vehicles need recharging, then the charging process must be fast and convenient.

Figure 6.21: Electric Vehicle Charging Station for Cars

Source: Google Images

6.7 Feeder Roads Development

Investment in feeder roads is planned for the 10-year period 2016 to 2026. It is mainly to clear the backlog of road maintenance (routine and periodic). Minor rehabilitation over the medium term will be to upgrade earth to gravel and gravel – based on traffic growth – to bituminous seals. Table 6.29 below gives the effect on the feeder road network over the next 10 years assuming it does not increase.

Table 6.29: Investment in the Unpaved Segment of the Feeder Road Network

Surface Type	Current Length (km)	Upgrading	Length to be Upgraded (km)	Effect
Earth	12,886	Gravel	4,642	36% reduction of earth roads
Gravel	27,231	Bituminous Seal	6,752	350% increase in paved
Paved	1,928	-	-	-

Source: Department of Feeder Roads

From Table 6.29, over the next 10 years, the 36% of the classified earth roads will be upgraded to gravel, while the paved segment will increase by 350%. A separate investment plan from 2026-2046 is needed in order to be able meet the investment requirement of the GIP. The funding required is US$6.1 billion for maintenance and

6.8 Road Safety

6.8.1 Overview

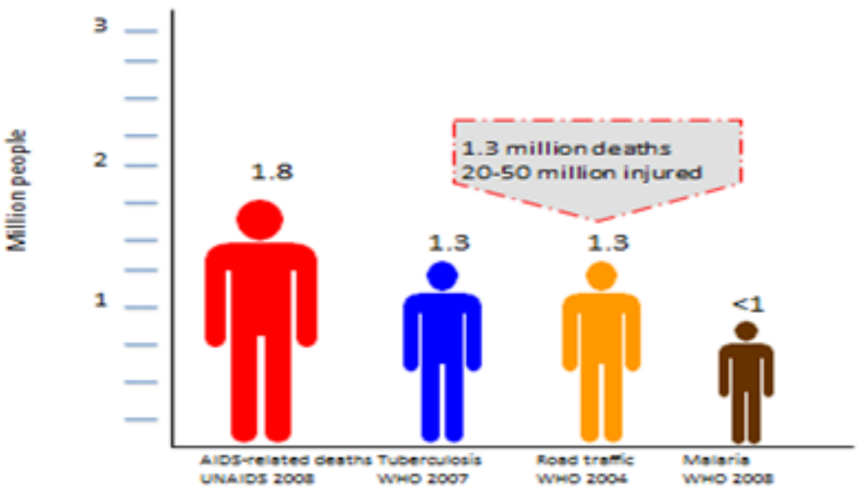
Road safety has gained global attention largely due to the rising trends in the number of persons killed and injured in road accidents and the growing concern for the associated social and economic burden to nations.

The Global Picture

Globally, it is estimated that 1.3 million persons get killed on the roads and 50 million others get injured to various degrees annually. Nations lose between 1%-3% of their GDP as a result of road crashes through loss of human capital, hospital costs, etc.

Road crashes have become a public health problem across the world. According to the World Health Organisation (WHO), road crashes kill more than malaria. Developing countries in Asia and Africa suffer the highest rates of road fatalities in spite of the fact that such countries are rather the least motorised. The WHO has predicted that road traffic crashes will become the third killer in the world above HIV/AIDS and tuberculosis by 2030 if nothing is done to halt the rising trend of road crashes and casualties.

Figure 6.22: Road Traffic Deaths - The Fact



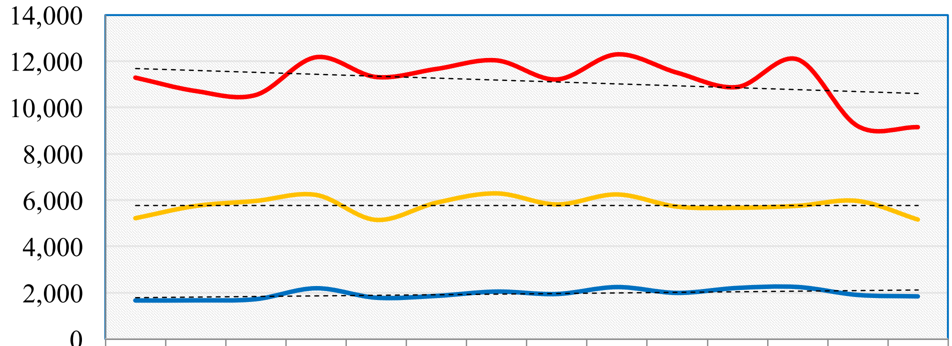
Source: World Health Organisation

6.8.2 National Road Safety Situation

The National Road Safety Commission (NRSC) is the body mandated to plan, develop, promote and coordinate policies relating to road safety in the country. In Ghana, road traffic crashes kill about 2,000 persons and injure about 14,000 others annually on the average. About 5,600 cases, representing 40% of the injured are serious.

Available statistics indicate that from 2001 to 2014, there has been a consistent decline in crash occurrences and seriously injured persons by annual rates of 82 and 34 persons per annum respectively. Trends in fatalities/persons killed however, keep growing at an annual rate of 26 persons (add-ons) per year.

Figure 6.23: Breakdown of Accident Severity (2001 – 2014)



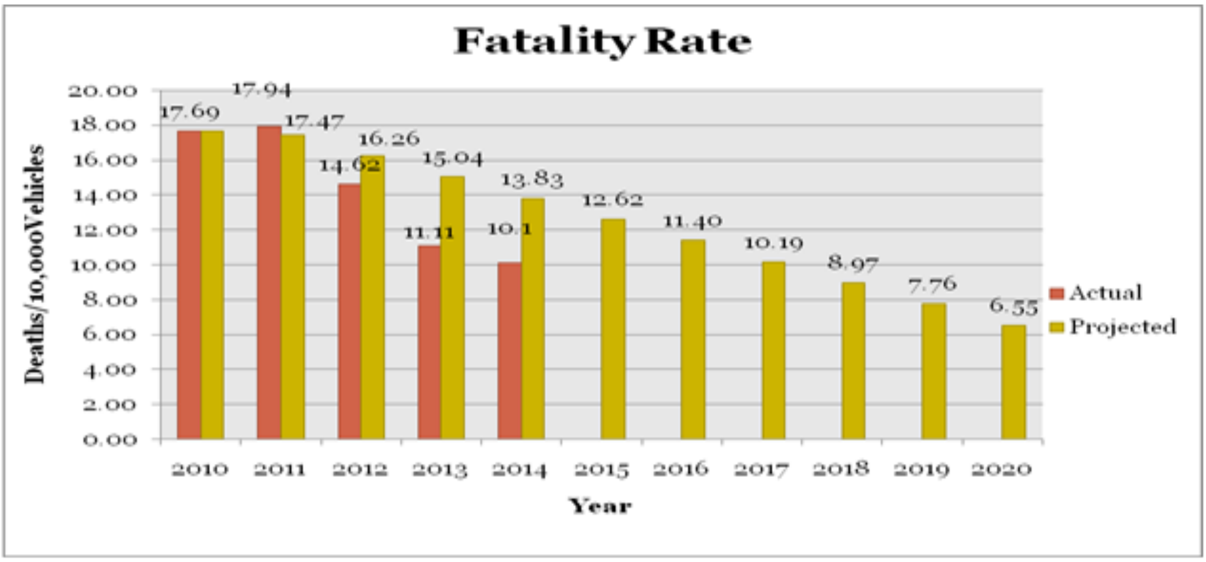
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Crashes	11,293	10,715	10,542	12,175	11,320	11,668	12,038	11,214	12,299	11,506	10,887	12,083	9,200	9,152
Persons Killed	1660	1665	1716	2186	1779	1856	2043	1938	2237	1986	2199	2240	1898	1836
Persons Seriously Injured	5210	5741	5960	6222	5138	5882	6287	5809	6242	5713	5663	5748	5959	5153

Source: National Road Safety Commission

Fatality Rate

Ghana's fatality rate (i.e. the number of persons killed in road traffic crashes per 10,000 vehicles in the country) has declined consistently from close to 18 in the year 2010 to 10 in the year 2014, representing an 80% reduction.

Figure 6.24: Fatality Rate (Actual and Projected)



Source: National Road Safety Commission

One of the indicators used to determine the level of safety of a road network is the Fatality Index. Table 6.30 gives the fatality indices for the period 2010-2014.

Table 6.30: National Traffic Fatalities Indices

Year	All Crashes	All Casualties	Fatalities	Estimated Population ($x10^6$)	Registered Vehicles	Fatalities per 10,000 Vehicles	Fatalities per 100,000 Population	Fatalities per 100 Casualties	Fatalities per 100 Crashes
2010	11,506	16,904	1,986	24.865	1,122,722	17.69	7.99	11.7	17.3
2011	10,887	16,219	2,199	25.099	1,225,754	17.94	8.76	13.6	20.2
2012	12,083	15,241	2,240	25.510	1,532,080	14.62	8.78	14.7	18.5
2013	9,200	12,509	1,898	26.004	1,708,958	11.11	7.30	15.2	20.6
2014	9,152	12,863	1,836	26.505	1,885,836	9.74	6.93	14.3	20.1

Source: National Road Safety Commission

6.8.3 National Road Safety Strategy

Ghana is considered as one of the countries in the world with a consistent policy, strategic and data-led framework approach to managing road safety. The National Road Safety Strategy (NRSS I) was implemented from 2001 to 2005, followed by NRSS II from 2006 to 2010 and now NRSS III from 2011 to 2020.

These strategies are derived from a comprehensive database well-structured and maintained since 1991 which incorporates the police data collection system, the hospitals and finally the research and analytic prowess of the Building and Road Research Institute (BRRI).

National Road Safety Policy

In addition to the above, there is a clearly defined national policy for road safety which calls for:

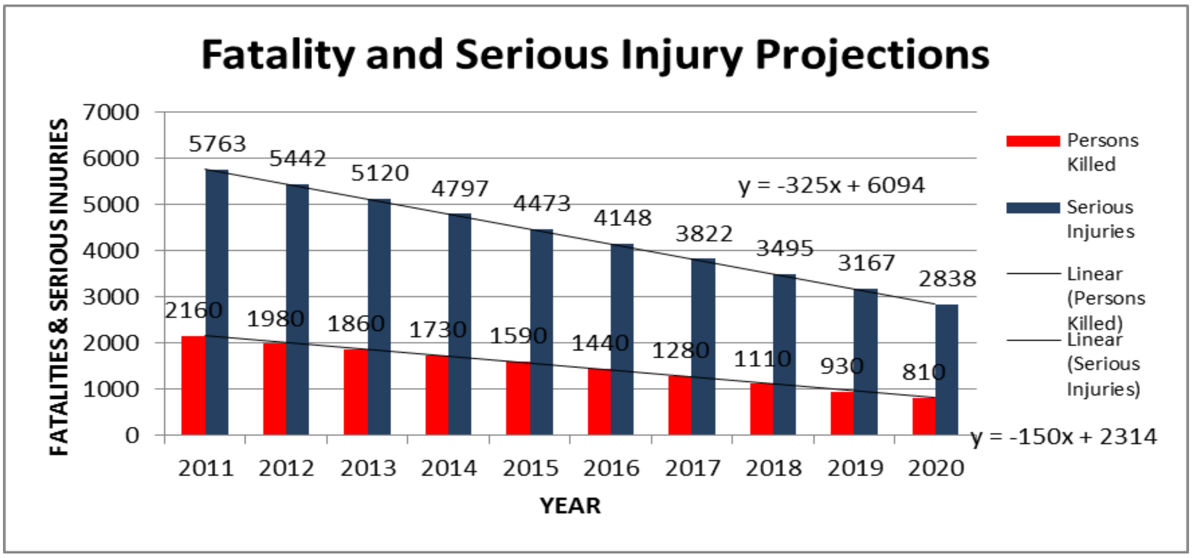
i. A national body to regulate the road transport industry;
ii. Competent drivers through proper training and licensing;
iii. Safety in vehicle assembly, modification, use and maintenance and less adverse effects on the environment;
iv. Safety in planning, design, construction and maintenance of road infrastructure;
v. Promotion and incorporation of intercity mass transit (IMT) in provision of road transport facilities;
vi. Promotion and incorporation of pedestrian safety facilities in design and construction of road infrastructure;
vii. Speedy and effective trauma care and health management;
viii. Enhancement of road traffic crash data collection and analysis;
ix. Sufficient and sustainable funding for road safety activities;
x. Encouraging and increasing funding for research, monitoring and evaluation (RM&E);
xi. Inter-agency collaboration, human resource and awareness creation.

Way Forward

The NRSC, as the main statutory agency for the promotion and management of road safety in Ghana, is leading the implementation of the Third National Road Safety Strategy (NRSS III) for the period 2011 to 2020. NRSS III was developed in line with the

United Nations Decade of Action (DoA) for Road Safety in which the UN is calling on all governments to invest in road safety and also to take measures that will aim at reducing the number of persons killed and seriously injured (KSI) in road traffic crashes by 50% by 2020.

Figure 6.25: Fatality and Serious Injury Projections



Source: National Road Safety Commission

The NRSS III target is fewer than 1,000 persons killed and 3,000 persons seriously injured. This is expected to help the nation attain a fatality rate of between 1 and 5, which will position Ghana among countries with high road safety records such as Denmark, Sweden and France.

6.9 Financing the Road Transport Sub-Sector

6.9.1 Investment for Road Construction and Reconstruction

The total investment to expand the current network size to the long-term objective of 253,000 km will require a financial outlay of US$271.7 billion. Table 6.31 shows the financing plan over the period. The budget is for construction and reconstruction only and does not cover maintenance and rehabilitation.

Table 6.31: Financing Plan from 2018 to 2047

Road Type	Motorway/ Expressway	High Speed Way (4-Lane)	4-Lane	2-Lane (High Standard)	2-Lane	Total
Trunk Roads						
Paved (km)	2,240	8,288	9,432	20,720	-	40,680
Unpaved (km)	-	-	-	-	15,920	15,920
Sub-Total (km)	**2,240**	**8,288**	**9,432**	**20,720**	**15,920**	**56,600**
Feeder Roads						
Paved (km)	-	-	-	101,540	-	101,540
Unpaved (km)	-	-	-	-	55,160	55,160
Sub-Total (km)	**-**	**-**	**-**	**101,540**	**55,160**	**156,700**
Urban Roads						
Paved (km)	285	3,298	10,449	20,748	-	34,780
Unpaved (km)	-	-	-	-	4,920	4,920
Sub-Total (km)	**285**	**3,298**	**10,449**	**20,748**	**4,920**	**39,700**
Total Network						
Paved (km)	2,525	11,587	19,880	143,008	-	177,000
Unpaved (km)	-	-	-	-	76,000	76,000
Grand Total Length of Roads (km)	**2,525**	**11,587**	**19,880**	**143,008**	**76,000**	**253,000**
Cost per km (US$m)	6	4	3	1	0.1	**-**
Total Cost (US$m)	**15,150**	**46,348**	**59,640**	**143,008**	**7,600**	**271,746**

Source: Author's construct

6.9.2 Investment for Road Maintenance and Improvement

A total amount of about US$40.1 billion will be required for road maintenance and improvement of the road network (Table 6.32).

Table 6.32: Summary of Estimates for Rehabilitation and Improvement of Road Transport Infrastructure

Term	Agency	Length (km)	Estimated Cost (US$m)
Short Term	Trunk Roads (GHA)	6,483	9,705
	Feeder Roads (DFR)	452	4,929
	Urban Roads (DUR)	9,228	8,137
	Road Safety (NRSC)	-	77
	Urban Transport	49	94
Sub-Total		**16,212**	**22,942**
Medium Term	Trunk Roads (GHA)	426	1,688
	Feeder Roads (DFR)	452	4,476
	Urban Roads (DUR)	3,848	3,294
	Road Safety (NRSC)	-	198
	Urban Transport	-	-
Sub-Total		**4,726**	**9,656**
Long Term	Trunk Roads (GHA)	867	1,173
	Feeder Roads (DFR)	452	4,476
	Urban Roads (DUR)	1102	1,824
	Road Safety (NRSC)	-	68
	Urban Transport	-	-
Sub-Total		**2421**	**7,541**
GRAND TOTAL			**40,139**

Source: Author's construct

Chapter 7 Aviation

7.1 Introduction

The aviation industry in Africa is projected to grow rapidly within the next two decades. For instance, in terms of air cargo transport, trade between Africa and Europe is expected to grow by 3.8 percent per year from 2015 to 2035, while Africa–Asia air cargo trade will expand at an average annual growth rate of 6.5 percent[54]. Similarly, air cargo trade between Africa and North America will grow by 5.3 percent per year, albeit from a smaller base than either Europe or Asia within the same period.

Consequently, the Government of Ghana aims to modernise the country's airports and turn Ghana into a competitive West African air transport hub and gateway to meet demands from economic growth. Air transport will remain a preferred solution for transporting higher value goods that are sensitive and economically perishable. It is therefore imperative that Ghana's aviation industry is developed to take advantage of the present and future opportunities to facilitate the socio-economic development of the country. To this end, infrastructure improvements are required to accommodate not only forecast demand, but to ultimately ensure the long-term competitiveness and financial viability of the aviation industry.

Although Ghana desires to become an aviation hub in West Africa, the country captures only 10% of the aviation market in the West African sub-region, second to Nigeria that captures 57% of the market[55]. Other airports in the sub-region also compete for the hub status. It is for these reasons that there is the need to develop plans and strategies that will spur the development of the sub-sector in order to strengthen its contribution to the socio-economic development of the country.

7.1.1 Vision

The vision is "to position Ghana as the preferred aviation hub and leader in the airport business in West Africa."

7.2 Main Institutions in the Aviation Sub-Sector

7.2.1 Ghana Airports Company Limited

Ghana Airports Company Limited (GACL) is the institution mandated to provide world-class airport facilities and services in the country. GACL was established as a result of the decoupling of the existing Ghana Civil Aviation Authority (GCAA) in line with modern trends in the aviation industry. The company is responsible for planning, developing, managing and maintaining all airports and aerodromes in the country.

[54] Boeing World Air Cargo Forecast, 2016-2017
[55] Ghana National Spatial Development Framework, 2015-2035

7.2.2 Ghana Civil Aviation Authority

Ghana Civil Aviation Authority (GCAA) is the regulatory agency for air transportation in the country. GCAA provides air navigation services within the Accra Flight Information Region (FIR), which comprises the airspace over Ghana, Togo and Benin and a large area over the Atlantic Ocean in the Gulf of Guinea. The company also promotes the development of the country's civil air transport industry.

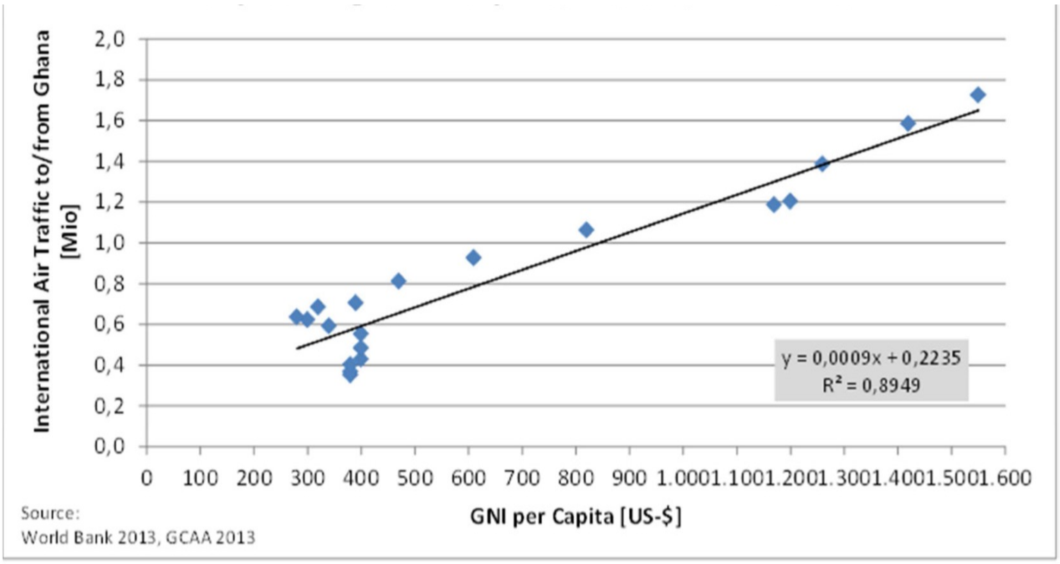
7.3 Existing State of Ghana's Aviation Industry

7.3.1 Overview

Normally, higher airport and aviation activity is directly reflected in a country's gross domestic product (GDP). Many international aviation forecasts determine future activity growth using GDP as the main and sometimes the only independent variable.

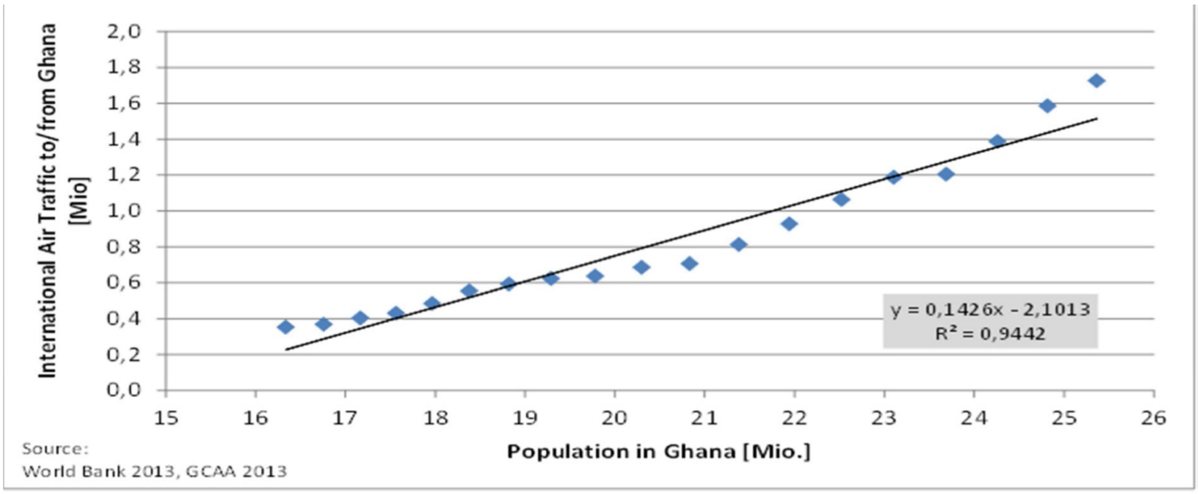
In Ghana, passenger traffic has grown recently following the upgrade of infrastructure facilities at the airports. This growth is estimated to be about 7% per annum and is closely aligned with economic growth over the last few years. There is a positive correlation between the Ghana's economic growth and air passenger transport for the period 1994 to 2012 (Figure 7.1). Similarly, a positive correlation exists between Ghana's population growth and air passenger transport (Figure 7.2).

Figure 7.1: Correlation between Economic Growth and Air Transport in Ghana, 1994-2012



Source: National Airport System Plan, 2014

Figure 7.2: Correlation between population growth and air passenger transport in Ghana, 1994-2012

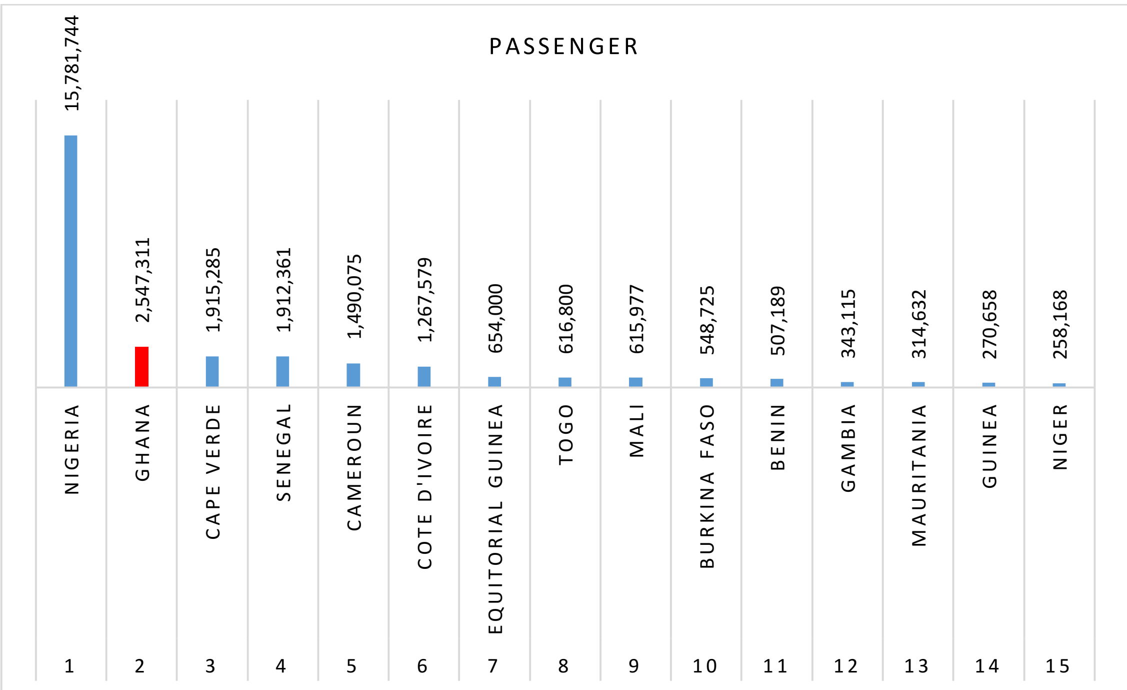


Source: National Airport System Plan, 2014

7.3.2 Ghana's Aviation Statistics

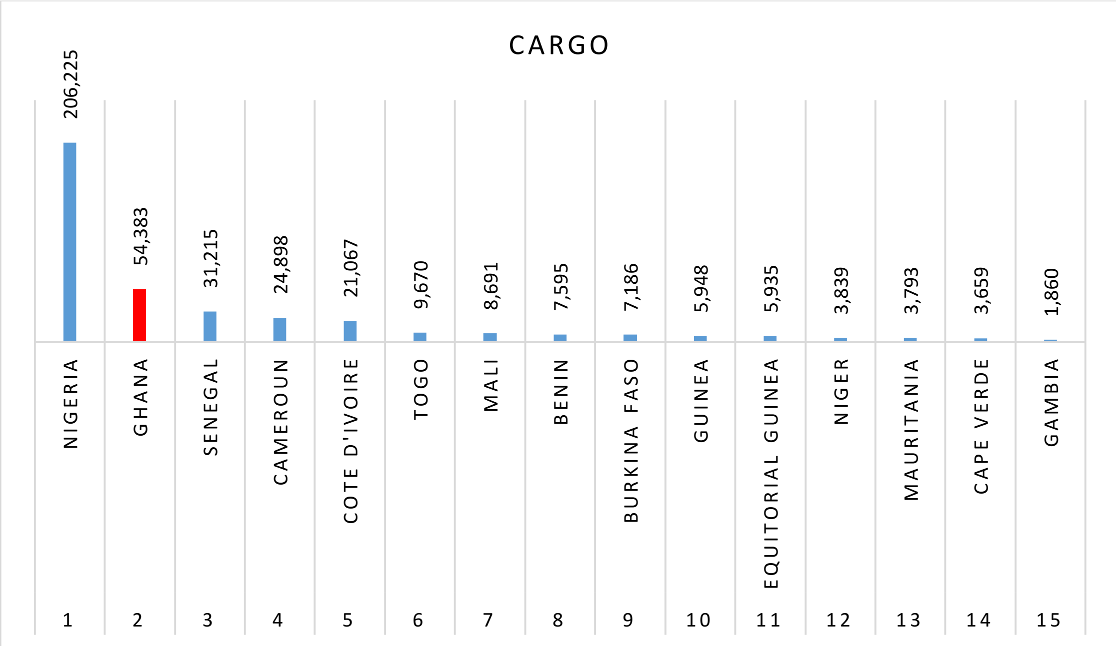
In recent times, Ghana's aviation industry stands out as one of the fastest growing and most competitive in the West Africa sub-region. However, Ghana currently lags behind Nigeria in terms of the market share in the aviation industry. Figures 7.1 and 7.2 show the passenger and cargo traffic rankings in West Africa.

Figure 7.3: Passenger Ranking in West Africa



Source: Ghana Airports Company Ltd, 2016

Figure 7.4: Cargo Ranking in West Africa



Source: Ghana Airports Company Ltd, 2016

7.3.3 Ghana's Airports in Operation

Kotoka International Airport (KIA) is the most frequently used airport for both domestic and international travels. It has passenger and freight terminals. Tamale and Kumasi Airports have also been refurbished and upgraded to the status of international airports but full operations are yet to commence. Sunyani and Takoradi Airports handle domestic air travel. There are other facilities used for emergency, medical and tourism purposes including airstrips with short runways. Table 7.1 provides information on the location and status of the country's airports in operation.

Table 7.1: Current Airports in Operation

Name	Region	Status
Kotoka International Airport, Accra	Greater Accra	Active
Kumasi Airport	Ashanti	Active
Paga Airstrip	Upper East	Active
Takoradi Airport	Western	Active
Sunyani Airport	Brong Ahafo	Active
Tamale Airport	Northern	Active
Wa Airport	Upper West	Active

Source: National Airport System Plan, 2014

Other Existing Aerodromes

Apart from the aforementioned airports, other aerodromes exist in the country. Table 7.2 shows the remaining aerodromes that are registered with the GCAA and their present status.

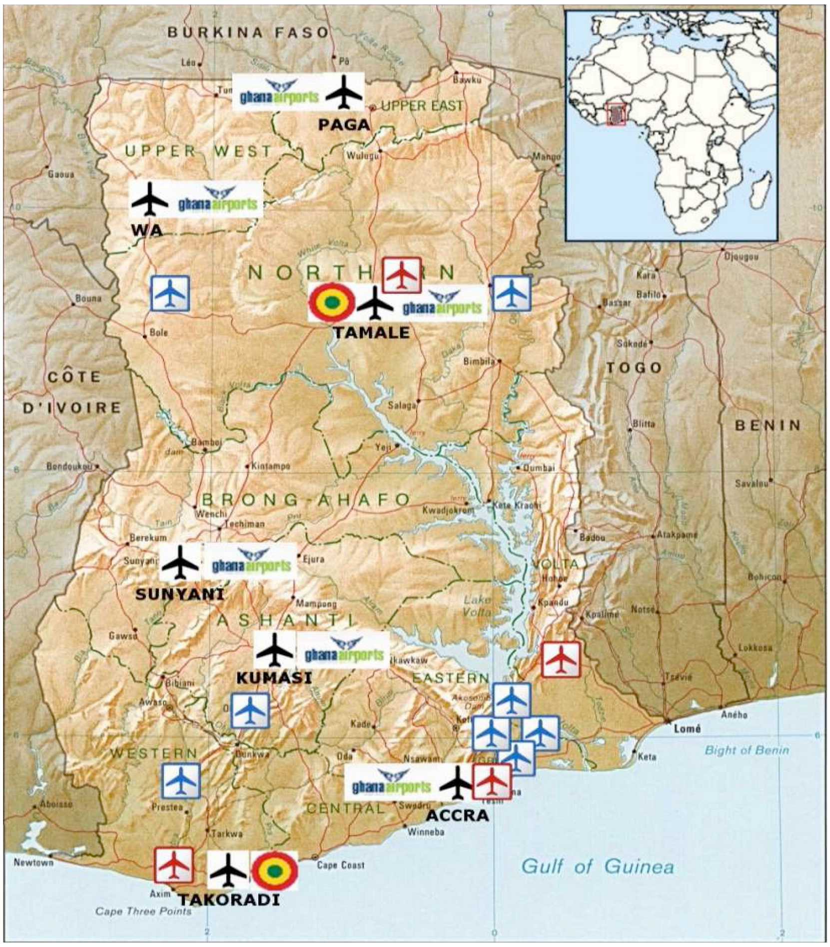
Table 7.2: Other Existing Aerodromes

Name of Aerodrome	Region	Status
Ho	Volta	Under construction and upgrading
Yendi	Northern	Inactive, closed
Obuasi	Ashanti	Active
Afienya	Greater Accra	Inactive
Golden Exotics Ultralight strip	Eastern	Active
Aveyime	Volta	Inactive
Okwenya-Akuse Ultralight Strip (Rocky Farms)	Eastern	Inactive
Barace	Western	Selected site, construction not commenced
Mole	Northern	Inactive
Chirano Airstrip	Western	Inactive, Unpaved runway; no other infrastructure
Akuse Airstrip	Eastern	Inactive; Paved; no other infrastructure
GOPDC Airstrip, Kwae	Eastern	Inactive; Unpaved runway; no other infrastructure
Obotan Airstrip	Ashanti	Inactive. Soon to be activated. Unpaved runway; no other infrastructure
Mim Cashew Airstrip	Brong-Ahafo	Inactive; Grass field; no other infrastructure
Tarkwa Airstrip	Western	Decommissioned and not in existence
Samreboi Airstrip	Western	Inactive; Paved runway; no other infrastructure
Bolgatanga Airstrip	Upper East	Construction abandoned. Only cleared area for the runway. At Anateem near Sumbrugu, off Bolga-Navrongo Road
Koforidua Airstrip	Eastern	Site selected in 1992. Location now built-up and densely populated
Kpong Airfields (Ultralight Strip)	Eastern	Active

Source: National Airport System Plan, 2014

Figure 7.5 shows the map of aerodromes and airport development programmes in the country.

Figure 7.5: Map of Aerodromes and Airport Development Programmes in Ghana



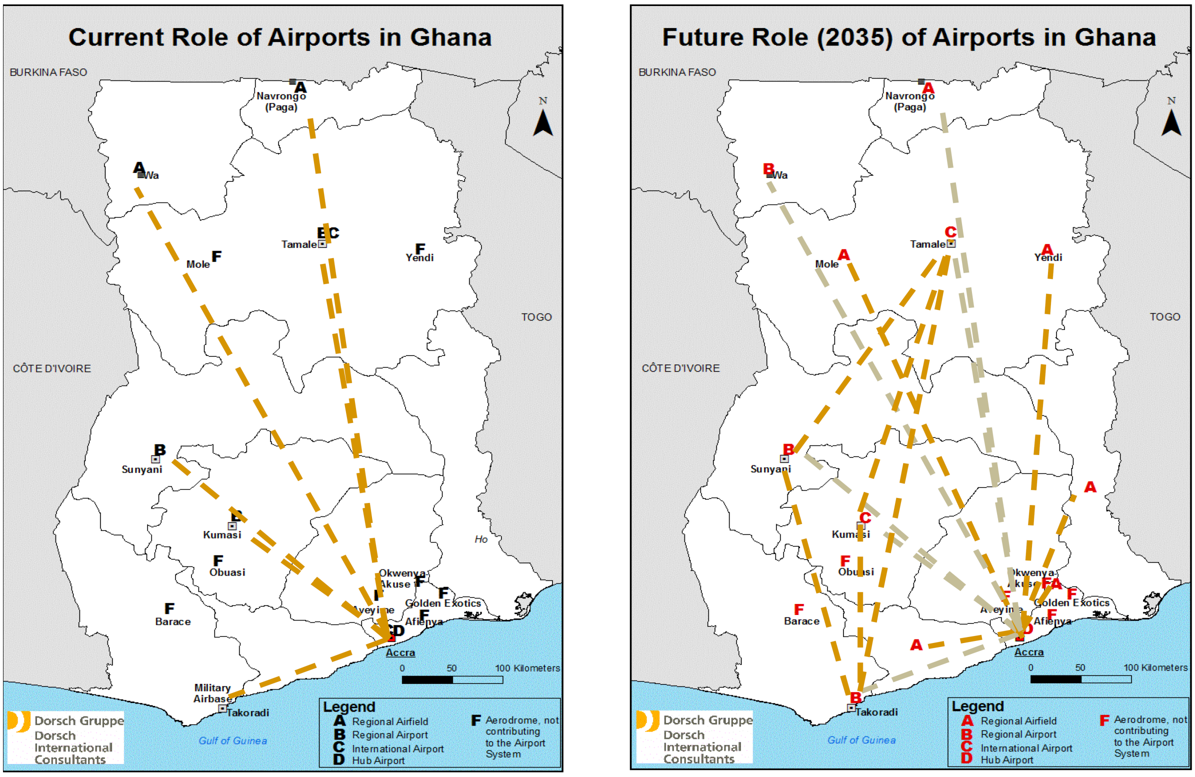
Existing Commercial Airports	Additional Aerodromes (non GACL)
Known Airport Development Programs	

Source: National Airport System Plan, 2014

7.3.4 Functional Roles of Ghana's Airports

Currently, Kotoka International Airport (KIA) functions as the aviation hub linking passengers from major cities in West Africa to Accra for onward transfer or stopover to Europe, the America, the Middle East and the Far East. Figure 8.6 shows the current and future air transportation system of the country. The definitions of the role categories contained in Figure 7.6 are presented in Table 7.3.

Figure 7.6: Current and Future Roles of Airports in Ghana



Source: National Airport System Plan, 2014

Table 7.3: Definition of the Role Category

Classification	Type	Definition
A	Regional Airfield	• Provides for air transportation in remote regions • Improves accessibility • Commercially not viable • Less than 2,000 pax/month
B	Regional Airport	• Noticeable number of passengers (> 2,000 pax/month) • Provides scheduled air transportation • Commercially viable • Provides potential for air cargo transportation
C	International Airport	• Provides both international and domestic connections • Provides scheduled air transportation • Commercially viable • Provides potential for air cargo transportation
D	Hub Airport	• Centre for international/domestic connections • Significant number of pax/month • Gateway function • Provides scheduled air transportation • Commercially viable • Provides potential for air cargo transportation
F	Aerodrome not contributing to the Airport System	• Privately owned and operated • No, or only limited services to the public • Private commercial interest

Source: National Airport System Plan, 2014

7.3.5 Issues to be addressed in the Aviation Industry

The implementation of both the liberalised skies policy and the fifth freedom right policy has led to an increased number of airlines operating in the country. However, the following issues need to be addressed:

i. Upgrading of equipment to enhance operational safety and efficiency;
ii. Upgrading and expansion of infrastructure facilities at airports/aerodromes to meet the future demand of international and local flights;
iii. Establishment other international airports in Ghana;
iv. Security of title to aviation/airports land(s) for future development;
v. Establishment of a framework for excellent service;
vi. Continuation of the implementation of liberalised skies policies in order to attract more airlines to operate international and/or domestic flights;
vii. Intensification efforts to achieve hub status;
viii. Full implementation of Yamoussoukro Declaration (YD);
ix. Facilitation of information collaboration, technical cooperation and operational coordination among African Air Navigation Service (ANS) providers;
x. Abolition of Bilateral Air Service Agreement (BASA's) between African Union (AU) member states;
xi. Capacity building;
xii. Modernisation and optimisation of Air Traffic Managements Systems.

A Master Plan exists for the development of some of the country's airport infrastructure such as at KIA, Tamale and Kumasi to meet the objective of making Ghana the aviation hub of the West Africa. However, there are no such plans yet for Sunyani, Wa and Ho. It is expected that an Aviation Industry Master Plan will be prepared for these cities.

7.4 Ghana's Aviation Sub-Sector Development

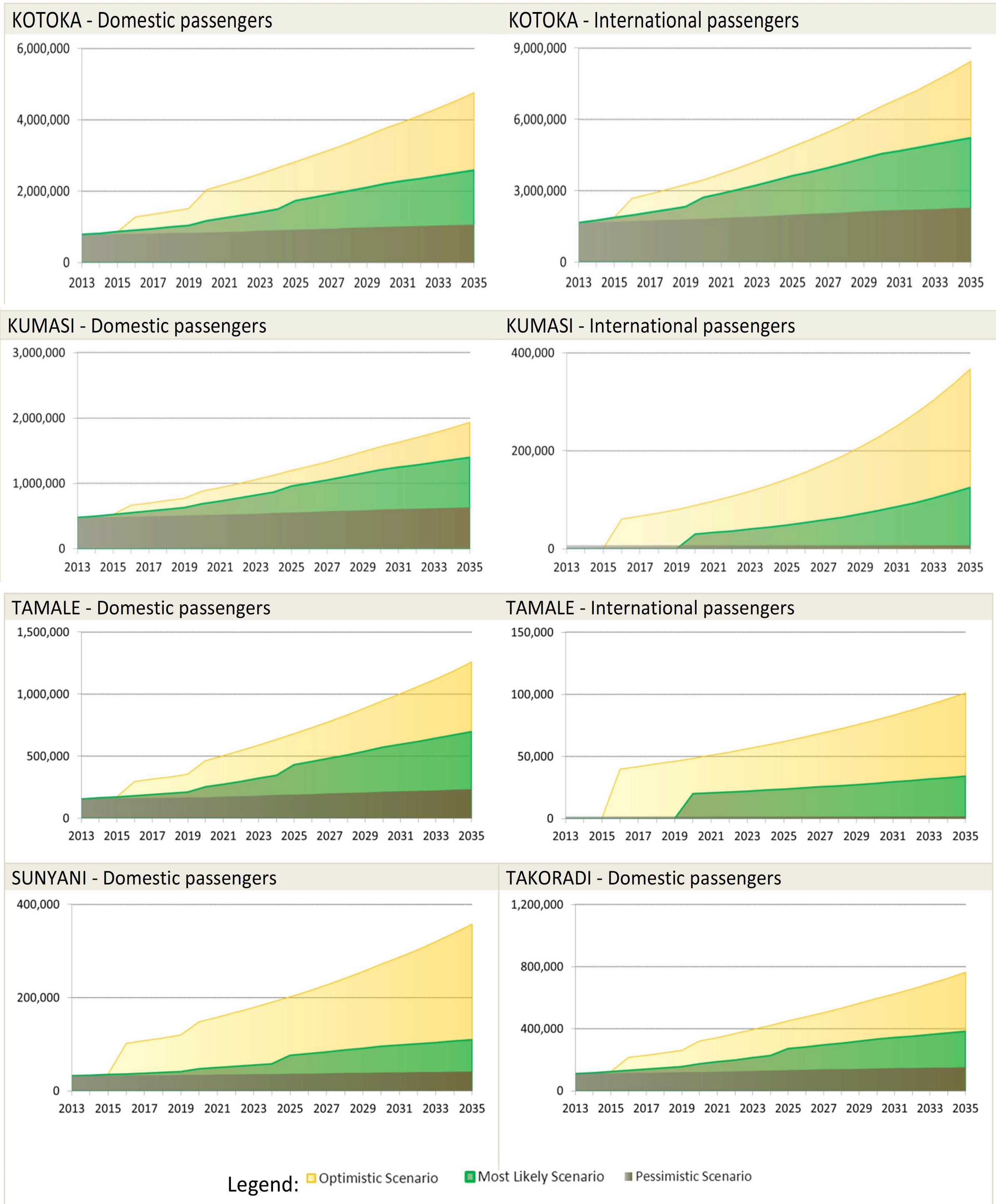
7.4.1 Air Traffic Forecast

It is expected that air traffic will increase within the planning period as a result of an increase in economic growth as well as tourism development. This projection is also consistent with recent trends and the high growth potential of the aviation industry.

Air Passenger Traffic Forecast

The forecasts for individual airports have been prepared under three scenarios (optimistic, most likely, and pessimistic) influenced by various factors such as hub effect, tourism traffic, pilgrims, and domestic route network. It also takes into consideration passengers, aircraft mix, operation and other peak considerations. Figure 7.7 presents a summary of the air traffic forecast (domestic and international passengers) for the five major airports.

Figure 7.7: Summary of Air Traffic Forecast (Passengers) for Selected Airports

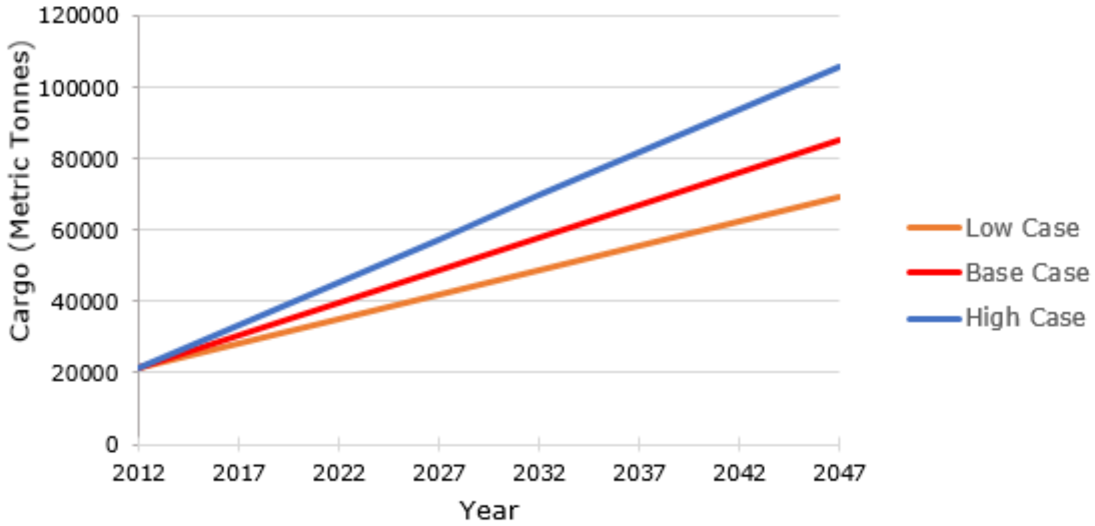


Source: National Airport System Plan, 2014

Cargo Traffic Forecast

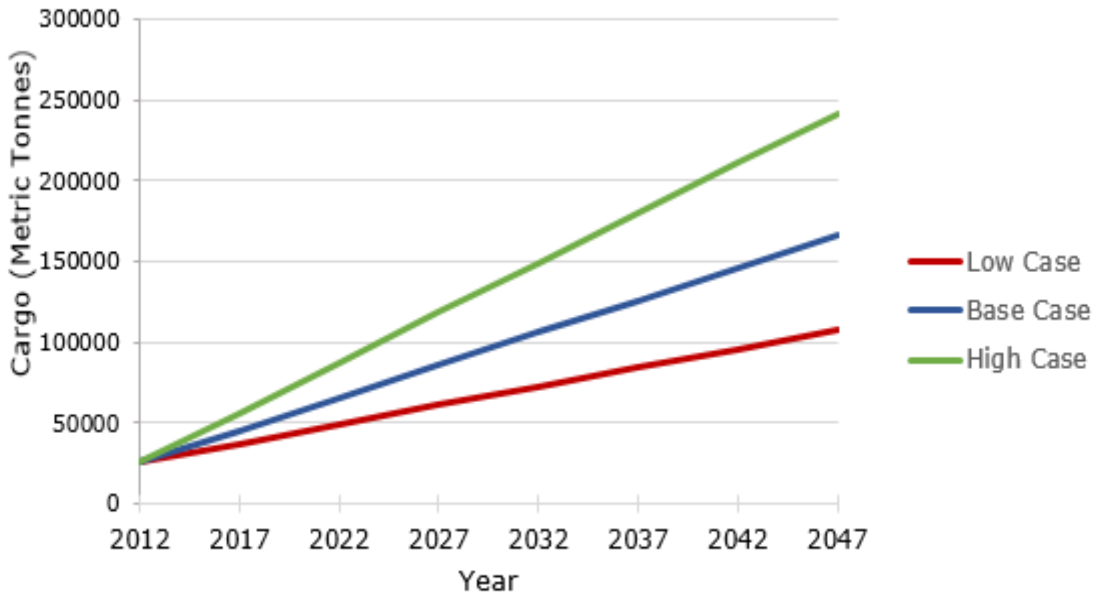
In terms of international import and export cargo, the forecasts for the low, base and high case scenarios for KIA are shown in Figures 7.8 and 7.9 respectively.

Figure 7.8: KIA International Imports Cargo Forecast (Metric Tonnes)



Source: KIA Masterplan, Final Report, 2008 updated by GIP Team

Figure 7.9: KIA International Export Cargo Forecast (Metric Tonnes)



Source: KIA Masterplan, Final Report, 2008 updated by GIP Team

7.4.2 Ghana's Airports Development

Within the plan period of the Ghana Infrastructure Plan, there will be enhanced interconnectivity between the country's airports. This will facilitate the movement of passengers and freight in an efficient and effective manner. The following section indicates the future roles of the various airports in the plan.

Kotoka International Airport (KIA)

KIA will remain an international aviation hub. It has huge potential to improve its market position. It will also continue to serve all domestic airports in Ghana. It is expected that Ghana will regain its Category 1 status based on United States Federal Aviation Administration assessment of the safety oversight provided by the Ghana Civil Aviation Authority (GCAA).

There is a master plan (including land use plan) which incorporates on-going projects and provides a cohesive framework for the future development and growth of KIA. The plan was created to identify the aeronautical and intermodal requirements of anticipated demand, surface area as well as potential environmental and socio-economic impact. Some aspects of the masterplan have either been implemented or are in progress.

Kumasi Airport

Kumasi Airport will function as an international airport. In 2013, the actual cargo volume was 43,688 tonnes[56], but the National Airport System Plan projects a cargo volume of over 60,000 tonnes in 2035. However, due to limited runway expansion opportunities, a new airport is planned on the outskirts of Kumasi and a site has been identified under the Greater Kumasi Urban Development Plan.

In the meantime, the technical masterplan for the existing Kumasi Airport outlines the development phases required to facilitate operations at the airport. Some aspects of the masterplan have been implemented while others have been phased according to the traffic forecast (Table 7.4).

Table 7.4: Development Phases of Kumasi Airport

Phase	Period	Description
Phase 1	2015 – 2020	Construction of new infrastructure in order to provide sufficient capacity according to the demand and to comply with international standards. Construction shall be completed latest in 2020. Applied design parameters are derived from the figures related to the capacity demand of year 2022
Phase 2	2021 – 2025	Further expansion measures shall be implemented by 2025 to meet the capacity demand of 2030
Phase 3	2026 – 2035	To cover the demand of 2035 and beyond, further expansion shall be implemented, according to the Master Plan

Source: Technical Masterplan for Kumasi Airport, Final Report, 2015

Due to rising air traffic demand and additional facilities planned on airport land (offices, shopping mall, and health facilities), traffic within the proximity of the airport is expected to rise tremendously. If these traffic challenges are not addressed from the beginning, congestion will worsen and it will impact negatively on productivity, safety, environment and socio-economic development.

It is recommended that collaboration between stakeholders starts with a study identifying future traffic development based on proposed land use and market capacity. As a result, stakeholders will be able to identify whether road construction as compared to the provision of an effective and efficient traffic management system – including the effective use of the traffic light system – will suffice. The development of an efficient

[56] Technical Masterplan for Kumasi Airport, Final Report, 2015

transport network to regulate the flow of traffic is highly recommended. This may include public mass transportation to reduce the number of vehicles within the area.

Tamale Airport

Tamale Airport will also function as an international airport. Currently, it serves domestic passengers and occasional international charter flights on request. It has the potential to generate international traffic and is therefore currently being upgraded to serve both international and domestic passengers.

Sunyani Airport

Sunyani Airport will continue to function as a regional domestic airport for the Brong-Ahafo Region. There is no anticipation for international flights within the planning period. A category B role is envisioned.

Takoradi Airport

Takoradi Airport is currently owned and operated by the military. It cannot be expanded in its current condition. As a result, a new greenfield airport development is planned to operate it as a regional airport.

Wa Airport

Wa Airport has recently been upgraded to a regional airport status to support the development of the Upper West Region.

Ho Airport

Ho Airport is under construction and will be upgraded to a regional airport status.

Paga Airstrip

The Paga Airstrip is in poor condition. Its current location close to the Burkina Faso border makes it necessary to relocate it. A new greenfield airport is envisioned for the Upper East Region.

Other Airports

According to the National Transport Policy of 2008, each region in the country should operate airport facilities of role category A or superior. The following major airport development projects are therefore envisioned within the planning period:

i. Princess Town, Western Region (development of new greenfield airport to take over the traffic from Takoradi);
ii. Prampram, Greater Accra Region (PPP development of greenfield international airport);
iii. New Kumasi Airport (Ankaase), Ashanti Region (development of new greenfield international airport);
iv. Bolgatanga, Upper East Region (development of greenfield regional airport);
v. Cape Coast, Central Region (development of greenfield regional airport);
vi. Koforidua, Eastern Region (development of greenfield regional airport);

Table 7.5 shows the summary of the airports/aerodromes envisioned for the development of the country's aviation industry.

Table 7.5: Summary of Airports/Aerodromes for the Planning Horizon

Airports	Region	Category of Airport		Future Status
		Current category	Future category	
Kotoka International Airport	Greater Accra	D	D	Hub Airport
Kumasi	Ashanti	C	C	International Airport
Tamale	Northern	C	C	International Airport
Sunyani	Brong Ahafo	B	B	Regional Airport
New Takoradi (Princess Town)	Western	-	B	Regional Airport
Ho	Volta	A	B	Regional Airport
Wa	Upper West	B	B	Regional Airport
Bolgatanga	Upper East	A	B	Regional Airport
Cape Coast	Central	-	B	Regional Airport
Koforidua	Eastern	-	B	Regional Airport
Prampram	Greater Accra	-	C	International Airport
New Kumasi (Ankaase)	Ashanti	-	C	International Airport
Mole	Northern	F	A	Regional Airstrip
Yendi	Northern	F	A	Regional Airstrip
Okwenya-Akuse	Eastern	F	A	Regional Airstrip

Source: GIP Team

7.4.3 Development of Airport Related Service Industry

A strategy is being prepared to regulate the use and development of land within the vicinity of the country's airports in order to stimulate investment in airport related service industries. Figure 7.10 is an artist's impression of land use planning for KIA airport-related industry, phases 2 and 3.

Figure 7.10: Land Use Plan of future airports – Artist's Impression

Source: Ghana Airports Company Limited

7.4.4 Aviation Safety and Security

The modernisation of air traffic control (ATC) systems is key to improving efficient operation and safety of airflows. ATC is a critical component of the air transport infrastructure. It is made up of a network of navigational aids, communication systems and manned control centres that direct and coordinate the aircraft flows in an efficient and safe way. In addition, the use of satellite and data-based technologies offers the most cost effective way to upgrade and modernise the provision of communications, navigation and surveillance infrastructure. Improving safety and security in the aviation sub-sector requires the full commitment and cooperation of all stakeholders and it will be pursued.

Chapter 8 Maritime

8.1 Introduction

The maritime sub-sector consists of the ports and the inland water transport systems of the country. Ports and inland water transport systems play very strategic roles in Ghana's socio-economic development. Whereas ports are the main international gateways for the country's import and export trade, inland water transport systems provide transport services mainly to local communities within the catchment area of the water body (river or lake), by linking ferries from one end of the water body to the other as well as providing tramping and cargo transfer services.

It is estimated that 90% of Ghana's international trade in merchandise by volume is routed through the seaports of Tema and Takoradi[57]. The ports also handle significant volumes of traffic destined to landlocked countries northwards of Ghana. The inland water transportation systems play similar roles as the ports by serving as a major means of transportation for people and goods. However, the performance of the sub-sector is challenged by myriad problems. There is an increasing amount of congestion at the facilities, non-existent intermodal interchange infrastructure and hinterland connectivity, and longer cargo dwell times relative to modernised systems. Therefore, this section presents the strategies to address the problems associated with the maritime industry in order to facilitate the socio-economic development of the country.

8.1.1 Vision

The vision is "to provide an efficient and reliable multimodal transport/ logistics and local connection transport system, and contribute to enhance regional economic development within a safe, affordable and sustainable environment."

With respect to the country's ports, the vision is not only to make them the leading trade and logistics hub of West Africa, but also to open up opportunities for accelerated socio-economic and industrial development in the sub-region, through Ghana.

8.2 Main Institutions within the Maritime Sub-Sector

8.2.1 Ghana Maritime Authority

The Ghana Shipping Act, 2003 (Act 645), mandates the Ghana Maritime Authority (GMA) to ensure safety of life at sea and inland waterways, and to protect the marine environment in order to facilitate the contribution of these assets to socio-economic development of the country. GMA's activities include the following: survey and inspection of boats on the inland waterways, training of boat operators/mechanics, the registration of ships, seafarers and related functions, operations (surveys, inspections and certification of ships), port state control of foreign ships, and flag state control of Ghanaian ships.

[57] Ghana Ports and Harbours Authority, 2015

The Authority is also responsible for conducting investigations into shipping casualties, manning of ships, crew welfare matters, and dealing with matters pertaining to prevention and control of marine pollution, the adoption and implementation of international maritime conventions, search and rescue, ship-building, ship-repairing, ship recycling, wrecks, dry-docking and port operations.

Maritime Domain Awareness Programme

In order to assist the government and security agencies to enforce security measures in our maritime domain, the GMA is to implement a Maritime Domain Awareness Programme to provide comprehensive information about Ghana's maritime domain through electronic surveillance systems.

The GMA obtained approval from the International Maritime Organisation (IMO) to establish an Area to Be Avoided (ATBA) around the Deep Water Port (DWP). The ATBA was established in order to enhance safety of navigation and ensure security of offshore installations and vessel traffic management in the vicinity of the Jubilee Field Terminal.

The ATBA alerts mariners to the presence of the floating production, storage and offloading (FPSOs) installations as well as underwater well-heads and production systems to ensure that mariners, including fishermen and vessels transiting the area, avoid interference with terminal operations at the oilfields.

Maritime Security

The Authority superintends the Ghana Maritime Security Act, 2004 (Act 675) and implements the provisions of this Act to ensure safety and security within Ghana's maritime domain. Act 675 also provides the legal framework for implementation of the International Ship and Port Facility Security Code (ISPS Code). It requires measures to be taken to ensure the safety and security of ships and port facilities. Thus in June 2011, the Authority signed an agreement for the procurement and installation of a Vessel Traffic Management Information System (VTMIS) for coastal surveillance and an Automatic Identification System for the Volta Lake.

8.2.2 Ghana Ports and Harbours Authority

The Ghana Ports and Harbours Authority (GPHA) is a state-owned enterprise (SOE) established by the Ghana Ports and Harbours Authority Act (PNDC Law 160) of 1986, mandated as the sole authority to plan, build, develop, manage, maintain, operate and control ports in Ghana.

By 2030, GPHA expects to have completed all its planned projects that would make the Port of Tema the leading container hub of the ECOWAS region, and the Port of Takoradi a dominant oil and gas services hub and a dry bulk/mineral ore cluster. Achieving hub status will transform the ports into veritable growth poles for industry, trade and regional socio-economic development.

In response to growing maritime trade demand, GPHA has over the years undertaken various master plan studies to guide infrastructure and organisational development of the ports.

8.2.3 Volta Lake Transport Company Limited

The Volta Lake Transport Company Limited (VLTC) is incorporated under the Companies Code 1963 (ACT 179) to operate as public carrier of all forms of water–borne transport, including hovercraft, for persons and/ or freight on the Volta Lake. VTLC is a subsidiary of the Volta River Authority (VRA), and manages existing inland water transport infrastructure while the latter provides oversight responsibility.

8.3 Existing Situation of the Maritime Sub-Sector

8.3.1 Overview

In 2016, GMA surveyed and issued certificates to one hundred and sixty-eight (168) ships comprising one hundred and thirty-two (132) fishing vessels and thirty-six (36) cargo/supply vessels. In addition, the Authority undertakes the upkeep and maintenance of national shipping fleets; and also, other related maritime activities such as maritime training (the conduction of examinations leading to the issuance of the appropriate certificates of competency and/or proficiency to various seafaring personnel). These training programmes are also conducted for the local people from the villages dotted along the Volta Lake like Dambai, Dzemeni, Kete-Krachi, Kpando-Torkor, Tapa Abotoasi and Yeji.

8.3.2 Ports and Harbours

Ghana’s two main seaports are in Tema and Takoradi. Adjoining these two seaports are the Tema and Sekondi Fishing Harbours respectively. GPHA currently owns, manages and operates these two seaports. It also owns and manages the Fishing Ports in Tema and Sekondi.

Waiting Time at Anchorage

Average ship waiting time at anchorage for Tema Port indicated significant improvement from 47 hours (almost 2 days) in 2005 to 31 hours (about 1.5 days) in 2010 whereas that of Takoradi increased from 11 hours in 2005 to 17 hours in 2010 due to the oil find. It is expected that the waiting times will decrease significantly after the expansion works.

The effectiveness and efficiency in the operations of Takoradi and Tema ports could be improved if the following issues are addressed appropriately. These challenges include:

i. Poor transport networks in and out of the ports;
ii. Inadequate spatial planning and enforcement of integrated port cluster development;
iii. Inadequate use of ICT in port operation systems and processes to ensure efficiency.

Dry Dock Infrastructure

Ghana has one dry dock facility, which is operating below capacity. It is situated at the shipyard of the Tema Port. The shipyard facility has two docks, a slipway and a fitting-out quay. There are also major mechanical workshop facilities originally planned for a full-fledged shipyard and shipbuilding activities. As of May 2017, the shipyard facility has begun to recover from a period of poor maintenance and mismanagement by various entities. It requires a major facelift and reorganisation as part of the Ghana Ports and Harbours Authority.

GPHA has plans to revamp the facility into a one-stop ship repair and rebuilding base on the west coast of Africa. The capacity of the Port of Tema Shipyard ranks first along the west coast's port facilities. However, it needs to be substantially re-organised to realise its full potential and to maximise the available land. The spatial plan and basic infrastructure of the facility hold immense potential for at least half a century of growth.

Artisanal Fishing and Canoe Landing Facilities

There are modern fishing ports at Tema and Sekondi which receive large fishing trawlers and vessels. However, given the prevalence of artisanal canoe fishing communities along the coast, the government, in collaboration with GPHA, launched a plan to develop 11 new or re-organised boat (canoe) landing facilities in fishing communities along the coast for improved seafood security. Considering that a large section of coastal dwellers resides in these fishing communities, the communities need to be carefully restructured. There must therefore be an integrated coastal zone management plan covering the complete structures for these canoe fishing ports and industry.

Tema Fishing Harbour

The Tema Fishing Harbour (TFH) is located to the east of Tema Port, and is made up of the Inner and Outer Fishing Harbours and a canoe basin. Other facilities located within and outside the fishing harbor include a fish market hall, ice plants, fish processing plants and several private cold stores.

Sekondi Fishing Harbour

GPHA is also responsible for the management of the Sekondi Fishing Harbour (SFH). There are sub-committee units responsible for the fishing communities such as the boat owners, fish sellers, pre-mixed fuel dealers, all regulated by the GPHA personnel appointed as manager of the SFH.

8.3.3 Inland Water Transportation

The Volta Lake is the main inland transport waterway in Ghana. It has a total surface area of about 8,502 km^2 and stretches to about 450 km from the north to the south. The communities within the Volta Lake basin are engaged mainly in farming and fishing. Many of these communities are however isolated due to inadequate road linkages. The Lake therefore serves as a major means of transportation for the indigenous people, and utilised for passengers as well as transferring farm produce to markets in neighbouring communities. Given the agricultural and mining potential within the communities scattered in and around the Volta Basin, it is important that this mode of transportation be developed adequately to support the socio-economic development of the area. The main challenges are as follows:

i. Facilities are generally not in good condition and therefore need maintenance or rehabilitation;
ii. Aging equipment, inadequate navigational aids and the lack of regulation for canoe construction, use and operations on the Lake; and
iii. Annual periodic drops in the level of the lake expose sand banks and tree stumps and other underwater obstructions that greatly hinder navigation along the length of the Lake.

The following comprise the existing infrastructure that supports inland water transport on the Volta Lake:

i. Vessels for north-south and tramping cargo routes, ferries and boats for informal services;
ii. Landside infrastructure for informal services, ferries, tramping cargo routes and port infrastructure at Akosombo;
iii. Warehousing and logistics installations;
iv. Roads connecting to lake transport services, including access roads between community and landside infrastructure, and feeder roads connecting from major roads to local communities in the case of ferries; and
v. Transport connection (road and rail) between Tema and Akosombo.

Current surveys show that about 69% of passengers plying the Volta Lake travel on market days, while about 31% travel on non-market days. The Yeji-Makango crossing seems to be the prime route, with estimated traffic of about 550,000 passengers yearly. The Dzemeni-Galelia; Digya Park–South Otisu Island–Tapa Abotoase; Kete Krachi – Kojokrom; Dambai – Dodoikope crossings are also principal sites, each accounting for more than 200,000 passengers annually. The major ferry stations along the course of the Lake as well as the type of service provided are summarised in Table 8.1.

Table 8.1: Major Ferry Stations along the Volta Lake

Transport Service	Port	Span (km)	Type of Cargo
North – South	Akosombo-Buipe-Yapei	Buipe (km 415) Yapei (km 450)	Passengers Liquid cargo: Diesel oil, kerosene, petrol Solid Cargo: Agricultural inputs and produce, general cargo, construction materials
Cross – Lake	Adawso-Ekye Amanfrom	4.6	Passenger Vehicle Other types of cargo
	Dambai and Over Bank	3.7	
	Kete Krachi – Kwadjokrom (Deifo)	12.03	
	Yeji – Mankango	10	
	Agordeke – Kpando Torkor	32	

Source: ROCHE - Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014

8.4 Development of the Maritime Sub-Sector

8.4.1 Port Infrastructure Development

Currently, GPHA has prepared two master plans to guide the expansion and development of Tema and Takoradi Ports. The plans are being executed over the GIP period.

Development Plan for Tema Port

The Tema Port Development Plan (2013–2043) is informed by traffic demand forecasts. It is a 30-year plan for which implementation started in 2015. The infrastructure development is phased to respond to traffic demand forecast. Table 8.2 indicates the traffic demand forecast.

Table 8.2: Main Commodities Cargo Projections for Tema Port (2023-2043)

Cargo/Target Year	2023	2033	2043
Container (1000 TEU)	2,095	3,494	4,581
Bagged Cargo (1000 tonnes)	1,427	1,664	1,696
Dry Bulk (1000 tonnes)	4,777	6,765	8,184
Liquid Bulk (1000 tonnes)	1,102	1,536	3,077
General Cargo (1000 tonnes)	1,111	1,577	2,195

Source: Tema Port – Feasibility and Master Plan Report

The capital expenditure required for the planned infrastructure investments is estimated at about USD2 billion, spread over the period 2016 to 2033. Table 8.3 also provides an overview of the distribution of the necessary infrastructure investments (including engineering costs and contingencies).

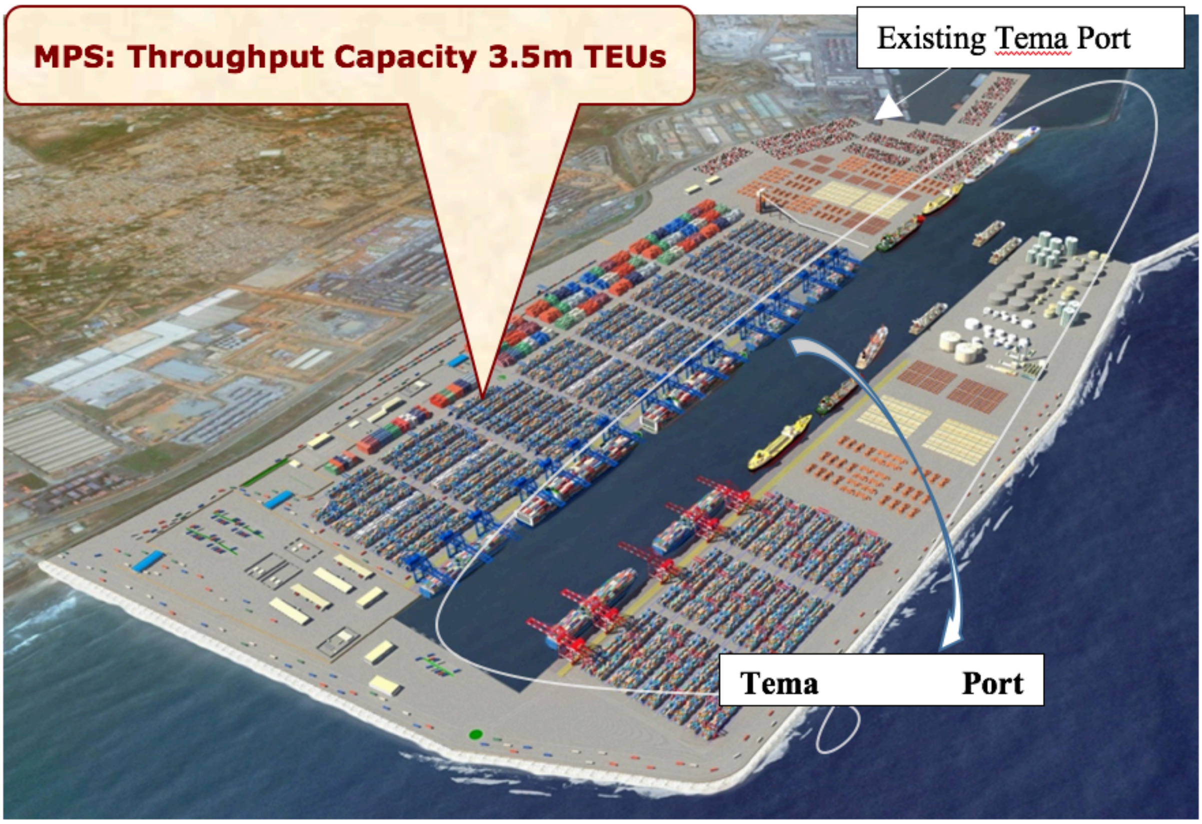
Table 8.3: Tema New Container Terminal Infrastructure Investment Cost (Estimates)

Item	Phase 1 ('000 USD)	Phase 2 ('000 USD)	Phase 3 ('000 USD)	Total ('000 USD)
Dredging	77,408	-	24,922	102,330
Reclamation	354,153	94,860	96,465	545,479
Breakwater	394,852	-	43,914	438,766
Quay Walls	188,800	80,240	82,600	351,640
Pavement, Terminal Access	269,748	20,768	9,912	300,428
Utilities	233,168	20,768	9,912	263,848
Fencing	1,614	226	276	2,116
Buildings	14,585	5,664	3,257	23,506
Gate Complex	1,180	-	-	1,180
Total	**1,535,508**	**222,526**	**271,258**	**2,029,292**

Source: Sellhorn, 2014

The equipment investments required to establish the various terminals consist of investments in quay cranes for vessel loading and unloading, horizontal transport machines for container transport between quay and storage yard, stacking equipment and miscellaneous terminal equipment. Ship-to-Shore (STS) cranes have been recommended for vessel operations, while rubber-tyred gantries (RTG), reach stackers (RS) and empty container handlers (ECH) will be deployed as stacking equipment, and tractor-trailer units (TTU) are planned as horizontal transport equipment. Works began in late 2016 and should be completed by 2022, though sections of this Phase will start operations by the end of 2019. The other phases are expected to unfold with the years as planned. The GPHA intends to develop Ghana's ports in readiness for the needed socio-economic growth and keep the competitive advantage within the maritime market. The capital expenditure required for the planned total infrastructure investments is estimated at about USD 2.0 billion, spread over the period 2016 to 2033.

Figure 8.1: Proposed Tema Port Expansion Project



Source: Ghana Ports and Harbours Authority

Development Plan for Takoradi Port

The Takoradi Port is being re-positioned through an extensive expansion and modernisation programme to better serve the needs of the oil and gas, mining and trading sectors. The key components in the development plan are:

i. Access channel dredged to 17.0 m water depths;
ii. Extension of breakwater 1.08 km northwards;
iii. Construction of bulk terminal with 16.0 m depth and 800 m quay length;
iv. Construction of oil services terminals;
v. Construction of multipurpose terminals berths with 1.65 km quay length;
vi. Construction of open storage area for oil field plants and machinery;
vii. Construction of selected access roads (in and out) to the Port.

Total investment cost for the final extension of Takoradi Port is estimated at USD990 million. The development strategy of GPHA is to invest in the basic port infrastructure of the breakwater and dredging, on behalf of the state, and cede the various terminal operations and services to private entities under strict terms and conditions.

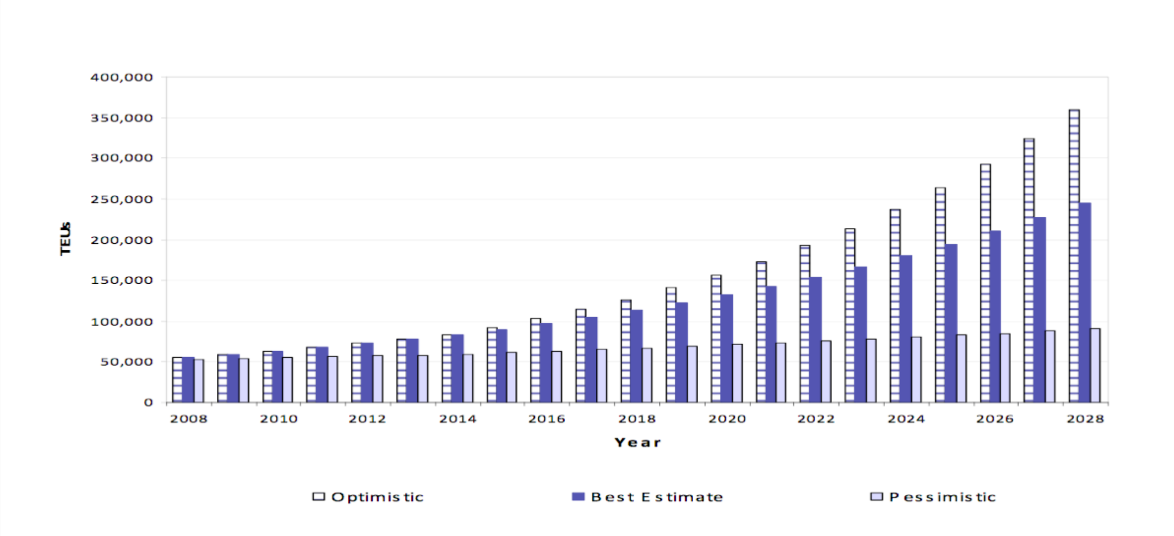
Table 8.4: Proposed Phasing of Takoradi Port Development

Phase	Completion Date (Capacities Available)	Construction Works
As-Is	May 2016	**Jan de Nul Project:** New breakwater Dry bulk pier: one berth 200 m length, -14m water depth (without equipment and pavement => not operational) Access channel, -17m water depth Turning basin, -16m water depth Oil/Cement area, -12m water depth
Phase A	Beginning of 2017	**Construction works to make dry bulk pier operational:** Installation of 1 loader for manganese Installation of 1 conveyor belt Pavement Relocation of manganese area Oil services hub area: Land reclamation at western side of harbour basin (Main Harbour), pavement and utilities
Phase B	Beginning of 2018	**Multipurpose and Container Terminals Construction** Construction of berths and reclamation works on southern side of new harbour basin for the development of container and multipurpose terminals.
Phase C	Beginning of 2019	**Oil Service Hub area:** Completion of oil service hub area including quay wall construction **Ship repair yard:** Dredging to -14m in main harbour basin and -14m in floating dock area and reclamation at old breakwater, construction of quay walls **Completion of dry bulk length:** Construction of quay wall for 2 new dry bulk berths Installation of 1 additional loader and 1 additional unloader Installation of additional conveyor belt New oil berth incl. pipelines **Multipurpose area – Phase 1:** Reclamation of land north of old pier Construction of 1st multipurpose berth on southern side of new harbour basin (Northern Basin) Other port and access facilities: Rehabilitation of existing pier New marine station, new civil engineering block, pavement + internal roads, access roads, access railway, bridge expansion, 2 gates etc.

Source: HPC/Sellhorn, 2015 and GPHA

The growth forecast of cargo and containerised port operations is indicated in Figure 8.2, demonstrating the need for rapid growth of Takoradi Port.

Figure 8.2: Takoradi Port Growth Forecast



Source: Sellhorn, 2014

Tema Shipyard and Drydock

In July 2016, the government assigned the PSC Tema Shipyard and Drydock to GPHA's management. The goal of GPHA was to return the Tema Shipyard to profitability. This will require infusion of new capital to rehabilitate rundown equipment, modernise facilities, acquire new equipment and provide technical training for staff. Acquisition of International Ship Repair Permits and Certifications will be needed for the promotion of the facility to international customers. A business case is currently under preparation to revive the facility.

Kpone Unity Terminal

This project involves the development of an Inland Clearance and Container Devanning Terminal in the Kpone Katamanso District of Tema. The area is about 40 acres and this would be used for devanning activities as additional capacity to the Golden Jubilee Terminal. It is also meant to divert the associated vehicular and human traffic away from the port area.

Boankra Inland Port

In furtherance of the Ghana Trade and Investment Gateway (GHATIG) Programme, the Ministry of Transport, acting through its agencies the Ghana Shippers' Authority (GSA) and GPHA, is promoting the development of an Inland Port at Boankra.

The Boankra Inland Port (BIP) Project will be an international business and distribution centre, offering similar services as a seaport without a waterfront. The BIP Project is to be sited on a 400-acre land at Boankra in the Ashanti Region.

The Boankra Inland Port will include the following components:

i. Container handling and storage depot;

ii. Custom bonded and open warehouses;
iii. Custom bonded sheds;
iv. Devanning yard;
v. Railway marshalling yard;
vi. Light industry zone;
vii. Truck parking areas.

It is expected that the combined Boankra Inland Port and the Eastern Railway Line Project when implemented will:

i. Create job opportunities for the people in and around Boankra;
ii. Reduce the aggregate transport cost of international cargo to importers and exporters from the middle and northern parts of Ghana;
iii. Facilitate the use of Ghana's transit trade corridor by the landlocked Burkina Faso, Mali and Niger;
iv. Promote the establishment of export processing zones in the vicinity of the inland port; enhance and facilitate customs examination, duty payment and cargo clearance;
v. Provide efficient and safer alternative to the road network, which is already congested, that is, when the rail system is revived.

The broader objective is that the inland port will provide depots, warehousing and other storage facilities for freight that moves directly and safely through and from the main seaports on the railway line and to ensure that both projects complement each other.

This project provides a unique opportunity for recapturing transit trade to the landlocked countries of Burkina Faso, Mali and Niger. The total estimated cost for the development of BIP is US$120million. Various PPP development options are being explored towards the development of the enclave.

Marine Fishing Ports/Landing Sites

The fisheries sector plays a major role in the Ghanaian economy. Although it contributes only 3% of gross domestic product (GDP), the indirect contribution is far more significant. The direct contributions include boat-yards, suppliers of auxiliary goods, services, etc. and foreign revenue. The indirect contributions are based on the importance of fish as a source of protein, indispensable for a balanced human diet.

It is estimated that over 150,000 fishermen are engaged in marine fisheries and about 1.5–2 million people rely on and/or provide support to these fishermen, including wives, children, close relatives as well as canoe carvers, input suppliers and office workers for industrial fleets.

The government has selected the following towns for improvement and development into fish landing sites for artisanal vessels:

i. Ada, Teshie, Jamestown, and Tema in the Greater Accra Region;
ii. Axim and Dixcove in the Western Region;
iii. Elmina, Winneba, Mumford, Senya-Beraku, Gomoa-Fetteh and Moree in the Central Region;

iv. Keta/Anloga in the Volta Region.

The proposed landing sites are made up of several physical facilities that are to be developed under the project. The facilities relate to the peculiar physical characteristics and potential fish production capacity of each existing landing site:

i. Breakwaters for a sheltered berthing and anchorage bay;
ii. Quay walls for the berthing, loading/unloading of canoes and trawlers;
iii. Navigational aids for the safe arrival and departure of canoes and trawlers;
iv. Fish landing sheds for the transfer and sale of fresh fish under all weather conditions;
v. Ice blocks/crushed ice making plants for the manufacture and sale of ice to fishermen;
vi. Net mending and drying yards for fishermen to spread and mend or dry their nets.

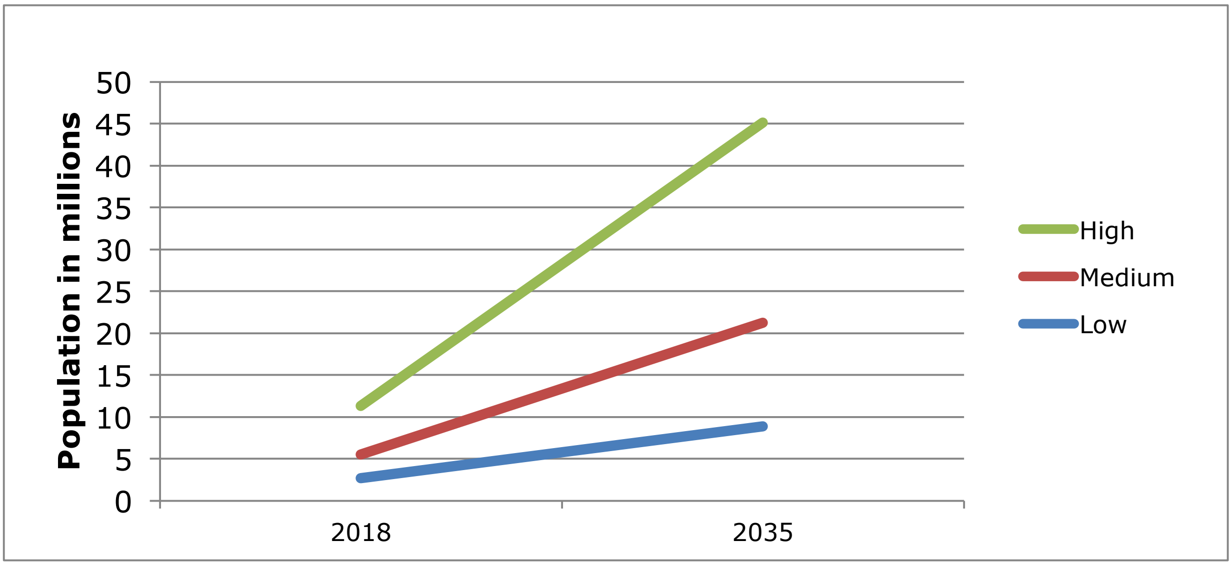
8.4.2 Development of the Inland Water Transport System

Passenger Forecast

It is estimated that between 2018 and 2035, the average number of passengers crossing the Volta Lake could increase from 11.3 million passengers per year to 45.6 million passengers (2035). This implies that passenger traffic around the principal crossing sites is expected to grow from 500,000 in 2018 to 3 million passengers per annum by 2035 (see Figure 8.3).

Freight transport on the Volta Lake to the northern part of the country is expected to grow from 262,000 tonnes in 2018 to 1 million tonnes by 2035, while that of the Northern and Central Lake areas will grow from 80,000 tonnes in 2018 to 360,000 tonnes in 2035. Consequently, ferry, local and tramping services as well as infrastructure will be developed to support the growth in both freight and passengers.

Figure 8.3: Yearly Passenger Traffic Forecast (2018-2035)



Source: ROCHE - Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014

Ferry, Local and Tramping Services and Infrastructure

Table 8.5 shows ferry services at various locations with an annual passenger forecast in 2018, and the action that needs to be taken, whether upgrading or new construction.

Table 8.5: Ferry Services and Action to be taken

Location	Ridership 2018 (pax/yr)	Action
Major Ferries		
Adawso/Ekye Amanfrom	500,000	Upgrading
Akateng/Adikukope	500,000	New Construction
Dzemeni/Galelia	500,000	New Construction
Kpando-Torkor/Agordeke	500,000	Upgrading
Dambai/Dodoikope	630,000	Upgrading
Kete Krachi/Kojokrom	630,000	Upgrading
Yeji/Makango	850,000	Upgrading
Intermediate Ferries		
Kpetchu/Adiembra	200,000	New Construction
Asuso/Begyemse	200,000	New Construction
Local Ferries		
Bridge-Ano-Ntaboma	90,000	Upgrading
Digya Park-South Otisu Island-Tapa Abotoase	120,000	New Construction
Kojokrom – Kete Krachi/ Atikagome-Sakpiti/ Okpalama/ Otisu Kpedzi	60,000	New Construction

Source: ROCHE - Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014

Even though it is not possible to make a clear forecast of tourism demand on the Lake over the plan period, there is a need for tourism services and infrastructure in areas around Akosombo, Digya Park and other urban centres around the Volta Lake area.

Transport on the Volta Lake is critical for boosting agriculture in the area, by moving produce from source of production to market centres. It is therefore important that crossing sites be planned to connect localities to market centres.

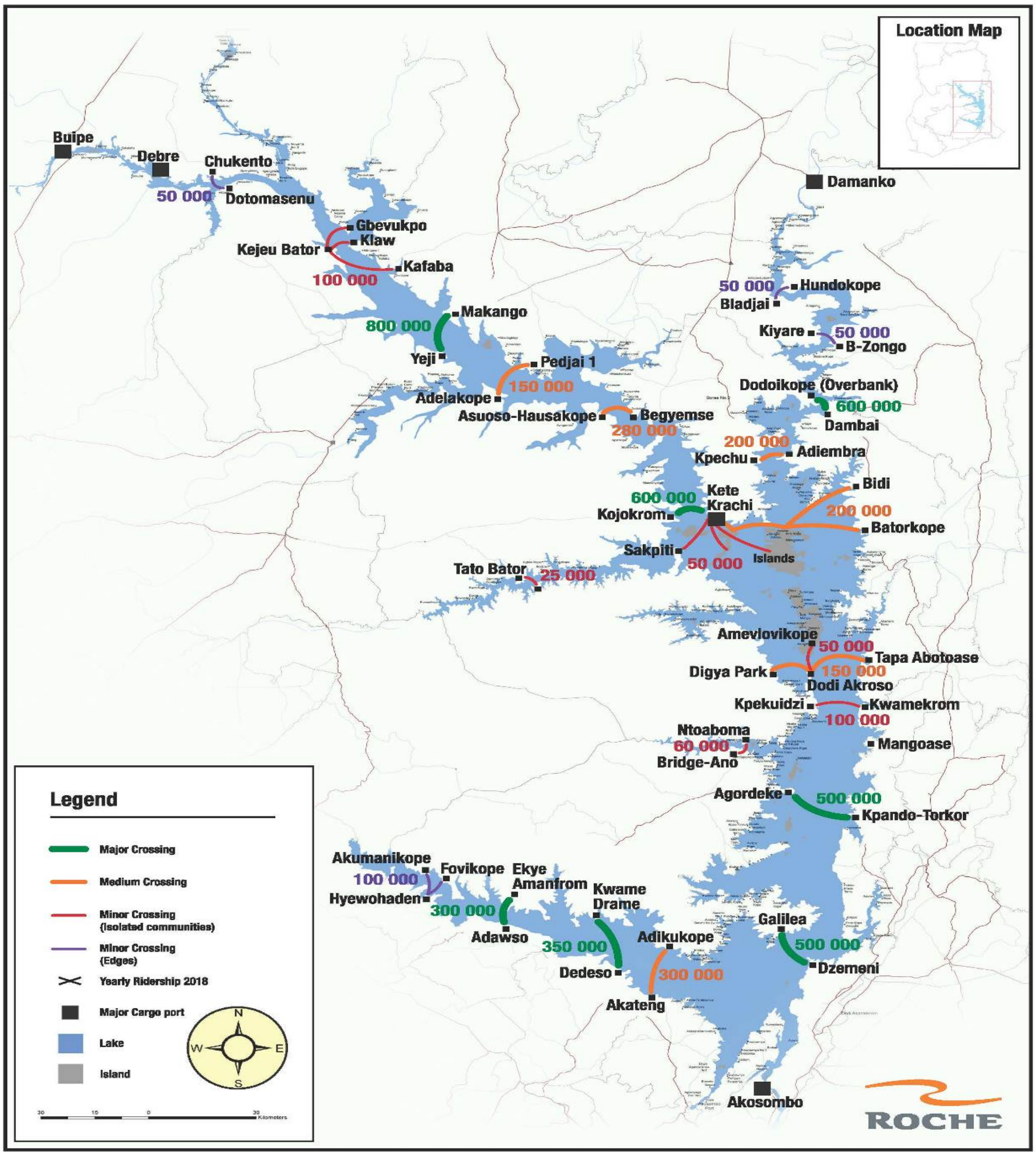
The transfer of freight on the Volta Lake to the northern part of the country as well as to landlocked neighbouring countries could also be a major area to capitalise on. Freight traffic is expected to fluctuate between 262,000 tonnes and 1 million tonnes in 2018 and 2035 respectively, while that of the Northern and Central Lake areas could vary between approximately 80,000 tonnes in 2018 up to about 360,000 tonnes in 2035. The volume of imports to the Afram Plains would be about 22,000 tonnes by 2018, and increase to 117,000 tonnes by 2035, all based on the medium case scenario.

On average, the landing stage investment cost for a local informal, ferry or tramping services is estimated at US$2.6 million. The costs are broken down as follows:

i. Landing Facilities — $900,000;
ii. Reception Facilities — $500,000;
iii. Accommodation Facilities — $300,000;
iv. Access Roads — $400,000;
v. Miscellaneous — $500,000.

Under the medium-term scenario, the forecast volumes would require two vessels for the north-south service and two vessels for the tramping service. One ferryboat is therefore required for each ferry cross-lake location.

Figure 8.4: Crossing Locations and Annual Passenger Traffic for 2018

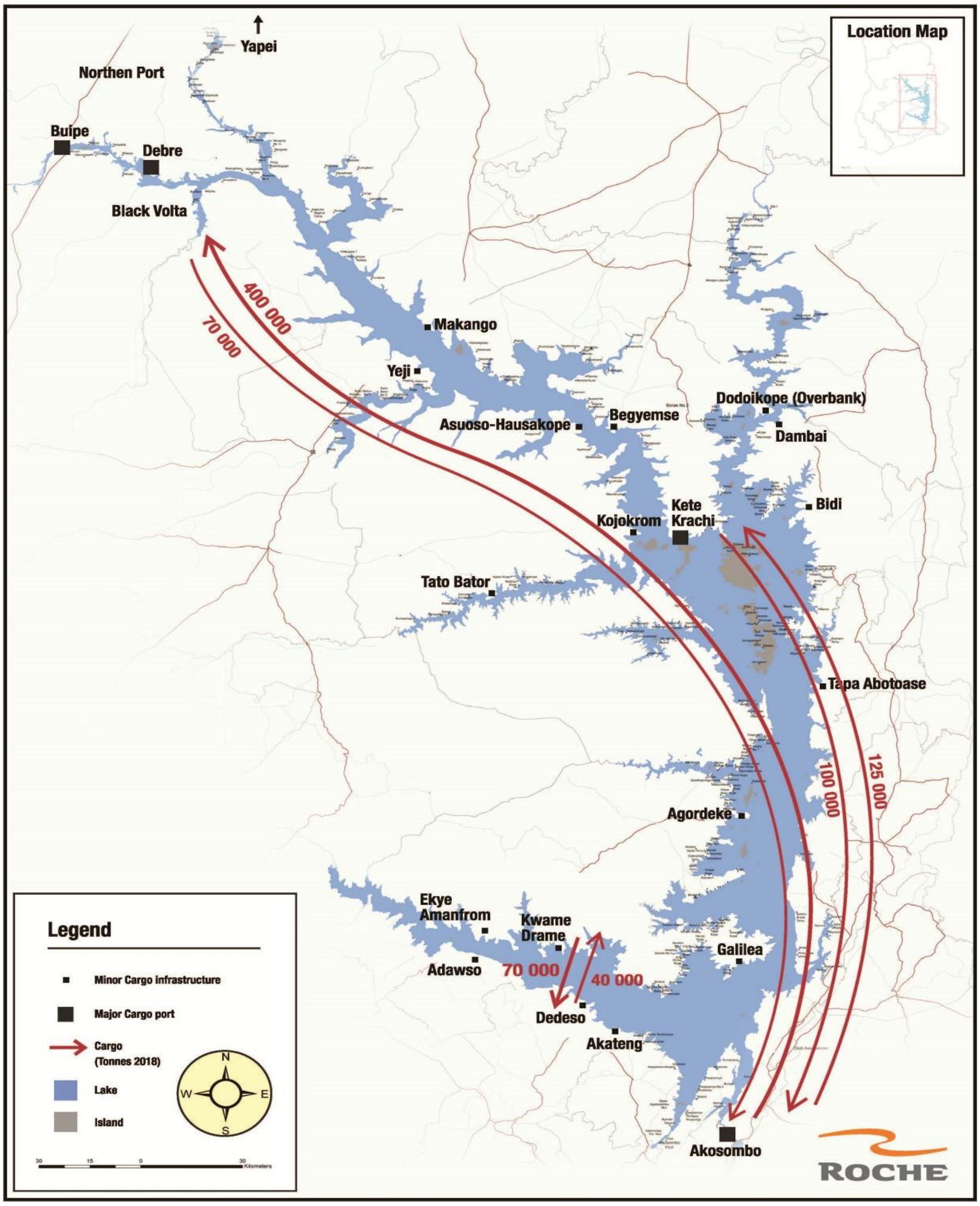


Source: ROCHE - Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014

The construction of a northern port should take the following into consideration:

i. Containerisation and handling capabilities;
ii. Workshops;
iii. Warehousing;
iv. Merchandise control; and
v. Offices.

Figure 8.5: Major Cargo Volume Forecasts for the year 2018



Source: ROCHE - Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014

Priority Locations for the Installation of Tramping Services

Priority locations for the installation of landing stages were selected based on the following indicators:

i. Boat numbers;
ii. Estimated Cargo;
iii. Class of passengers' numbers;
iv. Type of slope on the bank; and

v. Town ranking.

In addition, in terms of the qualitative aspects such as the slope of the shore and the proximity of locations to each other, the following sites were selected:

i. Akateng, Dzemeni and Tapa Abotoase were identified for future ferry services;
ii. Bruben and Hyewohoden were selected for the importance of their cargo;
iii. Yeji, Dambai and Makango as well as Adakope and Bidi - high interconnectivity; and
iv. Kete Krachi – as a high ranking town and the future lake transport hub.

Agricultural production and the population of the area were the major factors considered in selecting priority locations for the installation of tramping services (see Table 8.6)

Table 8.6: Priority Locations for Tramping Service Installation

Potential Locations	Area Population 2010	Remarks
Fosu, Galelia, Agordeke	218,235	Agricultural development, could also use ferries
Ntoboma	59,405	No competition
Tapa Abotoase	184,385	
Dambai	299,235	
Kete Krachi	61,000	Could also be used for north-eastern districts, connection with other services
Anyinamae - Boafri, Begyemse	168,000	High costs at Anyinamae, ferry potential at Begyemse, Lower costs at Lonto
Hausakope, Asuoso	59,405	Hausakope identified by VLTC, ferry and informal service potential at Asuoso
Yeji	129,248	
Makango	135,450	Could also be used for northern districts

Source: ROCHE- Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014`

Major Installations

In spite of Buipe being a preferred location for the Northern Port over Yapei, given its size and function as well as the extent of existing landing and the handling and storage infrastructure, accessing Buipe safely from Debre requires a minimum water level of 250 ft. (76.5m) at Akosombo. This situation has not occurred consistently over a period of time; however it could be resolved by either dredging the Black Volta or by enhancing the installations at Debre.

The cost of developing and upgrading the northern port is estimated at US$25 million, and must include containerisation handling capabilities, workshops, warehousing, merchandise control and offices.

Developing Akosombo to serve as a major cargo hub has been estimated at US$55 million. This will equip Akosombo with facilities to perform trans-modal functions such as handling logistics, warehousing and merchandising.

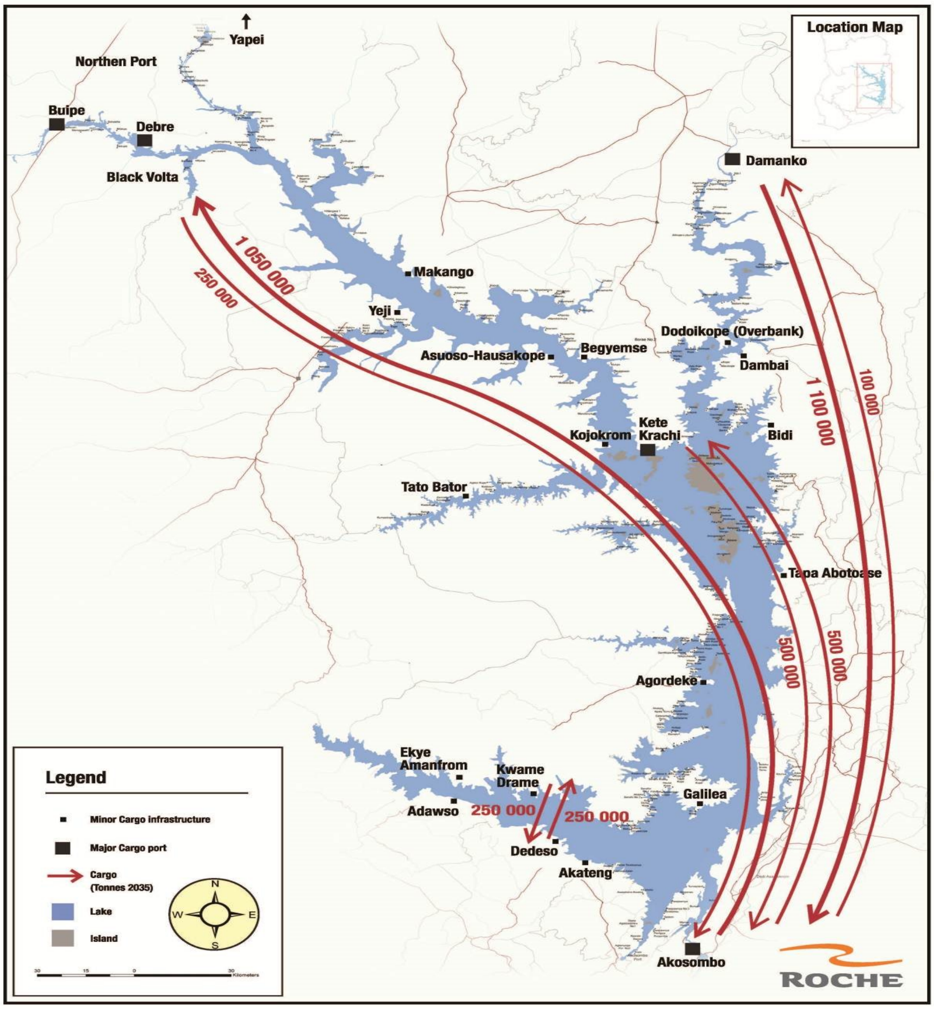
A fully integrated logistics system should be put into place for north south and tramping services, including some ferry connections, for example at Kete Krachi or Dzemeni.

Connections

Feeder roads need to be built to connect the different landing sites. Most of the cargo that passes through Akosombo either comes from or goes to Tema Port. This cargo must be transported by rail instead of trucking. A rail connection could also transport passengers between the lake area, Akosombo, Tema, and Accra. Given the volumes forecast, the railway is a solution to consider seriously in the medium term or over a longer timeframe. In 2017, the government awarded the contract for the construction of the Tema to Akosombo railway line.

Even though a railway would divert a large part of the cargo traffic and is most efficient for port-to-port, or port-to-storage/distribution centre movements, a number of passengers and cargo will continue to be transported by trucks. Therefore, the Tema to Akosombo road will be made a dual-carriageway, even as the construction of the new railway line is done. As a number of structures will be demolished along the right-of-way, it is expected that towns and settlements along the corridor will be planned and improved. The long-term cargo forecast for 2035 to and from Akosombo Port is shown in Figure 8.6.

Figure 8.6: Major Cargo Volume Forecasts for the year 2035



Source: ROCHE - Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014

Governance

In spite of the existence of a strong institutional framework, the contexts for coordination, collaboration and building of strong partnerships among stakeholders will be clearly defined, to ensure sustainability of the project.

A steering committee, coordinated by the Volta Lake Transport Company (VLTC) and comprising District Assemblies, MoFA, NDPC, MLGRD, MoT and Ghana Navy as well as the Department of Feeder Roads, Boat-Owners' Association and Boat-Builders' Association, will be constituted to manage and coordinate various aspects of the project.

The VLTC will ensure that enough boats and landing sites are provided and maintained in good condition for optimum performance. Total revenue accrued from the provision of transport services on the Lake will be sufficient to fund this.

Safety

1. There will be coherent regulations to enhance security on the Volta Lake. Steps to be taken include:

i. Identifying the most suitable navigation channels for all types of services plying the lake;
ii. Clearing navigation lanes of all obstacles, especially tree stumps;
iii. Demarcating suitable routes between destinations; and
iv. Resolving conflicts among all concerned stakeholders.

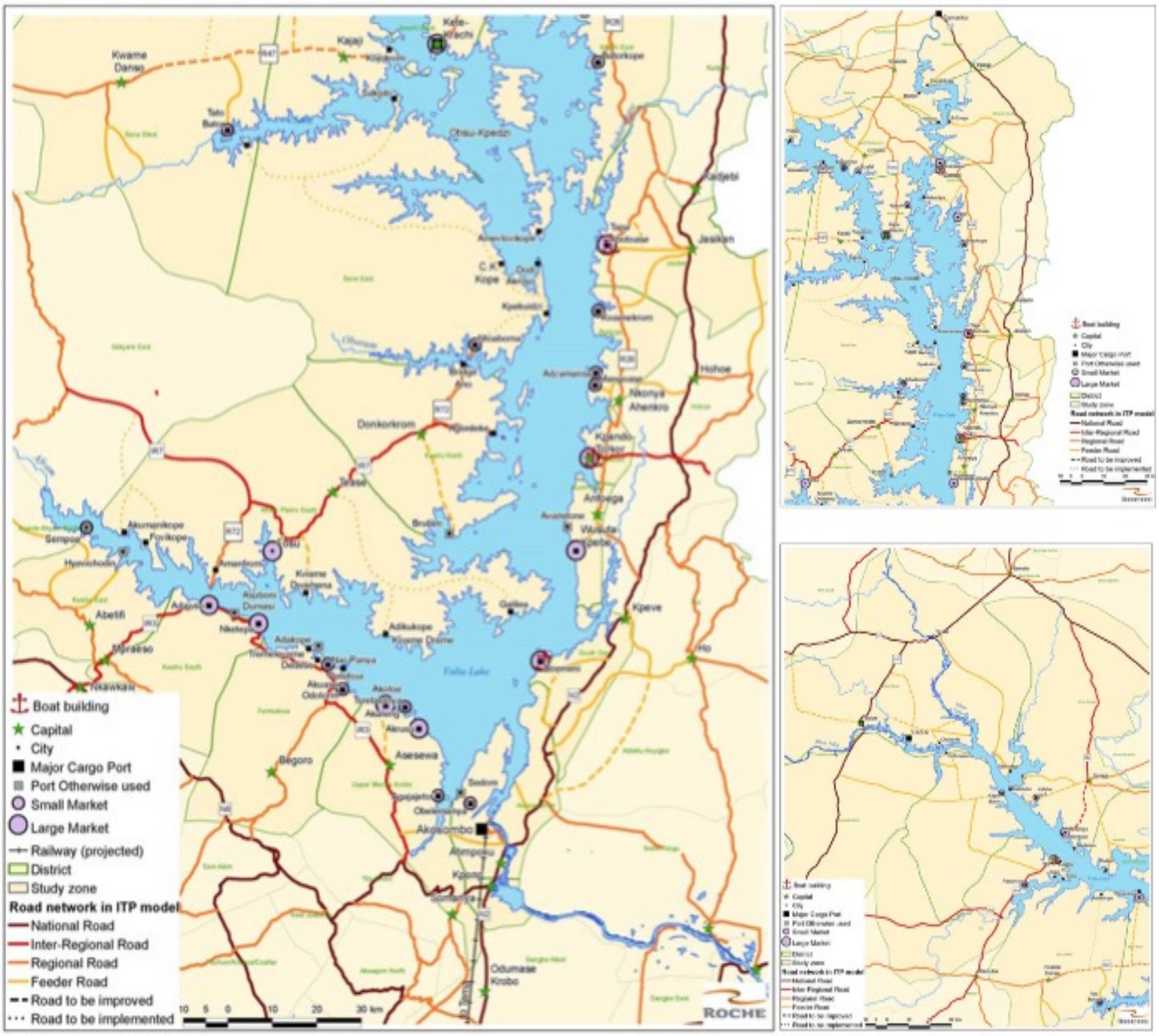
2. The following safety rules will be strictly enforced:
i. Intensifying the loading lines marking programme;
ii. Initiating specific boat loading regulations;
iii. Establishing desirable volume capacity of boats; and
iv. Empowering local associations and giving oversight responsibility for ensuring orderliness and sanity in the day-to-day operations.

Socio-Economic Development

There have been efforts to distribute basic services equitably around the Volta Lake area, however, it is the responsibility of the District Assemblies to plan on a long-term basis how to properly coordinate the transport system and the infrastructure on the Lake in order to optimise accessibility for their local populations.

Measures to be taken include the rehabilitation and maintenance of roads leading to and from boat landing sites as well as other social service facilities (e.g. health and market facilities, etc.), planning and growing medium or large towns around the Lake area to serve as growth poles. Figure 8.7 shows the road network that must be developed.

Figure 8.7: Landing Stages, Activity Centres and Road Connections



Source: ROCHE - Report for Preparation of a Medium-Term Master Plan for Transportation on the Volta Lake and its Surrounding Region, 2014

These settlements along the Lake will be well planned, and roads and other infrastructure leading to the towns along the Lake will be improved.

Figure 8.8: Sample bridge to be constructed at strategic locations across the Volta Lake

Source: Google images

Medium-sized towns will be developed into new growth poles to create jobs and provide alternative means of livelihood for the people.

Boat Building

The Ghana Maritime Authority (GMA) should adopt a standard boat design and size, giving consideration to the ability of the boat builders to develop and manufacture these in Ghana. These standards must be enforced and boat builders must comply accordingly. All new boats must undergo a registration process where they will be assessed to ensure that all requirements are adequately met, before they are licensed for operation.

Chapter 9 Railways

9.1 Introduction

The railway system comprises infrastructure and rolling stock (trains). The infrastructure is made up of the tracks or roadbed (including bridges and culverts); buildings (including station buildings, workshops etc. needed for train operations); and signaling and telecommunications systems (including safety assurance systems). The rolling stock is made up of locomotives, coaches, wagons, etc.

The main advantage of rail is its suitability for transporting bulk goods and passengers over long distances at cheaper rates. This buttresses the argument for ensuring the competitiveness of rail transportation in Ghana, particularly in view of the role played by other transport modes, especially road. Given its overall better safety record over road transport, rail transport should prove an attractive option to freight and passenger traffic. Rail transport also has great potential to address the challenges of reducing fuel dependency and thereby cutting down greenhouse gas emissions. Currently, rail transport's modal share in Ghana's transport mix is less than 1% for passenger traffic and 3% for freight. Future railway investments should therefore be planned and executed to achieve greater efficiency and attractiveness in order to grow its modal share.

9.1.1 Objective

The main objective of a rail investment plan is to improve the attractiveness of rail transportation in Ghana in relation to other means of transport and ensure it better serves the nation. Ghana is now poised to improve the entire rail travel chain, including ticket purchase, provision of real-time passenger information using modern communications technologies, clean and attractive passenger coaches, safe and clean passenger terminals and excellently maintained tracks for both passenger and freight trains.

9.2 Overview of the Railway Sector

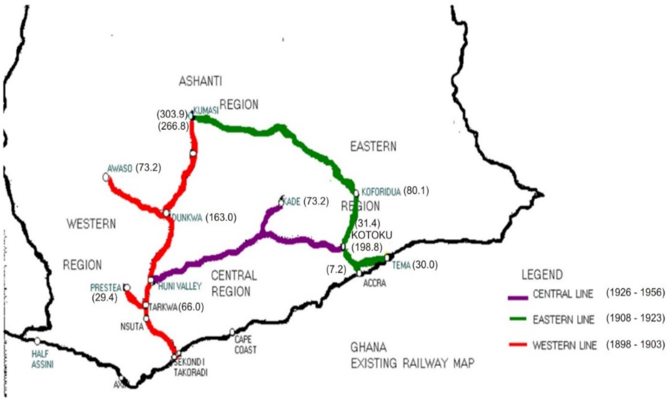
9.2.1 Rail Network Size

The railway network consists of 947 km route of 1067 mm gauge tracks (or a total of 1200 km of lines) located in the southern one-third of Ghana (Figure 9.1). The railway is predominantly single-track (except a 30 km stretch from Takoradi to Manso which is double track) and uses diesel electro-motive power.

The network forms a triangle between the cities of Takoradi and Accra, located about 200 km apart on the southern coast of Ghana, and Kumasi located about 250 km inland. The main network lines are designated the Western Line (Takoradi-Kumasi), Eastern Line (Accra-Kumasi), and Central Line, which connects the Western and Eastern Lines running parallel to the coast and about 80 km inland.

Track conditions have so deteriorated that out of the 947 km, only 13% is operational to some extent. A suburban passenger service operates between Accra and Tema, while another passenger train service runs between Accra and Nsawam on the Eastern Line. On the Western Line, a limited manganese freight service runs between Takoradi and Nsuta. The Central Line and the rest of the tracks on the Western and Eastern Lines have been rendered inoperable due to the poor state of the track.

Figure 9.1: Existing Rail Network



Source: Ghana Railway Company

9.2.2 Rail Track Infrastructure

Most of the railway was built in the colonial era, thus, the design of the track was made to follow river courses, which was the cheapest way to build railway route at the time. This makes the track curvy and steep, both on the main lines and branch lines. As most of the track traverse valleys, it is flooded at certain points during the rainy season due to the design and inadequate drainage.

Ghana's railway track was designed for a maximum speed of 58 km/h. In general, the track structure consists of a mixture of 30 kg, 35 kg and 40 kg rails with wooden and steel sleepers.

Bridges and Culverts

There are 287 bridges with a total length of 3,207m. Approximately 80% of these bridges are steel girders or truss bridges with timber decks, the remainder being reinforced concrete bridges.

Buildings

The Ghana Railway Company Limited (GRCL) has 2,643 buildings across the country. Over 70% of these are residential properties that are in various stages of deterioration. The breakdown between residential and other types of buildings is as follows:

- Residential – 1,923 buildings, covering an area of 288,788 m^2;
- Other types – 720 buildings, covering an area of 153,631 m^2 (including 159 station buildings);
- Currently 8 stations on the Western Line and 11 on the Eastern Line are functional.

9.2.3 Rolling Stock

The rolling stock of freight wagons, coaches and locomotives is in a poor state. Only 14.5% of all rolling stock is considered operational. As of 2015, only 8 out of 39 locomotives, 57 out of 420 wagons, and 25 out of 162 coaches are in reasonable condition for utilisation on trains. About 137 coaches are in various states of disrepair and most have been earmarked for scrap.

Almost half of the locomotives and over one-third of the wagons were purchased after 2000. All coach stock was purchased in the late 1980s. Nine locomotives and 44 coaches have been rehabilitated in the last eight years. The rail infrastructure has extensive rolling stock maintenance facilities at Location in Sekondi, with supporting facilities at other terminal stations.

Locomotives Fleet

The GRCL has a fleet of 61 locomotives, of which 26 are aged between 11 and 13 years, 10 are aged between 20 and 24 years, 22 are aged between 28 and 31 years and 3 aged above 40 years. About 22 of the locomotives meant for shunting activities are in various stages of disrepair and bigger locomotives have to be utilised to meet exigencies. At the present level of operations, the 26 fairly new locomotives are adequate. However, more locomotives may be required as and when the business grows.

Wagons

Over 50% of GRCL's wagon fleet consists of low-sided wagons used to transport bauxite and manganese ore. The rest of the fleet consists mainly of covered wagons and various types of flat wagons. All wagons are equipped with roller bearings and vacuum brakes (Table 9.1).

Table 9.1: Summary of Rolling Stock as at 2016

Rolling Stock	Total	Available For Immediate Use
Locomotive	39	8
Wagons	420	57
Coaches	162	25

Source: Ghana Railway Company Limited

9.2.4 Signalling and Telecommunication

The country lacks conventional signalling and telecommunication equipment for train operation on the rail network. Trains are therefore dispatched and received from one station to the other on the Western Line mostly using mobile phones.
Train accidents have been avoided largely due to the limited number of trains running.

9.2.5 Opportunities for Railway Investment

According to the 2013 National Spatial Development Framework (NSDF) report, Ghana is confronted with a number of challenges as well as opportunities. Part of the solution to the challenges depends on an improved and expanded rail infrastructure, which the Railway Master Plan promotes. Some of the challenges and opportunities are as follows:

Economic

Integrating Ghana into the West African economy can reduce income inequalities among member countries, and thus support dispersion of economic activities as well as attract investments to smaller urban settlements. The introduction of the Trans-ECOWAS Railway Line covering the entire sub-region is expected to enhance integration, and improve economic activities.

Population Distribution and Growth

Ghana faces the challenge of not only a growing population but an uneven concentration of the population in the coastal regions. Extension of the rail infrastructure to cover the entire country, as stated in the Ghana Railway Master Plan, has the potential to reverse rural-urban migration and reduce the population density along coastal towns.

Increasing Food Production

Ghana needs to increase food production to meet rising demand by expanding the area under cultivation, reducing fragmentation of cropland and increasing the land area under irrigation. Subsequently, there will be the need to provide adequate warehousing and improve the market outlets, many of which are old and unhygienic. An improved and expanded railway infrastructure is essential to support distribution of food at competitive prices and thus reduce the cost of living.

Transport

Ghana faces the challenge of an increasing demand for mobility because of population and economic growth and higher incomes. This will increase demand for more freight and passengers transport services on the road, rail, water, and air transport modes.

The rundown railway network will have to be resuscitated, improved and expanded, with links to important economic centres that may not have been included in the Ghana Railway Master Plan. Provision should be made in the Railway Master Plan to extend rail services to areas not connected by rail but identified in the Ghana National Spatial Development Framework as having great potential for growth.

Mining

Ghana has large deposits of exploited and unexploited bulk minerals such as manganese, bauxite and iron ore. For example, there are large deposits of bauxite at Awaso, Nyinahin and Kibi and other sites that are yet to be exploited. Lack of rail infrastructure has compelled mining companies to transport existing bauxite and manganese ore to Takoradi Port by road, with attendant rapid deterioration of the road network. The exploitation, processing and value addition of these minerals has been held back due to a lack of adequate rail infrastructure. Table 9.2 shows the mineral deposits located along the Western Line, that are yet to be exploited.

Table 9.2: Western Line Mineral Deposits

Mineral	Estimated Ore Reserves	Locality
Bauxite	350 million tonnes	Nyinahin
Iron Ore	150 million tonnes	Oppong Manso
Limestone	6 million tonnes	Buipe
Iron Ore	4 million tonnes	Pudo
Manganese	8 million tonnes	Kalimbi Hill, Bole
Manganese	880,000 tonnes	Seripe, Bole
Manganese	3 million tonnes	Kapili, Bole
Andalusite	600,000 tonnes	Bekwai
Bauxite	over 20 million tonnes	Sefwi Awaso
Manganese	over 20 million tonnes	Nsuta

Source: Industrial Mineral Resources of Ghana (Geological Survey Department)

Table 9.3 indicates mineral deposits along the Eastern Line that are yet to be exploited.

Table 9.3: Eastern Line Mineral Deposits

Mineral	Estimated Ore Reserves	Locality
Bauxite	150-180 million tonnes	Kibi
Iron Ore	1,270 million tonnes	Shieni
Limestone	15 million tonnes	Bong-Da
Dolomite	20-30 million tonnes	Akosombo
Kaolin	3 million tonnes	Kibi
Bauxite	5 million tonnes	Nkawkaw
Manganese	2 million tonnes	Konongo

Source: Industrial Mineral Resources of Ghana (Geological Survey Department)

9.3 The Railway Master Plan

The Railway Master Plan (RMP) was initiated by the Ghana Railway Development Authority (GRDA) in 2013. The plan envisaged that the rail infrastructure intervention would start in 2015 and be completed by 2047. The programme has not taken off to date. With the implementation of Ghana's LTNDP, it is expected that the intervention will start in 2018 and be completed by 2047.

9.3.1 Phases of Implementation

The project involves the construction of 4,007 km of rail network covering the entire country. The plan will be financed through Public-Private Partnership (PPP) arrangements, with freight traffic projections of 36 million tonnes in 2015 to 285 million tonnes by 2047. Passenger traffic is projected to grow from 730,000 passengers per day in 2015 to 1.38 million passengers per day in 2047. The rehabilitation is to be carried out in phases as indicated below.

1st Phase: Rehabilitation of the Existing Lines

Only two of the three existing lines are to be rehabilitated: the Western Line (Takoradi-Awaso-Kumasi) and the Eastern Line (Accra-Tema-Kumasi) for a total of approximately 668 km including branches to Awaso and Prestea. The Central Line, which is not very attractive for freight and passenger traffic, will be substituted in successive phases by the Coastal Line. The lines remain narrow gauge, but will be modernised with sleepers conditioned for subsequent transformation of the lines to standard gauge, while all new infrastructure will be developed to the new technical standards.

2nd Phase: Extension of the Central Corridor

Doubling of the track of the two lines rehabilitated in the 1st Phase and the conversion to standard gauge of the previously modernised track, thus creating two modern lines with double tracks on the routes with a high demand for freight and passenger traffic.

Construction of the new standard gauge single-track line that runs from Kumasi to Tamale and Paga in the north. This phase covers approximately 1,161 km.

3rd Phase: Extension of the Transversal Links

Construction of transversal railways with standard gauge single tracks, for the stretches Tamale-Yendi, Fufulsu-Sawla, Techiman-Kwadwokurom and Nyinahin-Kumasi for a total of approximately 484 km.

4th Phase: Extension of the Trans-ECOWAS Line

This is mainly a coastal line, with standard gauge single track, running from Aflao (near the border with Togo) westwards to Tema-Accra-Cape Coast–Takoradi-Tarkwa-Omape for a total of approximately 498 km.

5th Phase: Extension of the Western Line

Extension northwards of the original Western Line to reach and connect the future mines. The Line starts from Dunkwa-Awaso and extends towards Techiman, Sawla and Hamile for a total of approximately 729 km.

6th Phase: Extension of the Eastern Line

This is the new route to the east of Ghana, near the border with Togo; that from Tema reaches Akosombo and then heads towards Ho and Yendi to the north, for a total of approximately 468 km.

9.3.2 Review of the Railway Master Plan

The master plan implementation strategy was premised on the status of the railway as of 2008 when as many as 36 mainline locomotives were available. Each of the locomotives cost about US$ 2.85 million and were designed for narrow gauge tracks. The plan then was to rehabilitate the existing tracks with standard gauge materials in Phase 1, but the gauge adjusted to accommodate the narrow-gauge locomotives until the old locomotives were phased out. The tracks could then be re-adjusted into standard gauge in Phase 2.

The plan was scheduled to commence in 2015 but by then, only six out of 36 mainline locomotives were available so the reasons for that strategy were no longer tenable. Implementation will now commence from 2018 with the necessary adjustments. Details of the Amended Implementation Plan are shown below:

i. The Master Plan in Phase 1 proposed the rehabilitation of two of the existing lines; namely Western Line (340 km) inclusive of the Awaso Branch Line, and the Eastern Line (327 km). The amended programme proposes going straight ahead with the modernisation of the Western and Eastern Lines in Phase 1 instead of rehabilitating the existing lines as originally proposed. It is noteworthy that modernisation means conversion to the standard gauge, which is normally described in the Master Plan as expansion;

ii. The Master Plan in Phase 2 proposed a Central Corridor Expansion and mentioned various sections including the existing Western and Eastern Lines. It has already been recommended that the existing lines be modernised, so Phase 2 has been adjusted accordingly. The central line by-pass at Kade could also be extended through Kibi or Abirem to link the eastern line to boost the economy within the corridor, especially bauxite deposits at Atiwa, near Kibi.

All other phases remain as originally planned. The revised Master Plan is shown in Table 9.4:

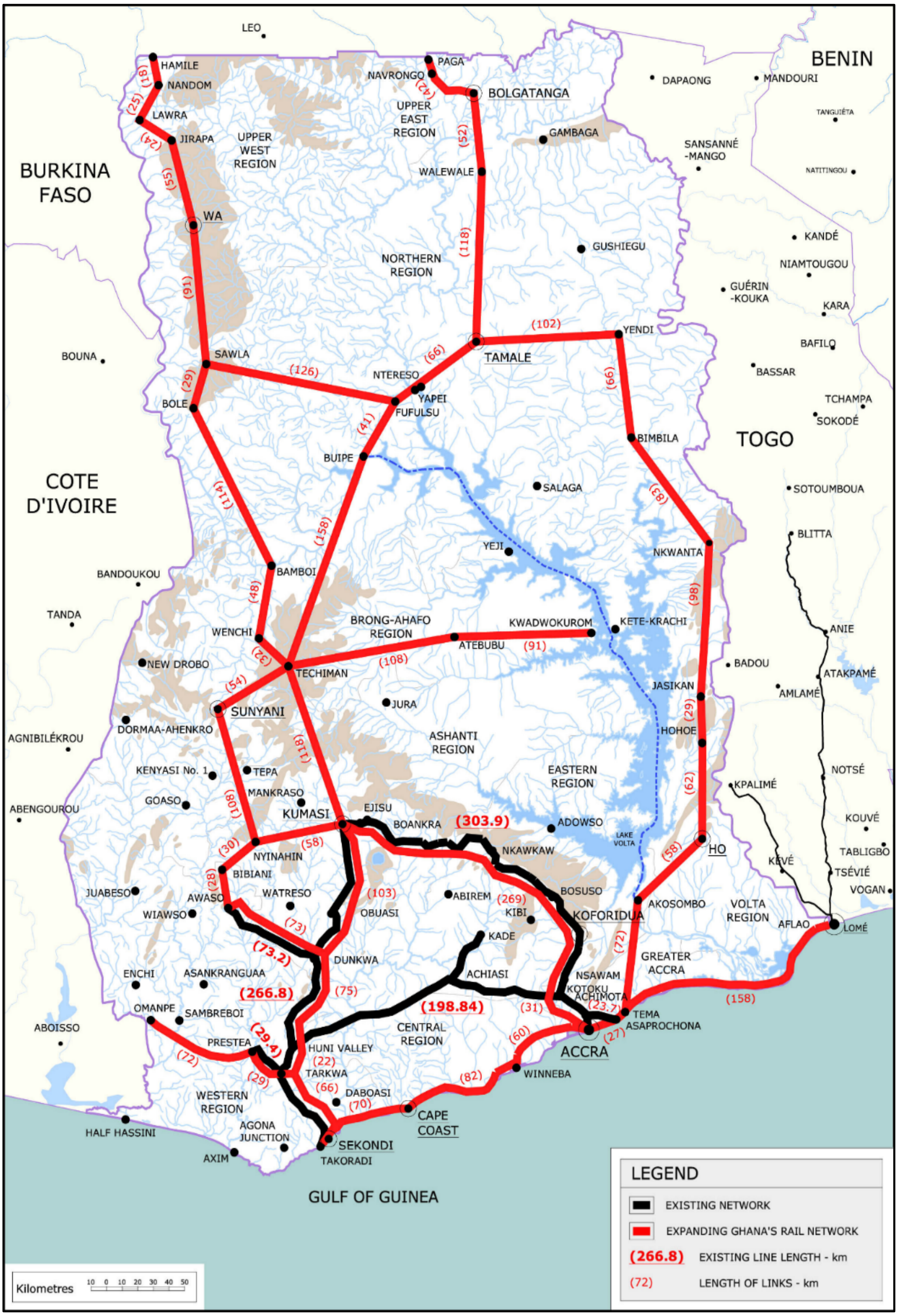
Table 9.4: Summary of the Revised Railway Master Plan

Phase	Link	Description
1	Modernisation of the Existing Lines	• Only two of the three existing lines are modernised into standard gauge infrastructure: the Western Line (Takoradi-Awaso, Dunkwa-Kumasi) and the Eastern Line (Accra-Kumasi) for a total of approximately 668 km including the Tema branch.
2	Extension of the Central Corridor	• Doubling of the track of the two lines modernised in the 1st Phase, thus creating two modern lines with double tracks on the routes with a high demand for freight and passenger traffic. • Construction of the new standard gauge single-track line that runs from Kumasi to Tamale and Paga in the North. • This phase covers approximately 1161 km.
3	Extension of the Transversal links	• Construction of transversal links railways with standard gauge single tracks, for the stretches Tamale-Yendi, Fufulsu-Sawla, Techiman-Kwadwokurom and Nyinahin-Kumasi for a total of approximately 484 km.
4	Extension of the Trans-ECOWAS Line	• This is mainly a railway line with standard gauge single track that runs from Aflao (near the border with Togo) westwards to Tema-Achimota-Kotoku-Huni Valley-Tarkwa-Omape for a total of approximately 498 km.
5	Extension of the Western Line	• Extension northwards of the original Western Line to reach and connect future mine developments. • The line starts from Awaso and extends towards Techiman, Sawla and Hamile for a total of approximately 729 km.
6	Extension of the Eastern Line	• This is the new route to the east of Ghana, near the border with Togo; that from Tema reaches the river port of Akosombo and then heads towards Ho and Yendi to the North, for a total of approximately 468 km.

Source: Railway Master Plan for Ghana, Final Report, December, 2013

Figure 9.2 shows the extended railway network after the implementation of the Master Plan in six phases.

Figure 9.2: Map showing the future railway network



Source: Railway Master Plan for Ghana, Final Report, December, 2013

9.3.3 Implementation of the Plan

Cost of the Plan

In effect, in the 1st Phase of the original Master Plan, 668 km of the existing narrow gauge line were to be rehabilitated, and in the subsequent 5 phases the network extended by a further 3,340 km of new lines and the first phase to be later converted to standard gauge. In 33 years, a total of 4,007 km of lines will be constructed for an investment of US$ 21,508 million.

A further investment of US$ 53 million should be added for the management company operating under a PPP; about US$ 1,200 million for the rehabilitation and purchase of the freight and passenger rolling stock; and US$ 220 million for signalling and telecommunications. The breakdown of the cost is shown in Table 9.5.

Table 9.5: Cost Profile for Railway Investment 2015-2047

Phases –Lines	Length (Km)	Financial Cost (Us$)
PHASE 1: Expansion of existing line	**667.6**	**3,738,560,000**
1W -Old Western Line	**340**	**1,904,000,000**
1 - Takoradi - Tarkwa - Dunkwa – Kumasi	266.8	1,494,080,000
2 - Dunkwa – Awaso	73.2	409,920,000
1E -Old Eastern Line	**327.6**	**1,834,560,000**
1- Accra – Kumasi	303.9	1,701,840,000
2 - Achimota – Tema	23.7	132,720,000
PHASE 2:Eastern "A" Expansion	**1165.6**	**6,527,920,000**
2C – Kumasi – Techiman – Tamale	383	2,144,800,000
Tamale – Paga	212	1,187,200,000
Takoradi – Kumasi	266.8	1,494,080,000
Achimota – Kumasi	303.8	1,701,840,000
PHASE 3: Transversal Expansion	**486**	**2,721,600,000**
1 – Tamale – Yendi	102	571,200,000
2 - Fulfusu – Sawla	128	716,800,000
3 - Techiman - Atebubu – Kwadwokrom	198	1,108,800,000
4 - Nyinahin – Kumasi	58	324,800,000
PHASE 4: Trans ECOWAS Expansion	**455**	**2,548,000,000**
1 – Aflao - Tema	154	862,400,000
2 - Huni Valley – Kotoku	200	1,120,000,000
3- Tarkwa – Omanpe	101	565,600,000
PHASE 5: Western Expansion	**656**	**3,673,600,000**
2 - Awaso – Techiman	220	1,232,000,000
3 - Techiman – Sawla	223	1,248,800,000
4 - Sawla – Hamile	213	1,192,800,000
PHASE 6: Eastern "B" Expansion	**468**	**2,620,800,000**
1 - Tema – Ho	130	728,000,000
2 - Ho – Yendi	338	1,892,800,000
INFRASTRUCTURE INVESTMENT COST		**21,830,480,000**
* PPP/Management Contracting		53,000,000
*Procurement of freight and rolling stock		1,200,000,000
*** Signal and telecommunications**		200,000,000
TOTAL INVESTMENT COSTS		**23,283,480,000**

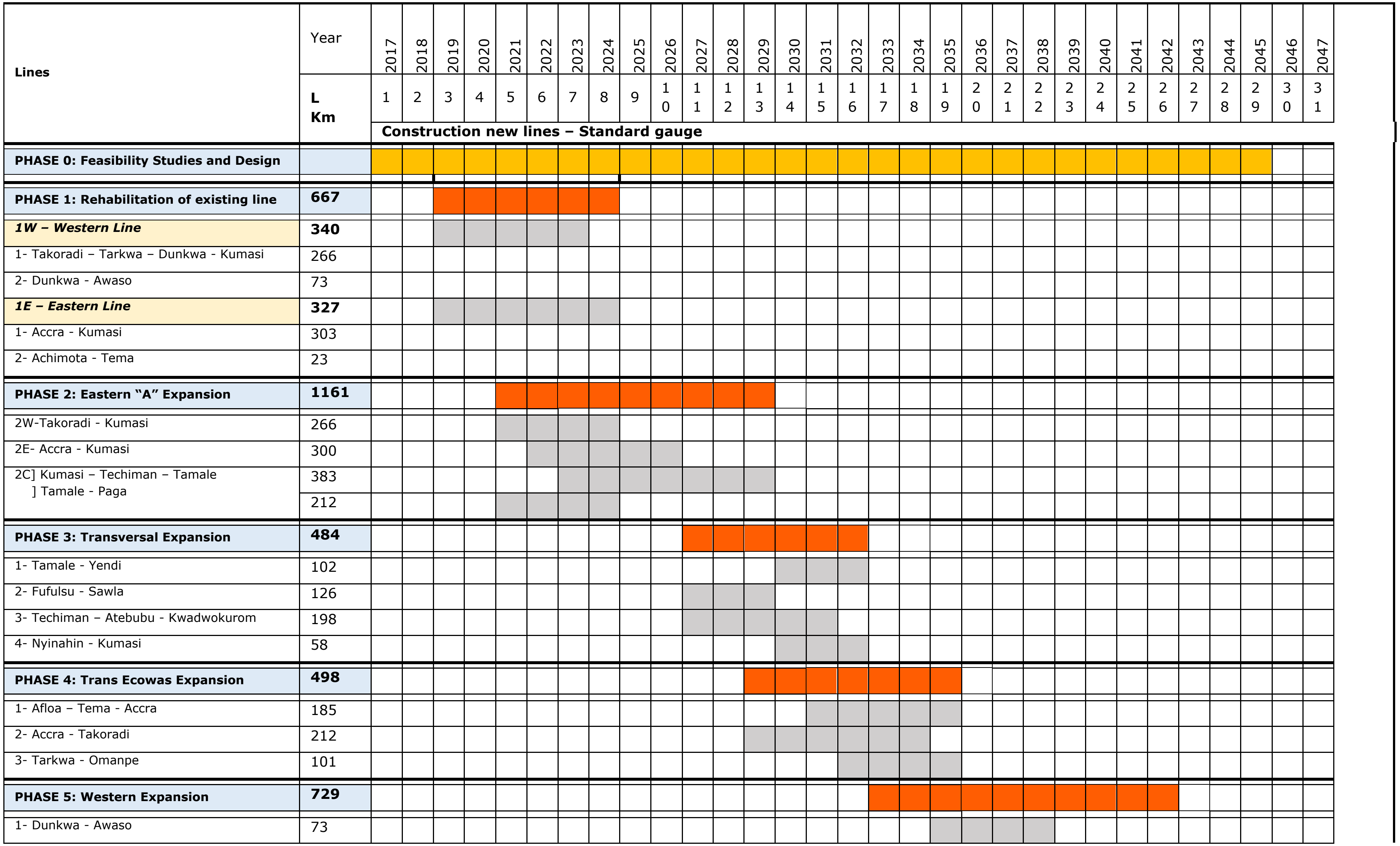
Source: Railway Master Plan for Ghana, Final Report, December 2013
* Additional items added by the Ghana Infrastructure Plan Team

Implementation Programme

Assuming that year 2017 will be dedicated to studies of the Ghana Railway Master Plan and the year 2018/2019 for the assignment of the first construction contract, construction could begin in 2018/2019. A preliminary implementation schedule indicating in detail the execution items is shown in Figure 9.3.

It is recommended that the government appoint a small committee comprising a restricted number of qualified people with strong technical background in management in both the public and private sectors to oversee the implementation. The Chairman of GRDA would be an ex-office member of the Steering Committee.

Figure 9.3: Ghana Railway Master Plan Implementation Programmes



2- Awaso - Techiman	220
3- Techiman - Sawla	223
4- Sawla - Hamile	213
PHASE 6: Eastern "B" Expansion	**468**
1- Tema - Ho	130
2- Ho - Yendi	338
PHASE 7: Suburban	
1- Accra	
2- Kumasi	
3- Tamale	
4- Sekondi/Takoradi	
Total New Construction Km	**3,340**
Grand Total (Rehabilitation+New Construction) Km	**4007**
Procurement of Goods	
Procurement of freight and rolling stock	
Signal and telecommunications	

Yearly investment at constant rate (million US$)																																TOTAL m$
Feasibility Studies and Design																																
New Construction	632	632	523	488	727	727	727	727	716	716	476	476	476	457	457	457	575	812	428	496	935	935	902	939	1005	755	998	998	513	270	270	20243
Procurement of freight and rolling stock																																
Signal and telecommunications																																
TOTAL YEARLY INVESTMENT (m$)																																

Source: Railway Master Plan for Ghana, Final Report, December 2013 updated by the Ghana Infrastructure Plan Team

9.4 The Trans-ECOWAS Railway Line

Efforts toward the ECOWAS Initiative - Using Existing Central Line

The Railway Master Plan proposed an entirely new coastal line from Aflao through Accra and Cape Coast to Takoradi (Phase 4), a total distance of 498 km, to serve as the ECOWAS Line, thus discarding the existing Central Line between Kotoku to Huni Valley, a distance of approximately 200 km. This proposal will have to be evaluated for economic viability.

The proposed ECOWAS Line can thus be either of the following two line options:

i. Aflao-Tema-Achimota-Accra-Takoradi-Tarkwa-Prestea-Omape: Total distance approx. 498 km; or,
ii. Aflao-Tema-Achimota-Kotoku-Tarkwa-Prestea-Omape: Total distance 511 km.

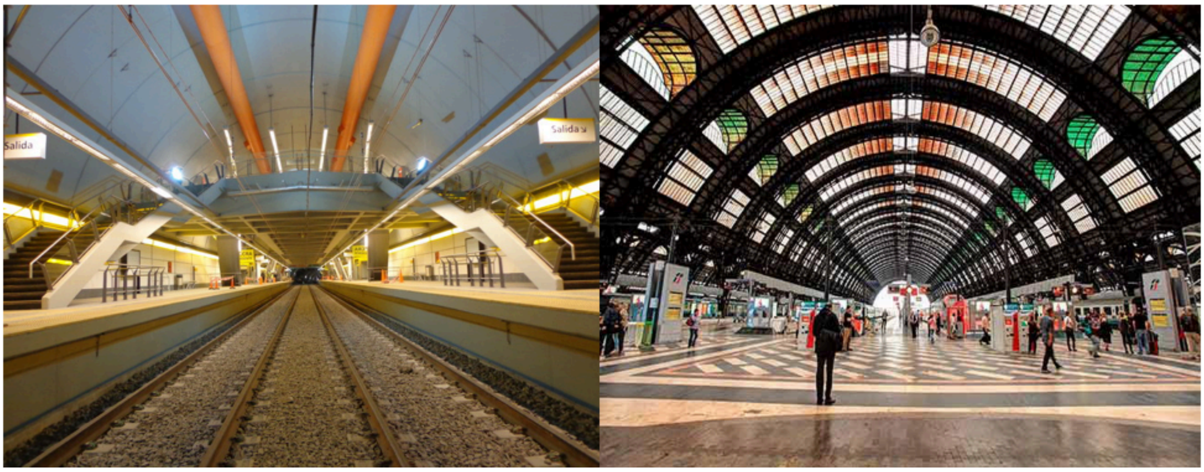
The Master Plan stated cost as the main reason for selecting the coastal line option for the Trans-ECOWAS Line, but the distance between Kotoku and Huni-Valley compares favourably with that between Accra and Takoradi. Besides, an existing right of way is available for the Central Line. Furthermore, allowing trains from the Trans-ECOWAS Line to pass through the Takoradi–Tarkwa section in addition to existing Western Line trains has the potential of creating congestion along that corridor. It would not be in the interest of the State to cut off people along the existing central corridor, which has a poorer road transportation network than those along the coast from Accra to Takoradi, from accessing train services.

A well-paved road network exists between Accra and Takoradi (228 km) and transport accessibility is generally adequate and easier. While there is not much heavy agricultural activity, the right of way needs to be acquired. On that basis, it can be conjectured that it will be more expensive to construct the coastal line. While the Master Plan identifies cost and difficulty in construction as the main reasons for the coastal line option, on the contrary, it could be cheaper and easier to build along the existing Central Line since the right of way is already available. It is therefore recommended that the Trans-ECOWAS railway line utilises the existing Central Line. That notwithstanding, the proposed coastal option could be revisited in future. It is noteworthy that Option A traverses 4 regions — Volta, Greater Accra, Central and Western Regions, while Option B traverses 5 regions — Volta, Greater Accra, Eastern, Central and Western Regions.

The Master Plan also proposed in Phase 5 the Western Expansion linking Dunkwa–Awaso–Hamile. Awaso is very important because of bauxite mining therefore modernisation of the Dunkwa–Awaso Line should be tackled in Phase 1. Consequently, the Western Expansion proposed in this phase should be from Awaso to Hamile. Finally, Phase 6 of the Master Plan proposed the Eastern Corridor Line from Tema through Akosombo to Yendi and to Tamale. In October 2016, Ethiopia and Djibouti launched the first fully electrified cross-border railway line in Africa. ECOWAS should be able to undertake a similar venture by 2035.

Figures 9.4 shows some railway stations in developed countries and Figure 9.5 shows a futuristic train that could be considered for the modernised railway system of Ghana.

Figure 9.4: Some Railway Stations in Developed Countries



Source: Google Images

Figure 9.5: Ghana Train by 2020

Source: Google Image

ECOWAS Railway Programme

There is no real regional rail network in the ECOWAS area. Since 2009, ECOWAS has been pushing for the interconnection of the rail networks that exist in 11 of its 15 member states. But unlike in Southern Africa, where intra-regional rail networks are well developed and integrated, in West Africa the rail systems are mostly fragmented and operate on three different rail gauges. Most francophone countries' rail gauges are 1,000 mm wide, but Ghana and Nigeria rails 1,067 mm wide, while Guinea and Liberia use the standard 1,435 mm width. The ECOWAS region is working on a programme to enable all West African countries to use the standard 1,435 mm width.

A proposed 1,178 km-long ECOWAS coastal railway system is expected to connect Nigeria to Benin, Togo, Ghana and Côte d'Ivoire. The coastal rail line project carries hope for the entire region, in part because its completion would demonstrate that the once insurmountable technical challenges can be overcome.

The project is expected to transform the region's transportation system by launching a new high-speed passenger and goods train services. This will allow large container ships to concentrate on a smaller number of ports, thereby increasing efficiency and reducing the costs of international trade. It is also to facilitate a major industrialisation of West African countries, improve transportation of agricultural produce, and create immediate economic emancipation for more than 300 million people within the sub-region. It will also ease the numerous transportation difficulties inhibiting economic development in the sub-region.

9.4.1 Technical Considerations

Environmental Health and Safety

It is the responsibility of the state to provide the safest railways possible at present. State and regulatory agencies have to ensure that the railway system is safe for passengers, provides a safe working environment for staff, and also protects the environment along which the railway system operates. Safety is expensive but the absence of good safety practices can negatively affect all aspects of railway development.

Development of the railway system should include establishment of a Safety Department responsible for monitoring and ensuring good safety practices at all levels in the railway operating companies. Safety practices of the operating companies will be supervised by the Railway Safety and Security Inspectors who will be appointed by the Ghana Railway Development Authority (GRDA), the holding company, as provided for in Section 61 of the Railway Act, 2008.

Staff Levels

Staff levels must be predetermined strictly in accordance with resources and business availability. This will ensure that no more than 20% of revenue goes into staff emoluments and other staff related packages, according to global best practices.

Passenger Trains

Steps need to be taken to set minimum standards that will help recapture lost traffic back to rail transport. A well-run passenger train service bolsters the image of the railway system and has the capability to attract more profitable freight traffic. Accra and Kumasi being the two largest and most populated cities in the country, the potential for successful passenger train services between them is very high in spite of the relatively short distance between the two cities. It should be noted that no public road transport vehicle can comfortably make the Accra-Kumasi journey in the 3.5 hours that can be achieved by an express train.

Freight Trains

A freight train or goods train is hauled by locomotives on a railway, transporting cargo between the shipper and the intended destination as part of the logistics chain. It is expected that the rail operation will be able to penetrate the freight corridor and recover business lost to road transport.

The following are suggested:

i. The bulk goods marketing companies such as Cocoa Marketing Company, Bulk Oil Storage and Transportation Company and some of the major shipping companies can be invited to participate as shareholders;
ii. Companies that do business with railways must be encouraged to own their own specialised wagons. This will go a long way to commit them to using rail services;
iii. Freight rate charges must be lower than road transport charges by at most 20% in the initial stages to attract more traffic to rail. With fixed costs as high as about 60%, rail can still carry more goods at relatively lower rates and be profitable. The target is for the operating companies to recover their variable costs, and part of the fixed costs;
iv. It should be ensured, possibly by legislative instrument that all container traffic to Boankra and other inland ports anywhere in the country is made by railway;
v. Modern, faster handling equipment must be installed at all terminals to ensure faster turnaround of wagons.

Train Speed

In order for existing locomotive drivers to get used to running trains at higher speeds, the maximum speeds of passenger trains should be gradually moved from 80 km/h to 160 km/h within a specified period. Locomotive drivers must be given proper orientation before being allowed to handle high-speed trains. Fencing of the track in densely populated areas will be necessary to prevent accidents that can delay train movements.

Signalling and Telecommunications

An effective signalling and communication system is necessary to monitor train performance in transit to ensure train timetables are maintained. It is critical to ensure that the right types of equipment are acquired.

9.4.2 Identification of Project Implementation Risks

The following risks factors have been identified and must be mitigated:

Technical

i. For standard gauge lines, the specifications conform to that of the railways in most developed countries;
ii. For the stations, adoption of European railway standards (in line with UIC recommendations) for the stops, secondary and main stations;

iii. For signalling and telecommunications, adoption of a network for long distance data transmission for every type of communication — voice, video service, data, etc.

Financial

There could be cost overruns that will make the project more expensive. Determination to make the project financially viable may call for high fares, which can affect demand with social and political implications. The state of the economy has implications on patronage and fares to be charged to make the project financially viable.

Safety

Careful planning is required to keep the railway safe when it is expected to travel at speeds of up to 160 km/h. The technical complexities of modern rail projects make the integrity of the rail system of utmost importance.

The current practice of the rail track being traversed indiscriminately by human and animal traffic poses a serious safety risk. The position of level crossings, whether at grade, underground tunnel or grade separation will be carefully decided, taking safety and cost into consideration. The speeds at which the trains will run will affect not only the technical specification of the track but also demand, with attendant safety implications.

Social and Cultural

Risks due to re-routing and legal actions against the project because rail tracks have to pass through heritage sites such as cemeteries, shrines, forest reserves, and private properties and built-up areas will need to be accommodated. This is very much expected when the tracks have to pass through areas where new right-of-way is acquired and opposition should be expected from people in instances where the project cuts through villages.

Political

The project spans 30 years and will necessarily traverse the tenure of different governments. The risks of discontinuation are ever present.

Regulatory

The government will review the Railways Act 2008, (Act 779) by 2018 to separate the regulatory function of the Ghana Railway Development Authority (GRDA) from its mandate of improving railway assets and promoting the development and management of the sub-urban railway systems. The role and interests of various ministries such as Transport, or Finance, or Roads and Highways, and other related ministries will have to be negotiated and accommodated where feasible. The Office of the President must be available to iron out all outstanding issues.

9.5 Promoting Multi-Modal Transportation

Intermodal transport will be promoted under the plan. Intermodal transport, also known as Intermodalism or multi-modal transport infrastructure allows the use of at least two different modes of transport in a trip from origin to destination. Intermodal transport enhances the economic performance of a transport chain by using modes in the most productive manner. For example, the line haul economies of railway may be exploited for long distances, with the efficiencies of taxis, buses and trucks providing flexible local pick-up and delivery.

The Ghana Infrastructure Plan recommends that the following actions:

i. Connect the railway network to the quayside in both ports at Takoradi and Tema;
ii. Connect the railway network to all existing airports and future ones;
iii. Connect the railway network to the inland port (or dry port) at Boankra and all such facilities established in future;
iv. Connect the railway network to all major road transport terminals;
v. Connect the railway network to the main lake transport terminals.

Additionally, it is highly recommended that all railway terminals or stations in the major cities and towns should be located within the Central Business District. Suburban trains can then be organised as feeders to the main stations. Where the Central Business District is inaccessible by surface trains, the underground line and station option must be pursued. Furthermore, the law in Ghana mandates accessibility for people with disabilities. Considerations include making all facilities accessible to people with all forms of disability.

9.6 Suburban Railway Network

9.6.1 GAMA Railway Network

The Greater Accra Metropolitan Area (GAMA) has two railway lines adding up to about 55.1 km. These are the Accra - Nsawam line, and the Accra - Tema line. Both lines have a single track and use the same track from the Accra station to the Achimota Overhead junction. As of end 2016, the Accra-Nsawam Line has 1 train, 5 stations and 9 halts, while the Accra-Tema Line has 2 trains, 7 stations and 6 halts. The railway lines are narrow gauges.

Given the long term vision to make rail transport the main mode of public transport in the metropolis, GAMA aims to turn the existing railway line into a standard gauge and double-track railway.

The GRDA has prepared a Railway Master Plan for the entire nation. In this plan, which has been approved by the government, priority has been given to the rehabilitation, extension and development of the national network, taking ECOWAS standards into consideration and incorporating the needs of the northern part of the country as well. There is also a plan for a new inter-state railway line between Takoradi and Tema, passing through the Greater Accra Region, using the Labadi corridor.

Railway Condition and Target

The GAMA reports states that the existing indicators for GAMA such as railway length and others are below the world average. Therefore, to boost its capacity in order to reach its target of achieving Accra's comparative high-income capital city public transport system, GAMA has to introduce about 250 km of railway route. The prevailing reality against the target that GAMA desires to attain by the end of the planned period is portrayed in Table 9.5.

Table 9.6: Railway Conditions and Target of GAMA

Class	GAMA's Status	GAMA's Target	Remarks
Railway Route (km)	55.1 km (20%)	128 km by 2035 250 Km by 2047	Construct New Line
Urban density (persons/ha)	31.6% (73%)	Transit Oriented Development	Urban structure of low density (Sprawl)
Public transport (journeys/persons)	52.1% (49%)	Transit Oriented Development	Hub & Spoke, Improve public transport

Source: The Transport Masterplan Project in Greater Accra Region, Final Report (Draft), 2016

Improvement of Railway Network

GAMA will therefore extend its urban railway system from 55.1 km to 127.7 km by 2035. In view of this, one axis additional to both the north-south axis and west-east axis, and use of both the Labadi-Teshie and the Kwame Nkrumah Motorway corridors are recommended.

The installation of a side-track in 2 stations as well as 4 halts, to boost train operations in the short term is also recommended. In the long term however, the recommendation is to construct a subway (due to the traffic conditions) from Adenta station to the Accra station using the Liberation corridor, while ensuring that all existing tracks are improved to the standard of double tracks.

The Proposed Accra Suburban Railway System

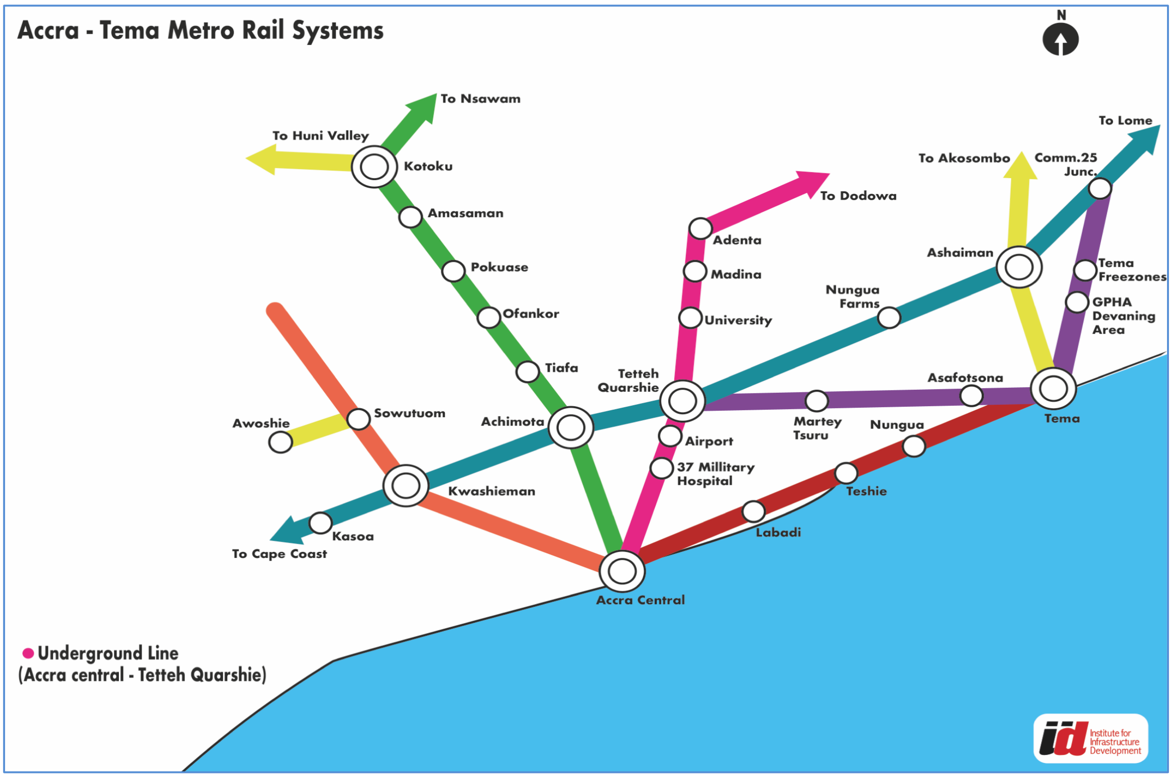
The Accra suburban railway system will largely be passenger rail transport services of length 250km that will operate between the city centre, Tema and other outlying suburbs that draw large numbers of people who travel on a daily basis. The development of the Accra suburban railway network will be linked with the planning and redevelopment of a new Accra city urban master plan. The Accra lines will have a combination of surface, underground and overhead rail lines across the city.

The line will adopt a train service that supports intermodal transport of both goods and people from the port to the inland areas of Accra and Ghana in order to ease the pressure on road travel. It will also accommodate part of the trans-ECOWAS railway route.

According to the Transport Master Plan for the Greater Accra Region (2016), GAMA's railway length in metres per 1,000 persons is 20% of comparative world cities. This means 275 km of railway routes have to be constructed in GAMA to meet the average of world cities. The current railway length is 55.1 km and the length proposed, based on Ghana's high-income aspiration is 250 km.

The Accra map in Figure 9.6 adopts the recommendations of the RMP and the Transport Master plan for the Greater Accra Region. The construction of the railway lines will influence the redevelopment of the GAMA area and harness its tourism potential.

Figure 9.6: Schematic Layout of the Proposed Accra Suburban Railway System



Source: Ghana Infrastructure Plan Team

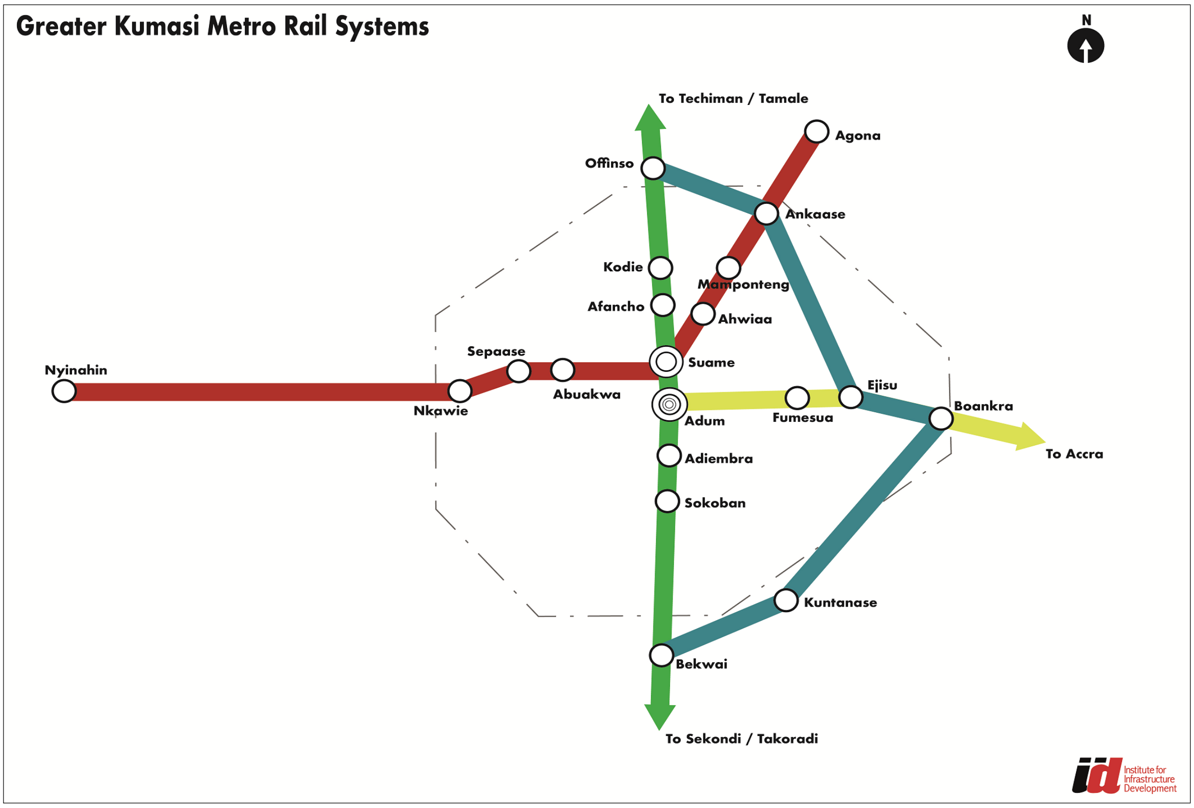
9.6.2 Greater Kumasi Suburban Railway System

The estimated length of the proposed Greater Kumasi Metro Railway System is 150 km. One of the two major terminals at Adum and Suame is expected to serve as the Central terminal. The Adum Terminal will serve passenger and freight transport from the Eastern Line and Western Line while the Suame Terminal will serve traffic from the Western line to the Central Spine Expansion to the north and the Transversal Lines.

There are two proposed bypasses from Ejisu to link with the Central Spine Expansion (Kumasi to the north) and the Western Line (Kumasi to Takoradi). These lines will also facilitate the transport of cargo directly from Boankra Inland Port. The proposed line from Ejisu linking the Central Spine Expansion will have a freight station at the proposed new Kumasi Airport at Ankaase.

A transversal line to Nyinahin is planned in the RMP, originating from Suame Terminal and passing through Abuakwa, Sepaase and Nkawie to Nyinahin. This line will serve both suburban passenger service and freight services, especially for the huge bauxite deposit at Nyinahin. Another proposed transversal line is to link Suame to Agona. This line will be necessary to provide suburban passenger and freight services along that corridor. Due to the massive difficulties in the right-of-way, the development of the railway system shall be tied to the preparation and construction of a new urban master plan for Greater Kumasi. Figure 9.7 shows the schematic layout of the proposed Greater Kumasi suburban railway network.

Figure 9.7: Schematic Layout of the Proposed Greater Kumasi Railway System



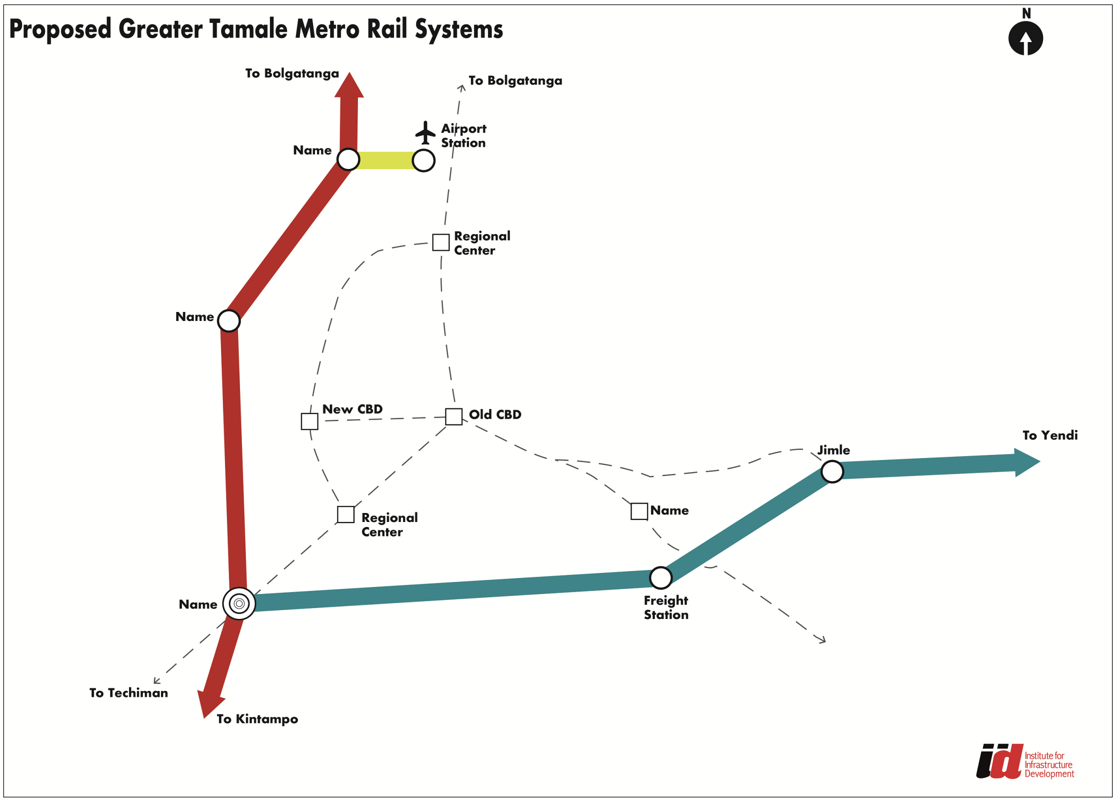
Source: Ghana Infrastructure Plan Team

9.6.3 Greater Tamale Metro Railway System

The estimated length of the proposed Greater Tamale Metro Railway System is 85 km. There are two proposed railway lines that pass along the periphery of the Tamale Metropolitan Area. These lines will be well integrated with Bus Rapid Transit (BRT) systems for inner city public transportation.

One of the lines branches from the Central Spine Expansion eastward to Yendi with a proposed freight station on that corridor. This line has the potential to service future light industries and link up with the huge iron ore deposits at Shieni in the Zabzugu-Tatale district. The other line branches westward and then turn northward towards Bolgatanga. On that line, two stations will serve the railway system: one at the central terminal which will serve as the Rail-BRT interchange and another station will be located close to the Tamale Airport to facilitate freight and cargo transport. Figure 9.8 shows the schematic layout of the proposed Greater Tamale suburban railway network.

Figure 9.8: Schematic Layout of the Proposed Greater Tamale Railway System



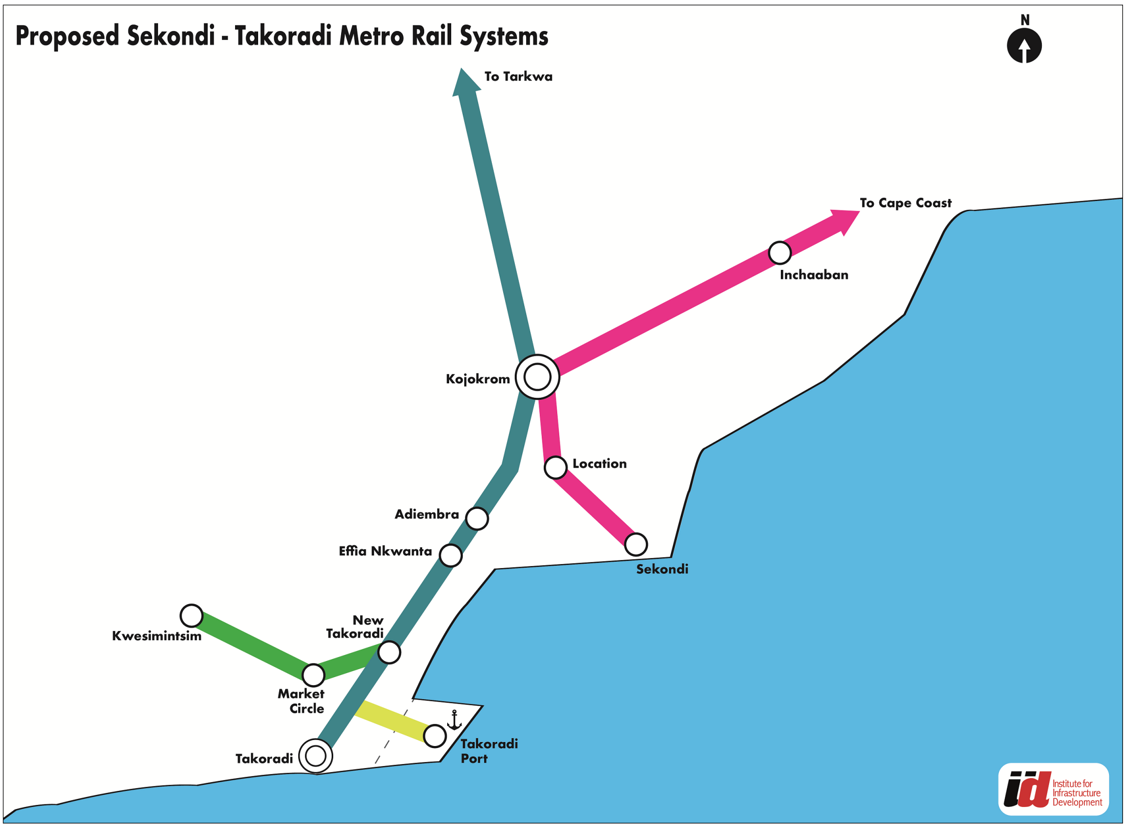
Source: NSEZ Regional Concept Master Plan Report, 2016 adapted by the Ghana Infrastructure Plan Team

9.6.4 Sekondi-Takoradi Metro Railway System

The estimated length of the Sekondi-Takoradi Metro Railway System is 35 km. The central terminal is proposed at Kojokrom. The main workshop headquarters of the Ghana railway system is at Location. The Western Line will facilitate freight transport to and from Takoradi Port to Kumasi and beyond. It will also provide suburban passenger services for towns on the route to Takoradi. A proposed railway line from Cape Coast will provide suburban passenger and freight services for towns such as Inchaban and Shama along that corridor.

A recently constructed suburban railway line links Kojokrom to Sekondi. This line provides both passenger and freight services, especially for the Sekondi Fishing Harbour. Another suburban line is proposed to link New Takoradi to Kwesimintsim with a proposed halt close to Market Circle. This line will cater for suburban passenger services for the increasing number of passenger traffic along that corridor. Finally, over the long term, the Sekondi-Takoradi line will be developed westwards to link the emerging oil and tourism towns of Cape Three Points, Princess Town, Domunli, Esiama, Atuabo and Half Assini. Figure 9.9 shows the schematic layout of the proposed Sekondi-Takoradi metro railway network.

Figure 9.9: Schematic Layout of Proposed Sekondi-Takoradi Metro Railway System



Source: Ghana Infrastructure Plan Team

9.7 Organisational Structure of the Future Ghana Railway System

The implementation of the Master Plan will give Ghana a modernised standard gauge rail infrastructure (single, dual and multiple tracks of 4,007 km minimum, terminals and signal and telecommunications) and rolling stocks. The total length of 4,007 km is too large to be effectively operated under centralised management.

The proposed Ghana Railway System will thus be converted into a holding company with five separate business centres identified for effective operations, monitoring and control. The proposed five entities are as follows:

i. The Western Railway Line;
ii. The Eastern Railway Line;
iii. The ECOWAS Railway Line;
iv. Sub-Urban Rail System;
v. The Workshops/Estate Company (non-core).

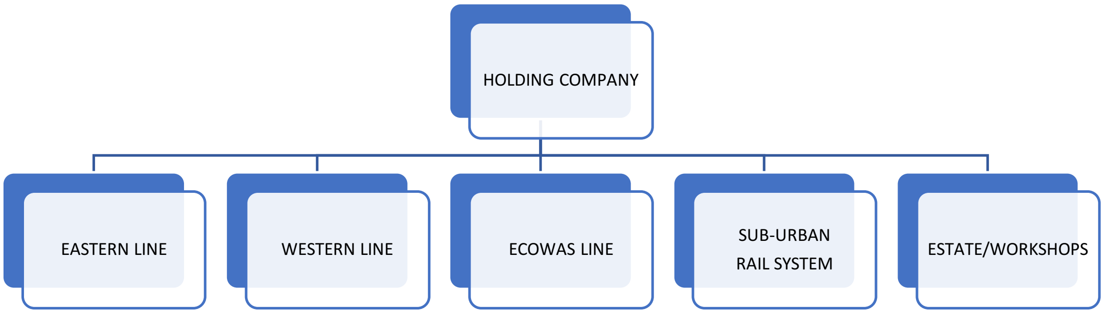
9.7.1 The Holding Company

The government of Ghana will own the railway infrastructure and set up an authority or holding company to regulate and ensure safety in the operations of the various companies likely to participate in the country's new railway system as well as be responsible for fixing any fees to be levied on the Train Operating Companies for using the railway infrastructure.

When the government decided to encourage private participation in railway operations, a new company was formed under the Railway Act 779 of 2008 called the GRDA. When the government decided to encourage private participation in railway operations, a new company was formed under the Railway Act 779 of 2008 called the GRDA. Under the law, the Authority was to own the railway infrastructure on behalf of the State, regulate all train operators, charge appropriate fees for using the infrastructure and assure passenger and fleet safety. The government is in the process of reviewing the Railway Act to separate the regulatory function of GRDA from its mandate of improving railway assets and promoting the development and management of sub-urban railway, to be completed by end of 2017.

The relationships among the companies are shown in Figure 9.10.

Figure 9.10: Organisational Structure of Future Railway System



Source: Railway Master Plan for Ghana, Final Report, December 2013

9.7.2 The Workshops/Estate Company

The Location Workshops in Sekondi will be refurbished to handle all heavy maintenance schedules to general overhaul for the operating companies for a fee. The operating companies can then focus on trip schedules and minor maintenance as specified in the rolling stock manuals. The Location Workshops need to be retrofitted to manufacture spare parts for the general public, as was the case in the past. The Location Workshops setup can be replicated at Kumasi or Tamale, for example, to serve the northern sector.

Currently, GRCL possesses 2,643 buildings out of which 1,923 are residential units. Most of the buildings are in various stages of disrepair. The railway operating companies can select from the stock of available buildings needed for their operations, and the remainder pooled and managed by an independent estate company. More buildings will be needed for operations on the extended infrastructure and an Estate Company will be in a better position to organise this business. A school focused on railway studies will be developed and affiliated to one of the existing universities to undertake formal post-graduate studies in railway engineering, economics and finance. GRCL also has a Training Institute that will be modernised into a centre of excellence for the training of railway staff on short-term course basis.

9.8 Delivering Rail Projects in Ghana

Railway projects are complex and fraught with financial, economic and technical challenges. Elsewhere, central and regional governments as well as private sector developers or investors implement railway projects. In Ghana, this is the first time the private sector is being called upon to participate in large-scale railway projects. It is important at this stage to consider some of the key factors that will determine the extent to which the railway project will be successful and that will need the expertise of the private sector.

9.8.1 Land Acquisition

Large-scale railway projects usually require land acquisition and displacement of homes and businesses, and involuntary resettlement of local populations. While governments may have the authority to acquire land when needed for development purposes, land acquisition often causes controversy, as the associated human costs may be much more than the monetary compensation available. Moreover, in countries without clear land acquisition laws, the challenge is complex.

Transparent and tested land acquisition laws and agreements between stakeholders over fair compensation play a crucial role in the timely and successful completion of railway projects. It is expected that the State will by legislation, formally acquire all the lands wholly or in sections for the project.

9.8.2 Allocating Risk Correctly

The private sector has a role to play, since governments alone cannot deliver railway projects. Private sector involvement can be through construction companies, systems suppliers, rolling stock manufacturers, private finance and numerous services associated with railway development. For the private sector to get involved in the project and provide value for money to the government, the allocation of various project risks will be done correctly.

9.8.3 Securing Funding

Transport infrastructure is a public good and the services benefit a large number of people. Hence, it is not just the financial returns, but also the social benefits that need to be considered when planning such projects. Prior to starting any railway project, the government will undertake feasibility studies to fully understand the funding requirements of the project and the key sensitivities to the project's finance on the budget. The private sector can then be invited to participate in sections of the programme on Build, Operate and Transfer (BOT) or other appropriate basis.

9.8.4 Integration with other Modes of Transport

Different modes of mass transit may be feasible and most appropriate in different areas of cities. A successful urban public transport strategy will offer convenience to the public by implementing integration of one mode with other modes so that they are more willing to switch to public transport from private ones.

9.8.5 Location Workshops

The location workshops, that were core to the old railway network, are proposed to be a separate cost centre to enhance efficiency of operations. Their mandate remains the same, overseeing heavy maintenance schedules for the railway companies. The others are the estate division, the stores division and the railway research body.

9.9 Financing the Ghana Railway Master Plan

9.9.1 Establishment of a Special Purpose Vehicle

Ghana's public finances are inadequate to meet all the huge infrastructure expenses. Since railway infrastructure has long life cycle costs, it is financed by both project equity and debt. Debts funding are flexible instruments and may take the form of bank loans and/or financing from bond issuance. Bonds typically exhibit interest rate certainty, have the potential to be low rated, and can be used on more than a single project[58].

The institutional investors and lenders (e.g. insurance companies, investment and pension funds) presenting long-term liabilities are more willing to assume long-term commitments in project financing, especially when the construction phase of the project is over. Collaborative infrastructure investments reduce the public sector borrowing requirements and the public debt ratio.

9.9.2 Public Private-Sector Partnership

The adoption of PPP procedures will help to reduce the overall capital burden of railway development on the public purse, and allocate revenue-generating activity to the private sector. The government will unbundle railway infrastructure (land, stations, rights of way, etc.) from rolling stock and other train services equipment.

Unless otherwise agreed, the government will continue to own the railway infrastructure through the revised Railway Act. The GRDA will remain the holding company, subletting safety and environment regulatory oversight to private companies. GRDA will also confer the railway infrastructure to a public company, the GRCL, and assure the competition in

[58] Deloukas, A. and Apostolopoulou. E. (2003), "Innovative Financing Techniques: European Urban Rail Projects and the Case of Athens Metro Extensions", Association for European Transport, 2003

railway usage for different private or public train operators. The provision of rail services and the ownership of rolling stock will be provided by the GRCL and private sector operators. The GRCL could also be one of the railway operators, and/or eventually offer workshop maintenance services for rolling stock.

The concession for the redevelopment of the railway system will be granted through bidding to the major users, mostly mining companies or freight carriers. The government should, in any case, try to extract the highest possible value from the concession, negotiating comprehensive mining and railway development agreements rather than separate mining or railway licenses, and acting to guarantee also the possibility of passenger train services accompanied by PSO (Passenger Service Obligation) contributions. The entire operation will be carried out with the active participation of Ghanaian building industry professionals (planners, architects, engineers, etc.) as well as contractors and service professionals during the design, construction and operation phases.

9.9.3 Land Leases and Tax

The land value increase around the railway lines and stations produces positive externalities that will be internalised to fund the investment. Land surplus value may be captured either by moderate leases or taxation or by voluntary cost sharing for joint development purposes with real estate companies, industries, industrial farming complexes, etc. These non-core activities are expected to generate tremendous revenue to the company.

It is expected that mining companies, major construction and logistics companies and other commercial entities will participate with equity capital in the concession structure. The efficiencies from an integrated value chain create economic gains if properly harnessed. The revival of the railway system is of interest to the major users, e.g. mining companies, agricultural exporters, construction companies etc., because they do not have any 'traffic risk', since they are transporting mainly their products, which amounts they know very well.

9.9.4 The Railway Development Fund

The Ghana Railway Act that established the GRDA has vested all regulations, ownership and development of the railway assets in Ghana to that Authority. The Railway Act 2008, stipulates the setting up of a Railway Development Fund in addition to other sources for funding the infrastructure development, such as the following:

i. Proceeds received by the Authority from the disposal of assets;
ii. Proceeds received by the Authority from investments;
iii. Allocations provided by the Minister for Finance with the approval of Parliament for the funding of railway development or for a specific project under the Fund;
iv. Levies approved by Parliament;
v. Loans granted for the purposes of the Fund; and
vi. Grants, gifts and income from other sources received for the purpose of the Fund.

There might be the need to revise the Railway Act 2008, to reflect the new and improved railway network, and include fuel tax as source of funds. If Ghana wishes to have a rail system similar to systems in high income countries, then the country's Gross National Income (GNI) should improve to the level of the advanced nations so it may not become necessary to rely solely on foreign financial support. Ghana is currently classified as a lower-middle income country with a GNI per capita of $1,400. Fortunately, the LTNDP is focused on increasing the per capita GNI to US$62,000 over the long term.

9.9.5 Recommendations

The following are recommendations for establishing a viable and self-sustaining railway system in the country:

i. The Government of Ghana must build and own the modern railway network as proposed in the Master Plan and allow private investors to use that infrastructure at an agreed fee;
ii. Ghana's tertiary engineering institutions will be supported to design courses to train students and practising professionals in railway technology in order to build the capacity for the country's railway industry;
iii. Retooling and upgrade of the Railway Institute to further train professionals in the sub-regional railway networks and businesses;
iv. Ghana will explore the need for further increase in the railway coverage beyond 30 years after implementing the Railway Master Plan;
v. Finally, the country will upgrade and re-tool the Location Workshops, near Sekondi, as a separate business centre to manage the maintenance of the rolling stock.

Chapter 10 Water Resources Management

10.1 Introduction

The water resources management plan sub-component deals with all the water cycle structures including water supply, flood control, drainage, irrigation, and waste water management. It sets out the strategy to effectively and efficiently develop, manage, protect and control the use of the water resources of the country. This is directed towards contributing to achieve the long-term national goals of building an industrialised, inclusive and resilient economy; and to create an equitable, healthy and disciplined society. The water resources management infrastructure plan covers strategic actions for securing the sustained use of internal freshwater resources and the protection of ecosystems to address long-term development of the country.

Indeed, measures of improved water resources management have shown considerable economic gains. For instance, a US$15 to US$30 billion investment in improved water resources management in developing countries can have direct annual income returns in the range of US$60 billion. Every US$1 invested in watershed protection can save anywhere from US$7.5 to nearly US$200 in costs for new water treatment and filtration facility[59]. Water investments help to reconcile the continuous increase in water use with the need to preserve the critical environmental assets on which the provision of water and the economy depend. Any possibility of sustaining the gains of economic progress relies on investing in the protection of water-related ecosystems for maintaining the essential and varied environmental services they provide, and upon which the economy depends.

10.1.1 Vision and Context of Water Resources Management

The national vision is to have assured water and healthy water ecosystems for the present and future through an efficient and effective management system.

The overarching goal is to ensure sustained availability, development, and management of water resources for an industrialised, inclusive and resilient economy; and an equitable, healthy and disciplined society.

The development, management and use of water now and in the future are the major challenges that need to be tackled to secure water for a healthy environment, economic growth and development. The global vision for the future of water by 2050 is to promote inclusive sustainable development, as it supports human communities, maintains the functions of ecosystems, and ensures economic development. The Africa Water Vision 2025 is to have water resources effectively and sustainably managed to meet basic needs, food security, economic growth, and protect terrestrial and aquatic systems.

Ghana's vision for water by 2025 is in step with the Global Water Vision 2050, the Sustainable Development Goals, the Africa Water Vision and the African Union policy direction. Two previous studies that sought to address the water resources infrastructure

[59] United Nations World Water Assessment Programme (WWAP), The *United Nations World Water Development Report 2015: Water for a Sustainable World (*Paris: UNESCO, 2015), 26

needs of the country are the 1998 Water Resources Management Study (WARM) and the 2016 Savannah Accelerated Development Authority (SADA) study on water resources of the savannah zone of the country. The WARM study consolidated information on water resources and the establishment of an enabling environment for management of water resources. The SADA study provided synthesised information and recommended the building of water storage facilities to access and optimise the use of available water resources as well as improve the knowledge on groundwater resources in the zone.

Accordingly, the Water Resources Management Infrastructure Plan sets out the strategy to effectively and efficiently develop, manage, protect and control the use of the water resources of the entire country. The water plan covers strategic actions for securing the sustained use of freshwater resources and the protection of ecosystems to address long-term development of the country.

10.2 Overview of Ghana's Water Sector

Ghana's water resources are largely underdeveloped. Very little of the total surface freshwater resources is currently accessed, and millions of people are suffering dramatically from the devastating effects of floods, droughts, water pollution, and waterborne diseases. Climate change and climate variability are skewing precipitation patterns and making the natural flow of water in the river channels immensely variable. Population growth and urbanisation have also set heavy demands on land, water and other natural resources besides generating pollution.

In resolving these issues, Ghana has introduced and made significant progress in implementing the concept of Integrated Water Resources Management (IWRM) as the comprehensive approach to the development and management of water. Despite the progress made, there are challenges and constraints that need to be further addressed.

10.2.1 Policies, Strategies and Plans

The overall development and management of water in Ghana hinges on the National Water Policy (NWP); the Ghana Water Vision 2025; the National IWRM plan; the Water Sector Strategic Development Plan (WSSDP); and the National Riparian Buffer Zone policy. The water policy, strategies and plans affirm the development of water infrastructure as one of the principal drivers to boost economic growth needed to reduce poverty and accelerate development in the country.

10.2.2 Legal and Regulatory Situation

Water resources management is governed by a statutory law (Water Resources Commission Act 522 of 1996), which places the ownership, control and regulation of water resources in the hands of the State. Three (3) regulations are in place: the Water Use Regulations, 2001 (LI 1692); the Drillers' License and Groundwater Development Regulations, 2006 (LI 1827); and the Dam Safety Regulations, 2016 (LI 2236).

Legislation for water quality is limited to the setting of quality standards for drinking water and provisions for the development of regulations for effluent discharge. The country needs to place premium on reviewing existing laws and policies on water resources to take account of recent international and regional agreements and protocols as well as contemporary global and regional considerations that are appropriate for the Ghanaian context.

10.2.3 Institutional and Organisational Context

The management and development of water resources in Ghana is quite well structured, and undertaken by many institutions which operate at three functional levels namely: policy, organisational, and operational.

At the policy/strategic level, three core ministries (Ministry of Sanitation and Water Resources, Ministry of Local Government and Rural Development (MLGRD), and Ministry of Finance (MoF)) provide policy direction and collaborate to ensure the delivery of water and sanitation services. At the organisational level, three distinct organisations perform different but complementary functions, namely: Ghana Water Company Limited (GWCL) for urban water supply, Community Water and Sanitation Agency (CWSA) for rural water supply and related sanitation provision, and the Water Resources Commission (WRC) for water resources management.

At the operational (or decentralised administration) level, ministries, departments and agencies, river basin boards (RBBs), non-governmental organisations (NGOs)/community based organisations and other civil society groupings work together within a river basin focused framework, to take charge and coordinate water resources management activities at the lowest level.

10.3 Situational Analysis of Water Resources (Availability)

10.3.1 State of Surface Water Resources (Availability)

Ghana is endowed with freshwater resources. However, the amount of water available changes markedly from season to season and from year to year. Also, water distribution within the country is not uniform, with the south-western part better watered than the coastal and northern regions.

The mean annual runoff ranges from 51 to 93 m^3/s, representing only about 69% of rainfall. The total actual renewable freshwater resources are estimated to be 53.2 billion m^3/yr, of which 30.3 billion m^3/yr are generated internally, with the Volta, south-western and coastal river systems draining 70%, 22% and 8%, respectively (Figure 10.1).

The available internal renewable freshwater resources are enough to support most uses in the country if adequately developed and managed. It is important to state that 22.9 billion m^3 of the total actual renewable water resources originates from outside of the country's international borders. Out of the total renewable water that enter the country annually, 8.7 billion m^3 come from Burkina Faso, 6.2 billion m^3 from Côte d'Ivoire and 8 billion m^3 from Togo. Thus, Ghana is to a large extent depending on collaboration with its riparian neighbours on sharing its water resources potential (Figure 10.2).

Table 10.1: Ghana's Renewable Water Resources Availability

Renewable Water Resources	
Average Precipitation	283.1 x 10^9 m^3/yr
Internal Renewable Water Resources	30.3 x 10^9 m^3/yr
Contribution from outside the country	22.9 x 10^9 m^3/yr
Total Actual Renewable Water Resources	**53.2 x 10^9 m^3/yr**

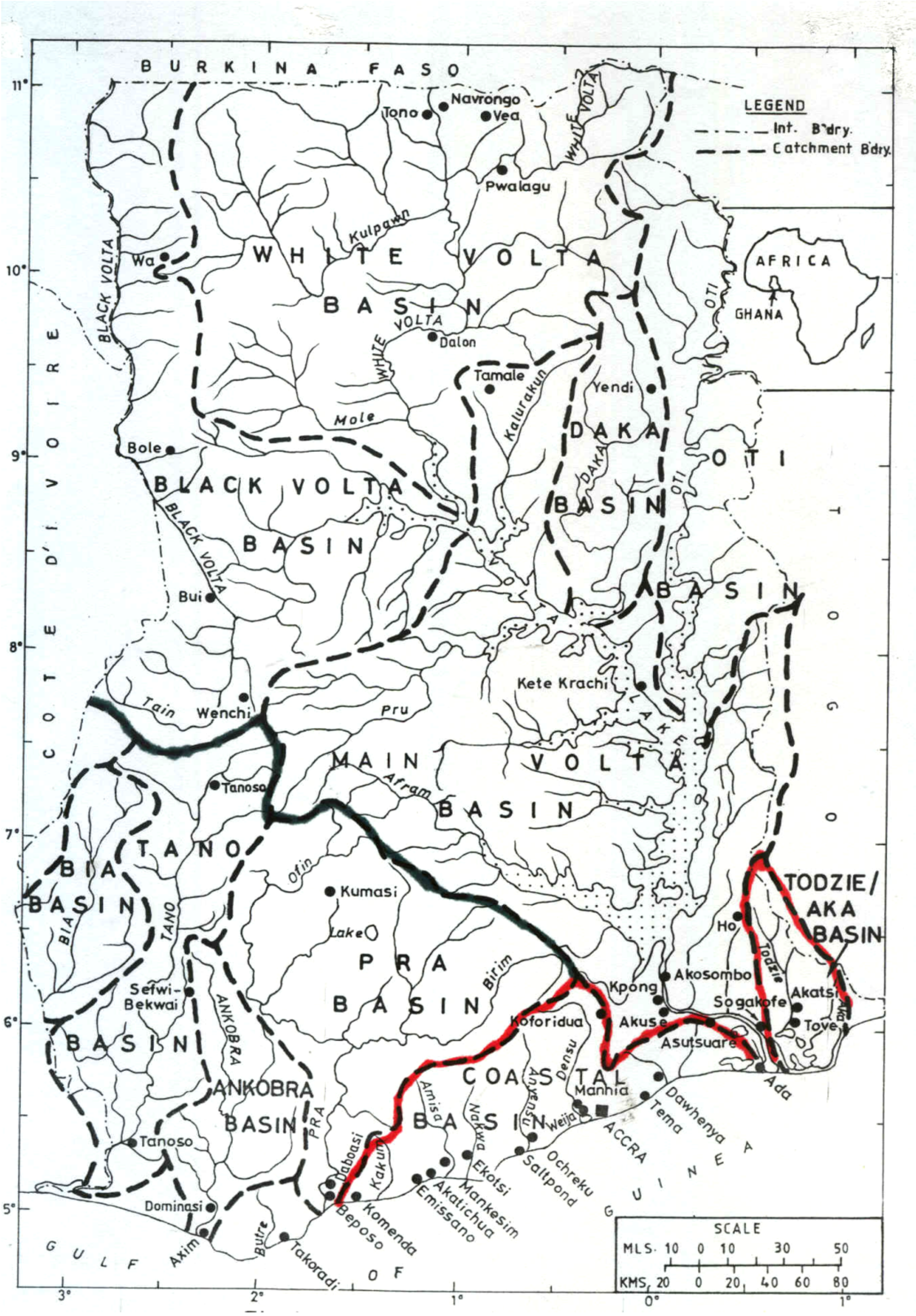
Source: WRC, 2012; FAO/AQUASAT 2005

Table 10.2: Surface Water from the Major River Basins

River Systems/Basins	Area (km^2)	Mean Annual Runoff (million m^3)
Volta Basin System		
Black	35,107	7,315
White	45,804	9,118
Daka	9,174	1,991
Oti	16,213	10,691
Lower	59,414	8,688
Sub – Total	**165,712**	**37,804**
South-Western Basin System		
Bia	6,965	1,420
Tano	14,872	4,033
Ankobra	8,461	2,121
Pra	23,188	5,723
Sub – Total	**53,486**	**13,298**
Coastal Basin System		
Todzie/Aka	1,865	440
Densu	2,551	476
Ayensu	1,709	326
Butre	466	105
Kakum	984	197
Ochi- Amissa	1,368	265
Ochi – Nakwa	1,502	289
Sub – Total	**10,445**	**2,098**
Grand Total	**229,643**	**53,200**

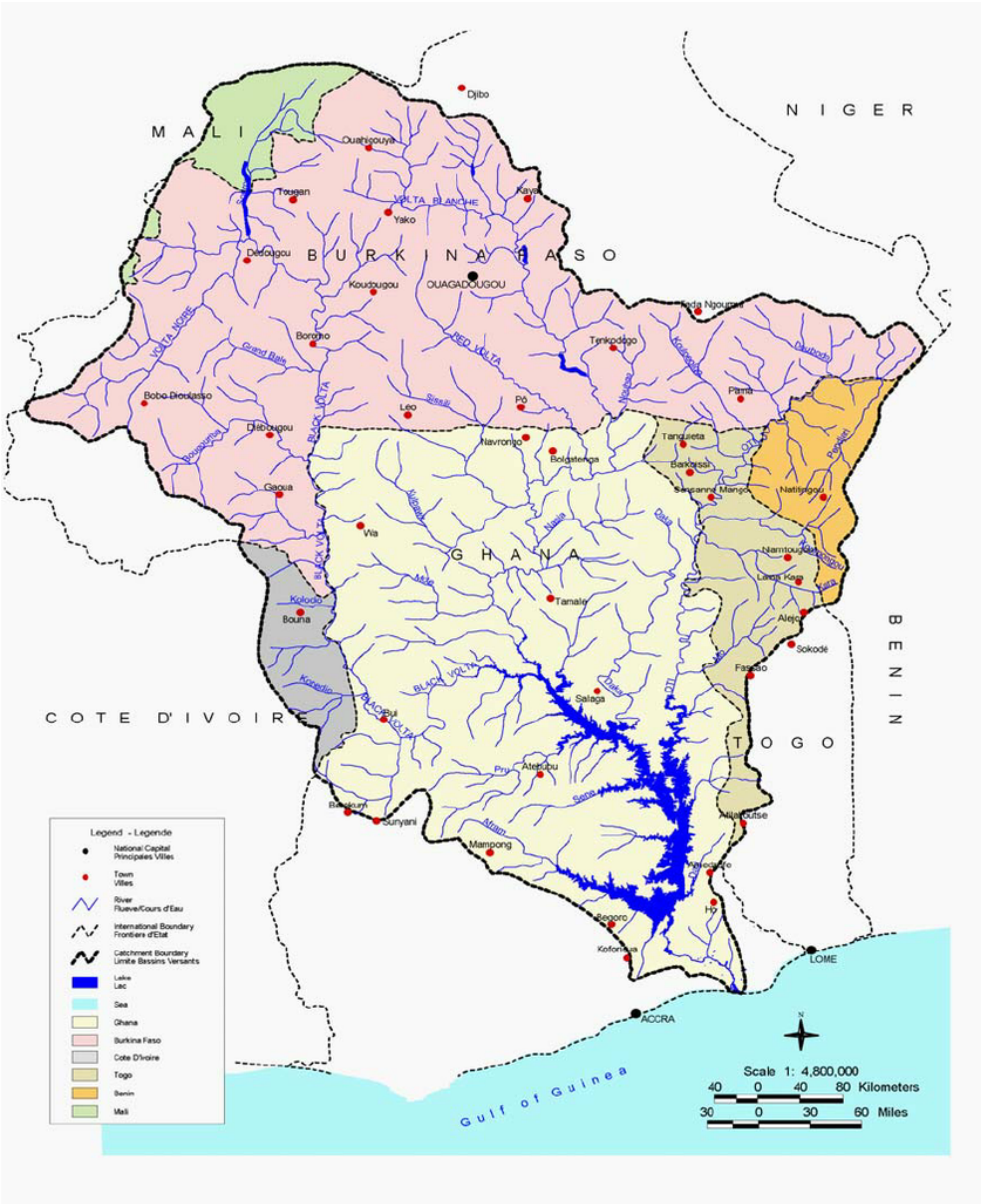
Source: MWH, 1998; WRC, 2012; FAO/AQUASAT 2005.

Figure 10.1: Drainage Map of Ghana showing various River Basins



Source: Water Resources Commission

Figure 10.2: Map of the Volta Basin showing Political Boundaries



Source: Andah and Gichuki, 2003[60]

[60] Andah, W. and Gichuki, F. (2003). Volta Basin Profile: Strategic research for enhancing agricultural water productivity (Draft). Accra: International Water Management Institute, Challenge Program on Water and Food.

10.3.2 State of Groundwater Resources (Availability)

Ghana is also endowed with groundwater resources even though this resource is not yet comprehensively studied. Reports portray average yields of between 6-180 cubic metres/hr. In Northern Ghana, aquifers have been located at between 10 and 150 metres deep. In Southern Ghana, borehole depths range between 25 and 90 metres, with an average of 42 metres. Only about 5% of the urban water supply is from groundwater. Groundwater for irrigation purposes is generally limited to subsistence farming and minor commercial vegetable farming. The assessment of groundwater recharge and development suggests that it would be sustainable from a geo-scientific point of view, at least in the foreseeable future.

10.3.3 Water Usage

The current water withdrawals are mainly for water supply, irrigation and livestock watering, and industrial purposes. In 2015, the total withdrawal as a percentage of total actual renewable water resources was about 8%, but constituted 13.4% of the water resources generated internally. About 3,123 million m^3 of total withdrawals was for irrigation (68%), 578 million m^3 for domestic use (20%), and 289 million m^3 for industrial purposes (10%).

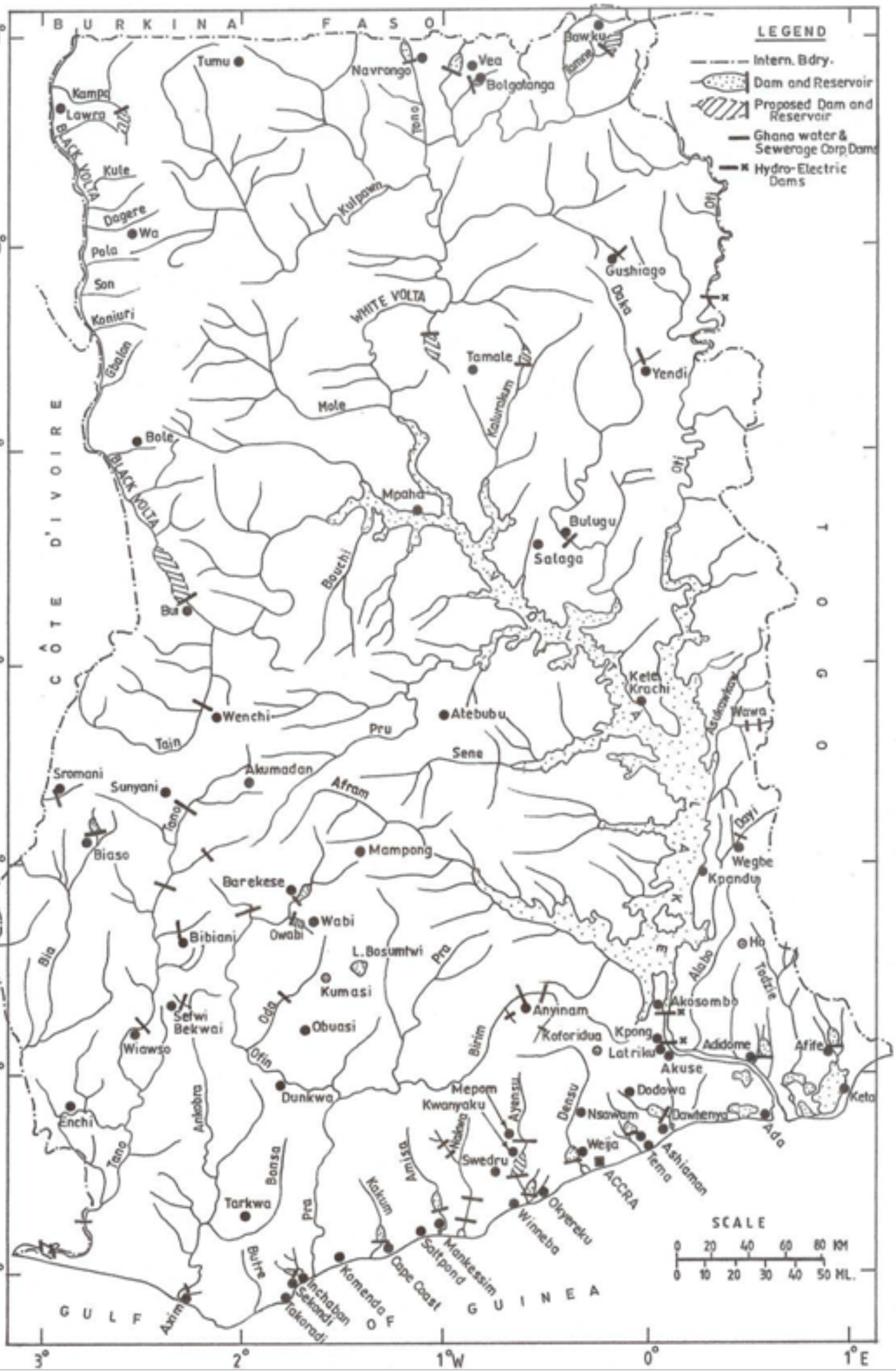
Current water use for hydroelectric power generation, which is not counted as consumptive water use, is about 37.843 km^3 per year. Thus, only a small proportion of total renewable water resources are withdrawn, with irrigation constituting the highest consumptive use of water. In terms of water withdrawal and usage per capita, the withdrawal per/cap/yr is about $80m^3$. The corresponding value for Sub-Saharan Africa (SSA) is 173 m^3 per/cap/yr and 1,300 m^3 per/cap/yr for North America. Clearly, the level of water use in Ghana is very low.

10.3.4 Water Storage

Water storage is categorised as a continuum of three primary, but overlapping storage types: natural wetlands, ponds/small tanks, and reservoirs. Based on these storage types, there are about 23 formal large and medium reservoirs nationally. There are also over 2,000 small and micro reservoirs and ponds located mostly in the northern regions and mainly used for domestic, irrigation and livestock watering (Figure 10.3). Excluding Lake Volta and Bui dam, the total potential storage is about 531.5 million m^3.

The Akosombo and Bui reservoirs have gross storage capacities of 37.8 billion m^3 and 12.35 billion m^3 respectively. The per capita water storage is $6,500m^3$, which is higher than the $6,000m^3$ in Northern America, $4,800m^3$ in Australia, $3,400m^3$ in Brazil, and $200m^3$ in Africa. The relatively high per capita water storage is entirely due to the huge volume of the Lake Volta, geared for power generation. Excluding Lake Volta, per capita water storage is just about $12m^3$.

Figure 10.3: Location of some reservoirs in Ghana



Source: Water Resources Commission

10.3.5 Water Quality

The adopted Water Quality Index (WQI) gives an overview and summary of the status of water quality at any time. The description of WQI is indicated in Table 10.3 below.

Table 10.3: Water Quality Indices

Class	Range	Description
I	>80	Good – unpolluted water
II	50 – 80	Fairly Good
III	25 – 50	Poor Quality
V	< 25	Grossly Polluted

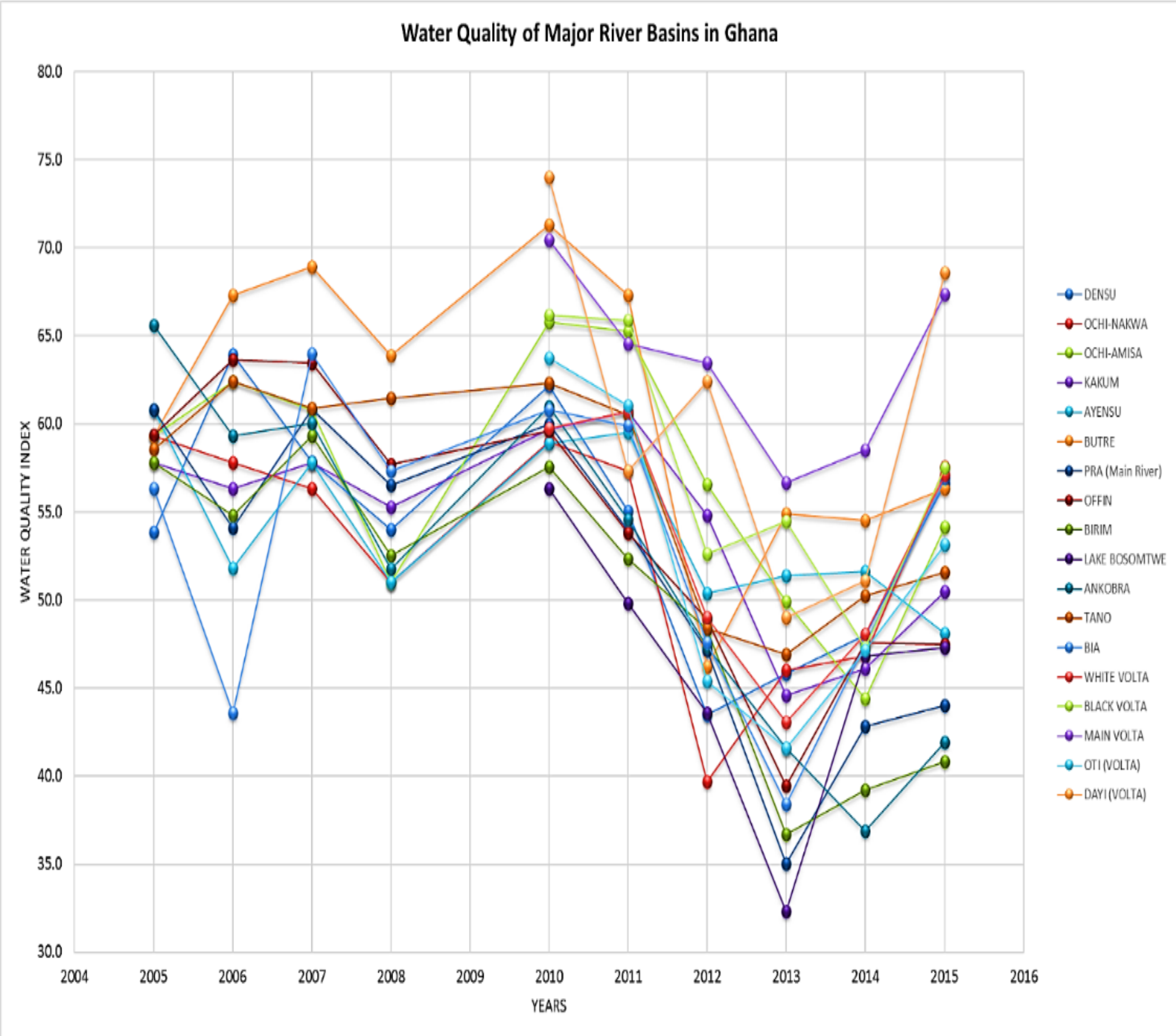
Source: Water Resources Commission

Water ecosystems are not in a healthy state. Many of the rivers deteriorated in quality in 2013 and were found in Class III, i.e. poor water quality as shown in Figure 10.4. Lake Bosumtwi recorded the minimum WQI score of 32.3, while Ajena in the main Volta Lake had the maximum WQI score of 62.2.

Generally, there was a slight improvement in all the rivers from 2014 to 2015. However, the situation remains dire since 2015. Out of the 40 river systems that were monitored countrywide, 60% were of poor quality (Class III), with 15% being critical. The continued and unregulated activities of small-scale miners ('galamsey') were almost entirely responsible for the apparent deterioration in the quality of some water bodies such as the Tano, Birim, Offin and Ankobra.

However, the quality of naturally occurring groundwater resources in Ghana is generally good for multipurpose use except for some cases of localised pollution and high levels of iron, fluoride and other minerals.

Figure 10.4: Summary of WQI of major water bodies from 2005 to 2015



Source: Water Resources Commission

10.4 Key Drivers of Recent and Anticipated Water Uses

The major driving forces relate to socio-economic development, such as growth in population and urbanisation; agricultural development; technological and industrial development; and economic growth; as well as environmental change including climate change. These are discussed below:

i. The population of the country, which is expected to double to 57 million by 2057 will create the greatest pressures on water resources quantity and quality;
ii. The urbanisation rate estimated to be 73% from the current 51% by 2057 would require significant investments in water infrastructure;
iii. Industrialisation (including mining) is anticipated to expand rapidly. This expansion would lead to more pressure on the water resources and natural ecosystem;
iv. Ensuring food security would require substantial volumes of water based on land–use patterns, irrigation efficiency and technology, and water use patterns;

v. Hydropower production would play a part in modernising the economy. It is considered an industry activity, with consumption (evaporation) estimated at 5% of withdrawals;
vi. Environmental flow is a water demand category in its own right. It covers the flow regime required to maintain a river ecosystem in a state that delivers its ecological functions and services;
vii. Climate change would have significant impact on the water resources. Realistic scenarios indicate reduction in runoffs between 15-20% over the coming 20-year period;
viii. Water demand will increase and exert pressure on water availability, unless there are corresponding increases in water conservation and other management techniques.

10.5 Water Resources Availability and Requirement

10.5.1 Future Water Availability

The total actual renewable freshwater resources (TARWR) gives the maximum amount of renewable water 'potentially available' for the country and is the basis for planning water development. The freshwater resources per capita provides the average annual per capita volume of water available to individuals within the country. A country is said to be rich in water when it has more than 1,700 m^3/cap/year, while a water scarce country is below 1,000 m^3/cap/year. The country becomes extremely water scarce when the water resources per capita is below 500 m^3/cap/year.

Currently, the national freshwater resources per capita is about 1,941 m^3/cap/year. Based on the Long-term National Development Plan (LTNDP) high population growth and the TARWR of 53.2 billion m^3/year (excluding groundwater), it is anticipated that the annual water availability per capita would drop below the water rich benchmark figure of 1,700 m^3 by the year 2021. By the year 2047, the situation would be critical with annual water availability per capita at about 1,040 m^3/cap/year. The country would be in a situation of water scarcity after year 2049 with the annual freshwater resources per capita at 969m^3 in 2053.

This analysis was made based solely on surface freshwater availability. There is a huge groundwater resources potential, which would be investigated, assessed and evaluated to constitute additional potential resource base.

Table 10.4: Freshwater Resources Per Capita (2018-2057)

Year	Estimated Population (million)	Water resources per capita (m^3)
2018	28.60	1,860
2021	31.35	1,697
2025	34.26	1,553
2027	36.23	1,469
2029	37.15	1,432
2033	40.33	1,319
2037	43.59	1,220
2041	47.03	1,131
2045	49.86	1,067
2047	51.15	1,040
2049	52.44	1,014
2053	54.90	969
2057	56.99	933

Source: Author's construct

10.5.2 Future Water Requirements

The anticipated major water uses that define water resources management infrastructural development are water supply (domestic/municipal), industrial (manufacturing, services, mining, and energy), and irrigation. The study determined the water requirements for each of these uses from 2018 to 2047.

The water requirements for these key water uses vary with population growth and well-being, urbanisation, environmental flow requirements, climate change considerations, the direction of development, and the degree of growth under the new national development framework for 2057. These variations are the basis for two alternative water requirement scenarios.

Basic domestic water requirement is expected to increase significantly as individual well-being improves. The basic domestic water requirement is estimated to be 75 litres/cap/day in 2018 (for Lower Middle Income Countries - LMICs) and expected to be 400 litres by 2047 (for High Income Countries - HICs). It is estimated that 71.4% of water is required to be used for agriculture (irrigation and livestock watering), 21.4% for domestic/municipal purposes, and 7.2% for industrial uses. Under this "business as usual" scenario and assuming the LTNDP high population growth and expected increases in the basic domestic water requirement, the estimated total water requirement (TWR) for 2018 would be 5.13 billion m^3/year representing 17% of the internal renewable freshwater resources (IRWR) and 10% of TARWR. The domestic, industrial and irrigation water requirements would be 783 million m^3/year, 234.8 million m^3/year, and 4.11 billion m^3/year respectively. The TWR is estimated to increase to 30.12 billion m^3/year by 2045, that is 57% of the TARWR and 99% of the IRWR, which would be completely exploited by 2047 should there be no planned interventions.

Ghana seeks to be ranked among HICs by the year 2057 through a transition from LMIC through Upper Middle Income Country (UMIC) and finally to HIC. Therefore, the alternative scenario was to benchmark the water requirements to the international standards, which is based on the level of Gross National Income (GNI) per capita. This exercise reveals the key sectors to target with needed infrastructure interventions to help the country move to a HIC. The global water withdrawal ratios for the three major sectors – domestic/municipal, industrial, and irrigation – based on economic status are shown in Table 10.5.

Table 10.5: Global Withdrawal Ratio of Sectors based on Economic Status

Sector	Global Withdrawal Ratio		
	LMIC	**UMIC**	**HIC**
Domestic/Municipal	21.4	13.3	15.5
Industrial	7.2	19.5	41.0
Irrigation	71.4	67.2	43.5

Source: World Bank (World Development Indicators, 2015)

These ratios were applied in the determination of the water requirements for each sector based on the LTNDP High Population Growth scenario to achieve UMIC and HIC status. Based on this scenario, the results of the estimated water requirements from 2018-2047 are presented in Table 10.6 below.

Table 10.6 shows that future total water requirement (TWR) is likely to rapidly exceed the available resources from 2027. The TWR is expected to double from 2027 especially for industrial uses (6.4 times) and irrigation (2.2 times) in view of the transition towards an UMIC. In this case, 99% of the IRWR or 57% of the total actual renewable water resources (TARWR) would be committed. The country would therefore rely mostly on the external water inflows from 2029 to 2037. Therefore, it will be difficult to meet the projected requirements without damaging the environment, which calls for well-informed infrastructural interventions.

Table 10.6: Estimated Water Requirements Based on Income Level Ratios (2018-2047)

Year	Domestic WR (million m^3)	Industrial WR (million m^3)	Irrigation WR (million m^3)	Total WR (million m^3)	TWR as % of IRWR	TWR as % of TARWR
2018	782.80	234.84	4,114.42	5,132.07	17	10
2021	1,716.42	514.93	5,149.27	7,380.62	24	14
2025	3,125.94	937.78	9,377.83	13,441.55	44	25
2027	3,966.86	5,950.29	20,231.00	30,148.16	**99**	**57**
2029	4,270.82	6,406.22	21,781.16	32,458.20	107	61
2033	4,931.26	7,396.88	25,149.40	37,477.54	124	70
2037	5,568.72	8,353.07	28,400.45	42,322.23	**140**	**80**
2041	6,265.78	16,291.02	17,920.13	40,476.93	134	76
2045	7,006.97	18,218.12	20,039.93	45,265.01	149	85
2047	7,468.31	19,417.60	21,359.36	48,245.26	**159**	**91**

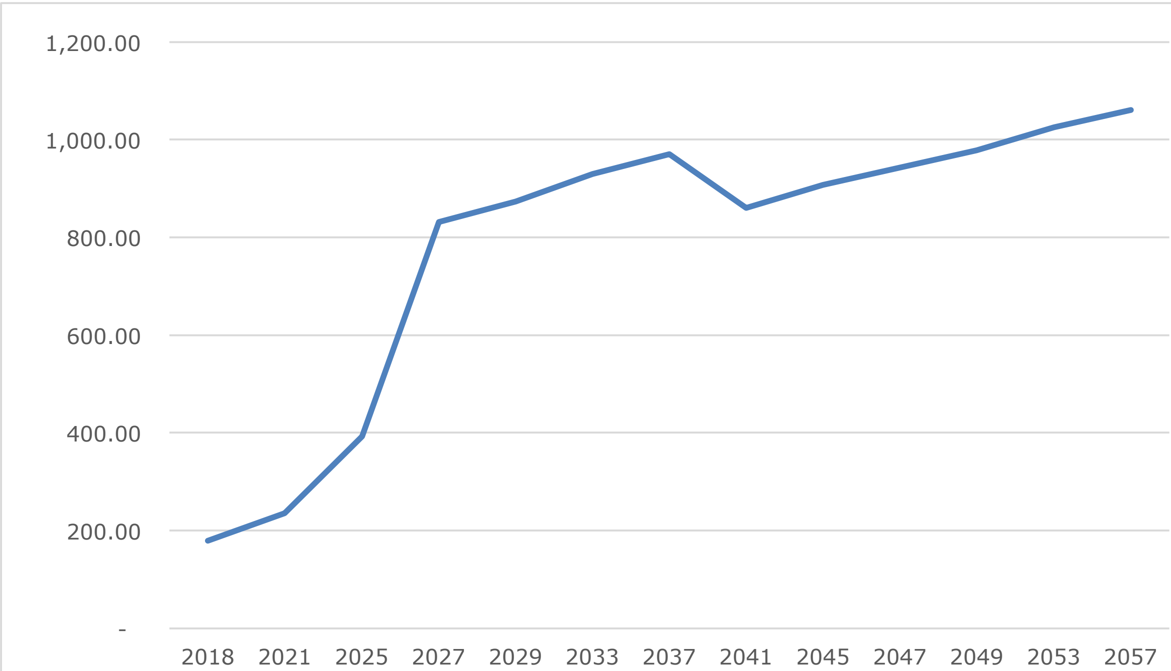
Source: Author's construct

The domestic/municipal water requirement does not change since the basic domestic daily water use was estimated based on the level of income and well-being. The estimated total water requirements (TWR) from 2018-2025 also remains unchanged based on the status of the country as a LMIC. The future TWR is likely to rapidly exceed the available resources from 2027. The TWR is expected to double from 2027 especially for industrial uses (6.4 times) and irrigation (2.2 times) in view of the transition towards an UMIC. In this case, 99% of the IRWR or 57% of the TARWR would be committed. The country would therefore rely mostly on the external water inflows from 2029 to 2037.

The *OECD Environmental Outlook to 2050* estimates that by 2050, the share of total water demands from manufacturing industries alone will increase by close to 400% in developing countries including Ghana[61]. Water availability per capita/year is established only with population growth without considering the planned water requirements by the key sectors. In terms of water use per capita, the withdrawal per cap/yr is expected to be 235m^3 by 2021, 874m^3 by 2029, and reach 943m^3 by 2047. These figures compare favourably to the corresponding values of 1,025m^3 and 809m^3 for Canada (North America) and Spain (Europe) respectively.

Figure 10.5 shows the trend of anticipated water use/withdrawal per cap/yr as the population grows and the economy transitions to a HIC.

Figure 10.5: Trend of anticipated water use per cap/yr



Source: Author's construct

Anticipated Water Use per cap/yr

Note that the water use per cap/yr falls briefly between 2037 (970.9m^3) and 2041 (860m^3) before increasing again. This is due to the anticipated transition to an industrialised and HIC economy by 2037. In such an emerging market economy, industrial demand for water is expected to rise with the country's rapid growth in manufacturing output and decrease in demand with respect to irrigation (agriculture).

[61] Organisation for Economic Co-operation and Development (OECD), Environmental Outlook to 2050: The Consequences of Inaction (Paris: OECD, 2012). doi:10.1787/9789264122246-en.

10.5.3 Main Challenges/Issues stemming from the Outlook

Two sets of challenges emerge from the outlook of water availability and requirements, which need to be addressed over the next 30 years. First, is the supply side challenge of how to:

i. Reduce quantitative pressures in order to have sufficient water resources to meet increasing water requirements (which in many cases increases by 100% - 600%);
ii. Effectively distribute the resource to decrease losses to meet the growing demands;
iii. Reduce qualitative pressures to improve the ecological health of water resources.

Second, is the demand side challenge of how to:

i. Manage water resources systems under variable conditions and conflict of uses;
ii. Introduce innovations to improve water use efficiency by all water users;
iii. Adopt sustainable practices that avoid damage to critical water resources and irreversible ecological processes;
iv. Improve the management capacities to develop, regulate and manage the utilisation of the resource.

10.6 Strategic Framework for Water Resources Management

Water resources infrastructural interventions have been identified to address the outlook challenges. The interventions are presented as a strategic framework for water resources infrastructure needed to optimise long-term growth potential, while also satisfying water requirements over the period 2018-2047.

10.6.1 Planned Strategic Areas

The strategies and indicative activities on infrastructure to realise the goal have been developed in line with the LTNDP and clustered into two (2) main packages as follows:

i. Meeting the growing water demands:
   - Enhancing the benefits of the existing water resources infrastructure;
   - Developing additional water resources through discovery and expansion of new sources;
   - Improving water quality and environmental protection.

ii. Enabling/Supporting interventions:
   - Improving management capacities;
   - Improving the policy, legal and regulatory frameworks.

10.6.2 Indicative Targets

The indicative water resources infrastructure targets envisaged at the end of the planned period are:

i. Increase water use or withdrawal to 1,025 m^3 per/cap/year;
ii. Meet total water requirement of 48 billion m^3/year;

iii. Improve the water quality of all river basins to a WQI of more than 80 (good quality water).

The indicative actions to address each of the main intervention packages, realise the envisaged targets, and reach the final goal are outlined in the strategic framework for water resources management infrastructure in Table 10.7.

Table 10.7: Strategic Framework for Water Resources Infrastructure

Sustained availability, development, and management of water resources

Meeting the Growing Water Demands

Enhance existing water resources infrastructure	***Develop additional water resources***	***Improve water quality and environmental protection***
1. Employ standardised approaches to map out and take inventory of existing storage facilities. 2. Systematically evaluate and improve the performance and complete planned expansion of water storage facilities. 3. Implement measures in water use efficiency. 4. Apply intermediate reuse and recycling of water resources. 5. Design and implement efficient/effective Integrated Decision Support for rational allocation and conservation of water resources. 6. Strengthen and apply technical, environmental and social safeguards that minimise potential adverse impacts for all water storage options.	1. Develop multi-purpose conservancy facilities to increase storage capacities to serve multi-uses and users. 2. Investigate and develop hydrogeological and groundwater base (sources) (i.e. shallow, intermediate and deep aquifers). 3. Generate additional water resources from rainwater and flash flood harvesting. 4. Develop natural infrastructure "natural harvesters" such as wetlands, and floodplains. 5. Develop basin based investment plans with clear objectives and priorities for investment in all water storage options. 6. Develop inter basin water transfer/diversion infrastructure schemes (both national and transboundary).	1. Ensure the use of cleaner and environmentally friendly methods and products in all uses (especially agriculture and industry). 2. Ensure treatment of industrial effluent and municipal sewage and wastewater. 3. Protect important ecological areas from pollution and contamination. 4. Protect sensitive water supply areas, e.g. groundwater sources and intake of public water supplies.

Enabling/Supporting Interventions

Improving management capacities	***Improving the policy, legal and regulatory frameworks***
1. Improve the water resources information and knowledge base. 2. Develop and strengthen protocols for developing and sharing transboundary water resources. 3. Develop and strengthen institutional planning and implementation capacities.	1. Review water and water-related policies to strike appropriate balance between supply and demand. 2. Harmonise legal and regulatory instruments for strategic development, management and use of water resources.

Source: Author's Construct

10.7 Implementation Plan

10.7.1 Implementation Timeframe

Although the strategic framework covers the period 2018-2047, its aspirations will be implemented under four (4) phases – two 5-year and two 10-year - timeframes over the entire 30 years. The timeframes are based on their derived purposes and the paths of the LTNDP that will together drive implementation of the strategic actions. The timeframes and their respective purposes are as shown in Table 10.8.

Table 10.8: Implementation Timeframes and Activities

Timeframe	Duration (Years)	Activity/Purpose
2018-2022	5	Strengthen the enabling environment and stabilise the water environment to meet anticipated increase in water requirements
2023-2027	5	Meet the anticipated significant water requirements towards an upper middle income economy
2028-2037	10	Maximise water availability to meet the growing water requirements towards a high income economy
2038-2047	10	Consolidate and sustain water availability and use in a developed economy

Source: Author's Construct

10.7.2 Implementation Packages

The indicative actions outlined in the strategic areas have been prioritised and synthesised into the four timeframes to successfully address the purpose and contribute to meeting the targets and goal of the plan.

The prioritised indicative actions are by no means distinct to each timeframe, but will be relevant and implemented under subsequent timeframes. Other indicative actions will also complement the prioritised actions in each timeframe. The implementation framework showing the prioritised indicative actions under their respective strategic area for each timeframe is presented in Table 10.9 below.

Table 10.9: Implementation Framework of Prioritised Indicative Actions

Strategic Areas	**Time Frame and Priority Actions**			
	2018-2022 (5-year)	**2023-2027 (5-year)**	**2028-2037 (10-year)**	**2038-2047 (10-year)**
	Strengthen the enabling environment and stabilise the water environment to meet anticipated increase in water requirements	***Meet the anticipated significant water requirements towards an upper middle income economy***	***Maximise water availability to meet the growing water requirements towards a high income economy***	***Consolidate and sustain water availability and use in a developed economy***
Enhance existing water resources infrastructure	Design and implement efficient/effective Integrated Decision Support for rational allocation and conservation of water resources Implement measures in water use efficiency	Employ standardised approaches to map out and take inventory of existing storage facilities Systematically evaluate and improve the performance and complete planned expansion of water storage facilities	Apply intermediate reuse and recycling of water resources	Strengthen and apply technical, environmental and social safeguards that minimise potential adverse impacts for all water storage options
Develop additional water	Investigate and develop hydrogeological and	Develop multi-purpose conservancy facilities to increase	Generate additional water resources from rainwater and flash	Develop inter basin water transfer/ diversion

	Time Frame and Priority Actions			
	2018-2022 (5-year)	**2023-2027 (5-year)**	**2028-2037 (10-year)**	**2038-2047 (10-year)**
resources	groundwater base (i.e. shallow, intermediate and deep aquifers)	storage capacities to serve multi-uses and users Develop basin based investment plans with clear objectives and priorities for investment in all water storage options	flood harvesting Develop natural infrastructure "natural harvesters" such as wetlands, and floodplains	infrastructure schemes (both national and transboundary)
Improve water quality and environmental protection	Ensure treatment of industrial effluent and municipal sewage and wastewater Protect important ecological areas from pollution and contamination Protect sensitive water supply areas, e.g. groundwater sources and intake of public water supplies	Strengthen the treatment of industrial effluent and municipal sewage and wastewater Strengthen the protection of important ecological and sensitive areas from pollution and contamination	Ensure the use of cleaner and environmentally friendly methods and products in all uses (especially agriculture and industry) Strengthen the treatment of industrial effluent and municipal sewage and wastewater Strengthen the protection of important ecological and sensitive areas from pollution and contamination	Ensure the use of cleaner and environmentally friendly methods and products in all uses (especially agriculture and industry) Strengthen the treatment of industrial effluent and municipal sewage and wastewater
Improving management capacities	Improve the water resources information and knowledge base Develop institutional planning and implementation capacities	Develop and strengthen protocols for developing and sharing transboundary water resources Strengthen the water resources information and knowledge in tune with changing circumstances	Strengthen institutional planning and implementation capacities in tune with changing circumstances Strengthen the water resources information and knowledge in tune with changing circumstances	Sustain institutional planning and implementation capacities in tune with changing circumstances Strengthen protocols for developing and sharing transboundary water resources in tune with changing circumstances
Improving the policy, legal and regulatory frameworks	Review water and water-related policies to strike appropriate balance between supply and demand Harmonise legal and regulatory instruments for strategic development and use of water resources	Adopt policies, legal and regulatory instruments for strategic development, management and use of water resources to changing circumstances	Adopt policies, legal and regulatory instruments for strategic use of water resources in tune with changing circumstances	Adopt policies, legal and regulatory instruments for sustained use of water resources in tune with changing circumstances

Source: Author's Construct

10.8 Financing Strategy

Currently, funding commitment to ensure implementation of water resources management measures is inadequate. Annual budgetary allocations meet less than 15% of total annual financial requirements on a consistent annual basis.

The three main sources of funding for water resources management are the Government's annual budgetary allocations, external support agencies, and internally generated funds (IGFs). Support from external agencies (in the form of grants) has been the largest source, while the other sources have not yielded sufficient funds. Water use charges have yielded only 60% of targets. Financing for water resources management needs to be given increased attention, following the support provided for water supply.

10.8.1 Financial Requirement

Financial requirements for water resources management is for planned programmes up to 2025 and is indicative for the initial phase, which focuses on actions that will serve to strengthen the enabling environment and stabilise the water environment. The estimated total financial requirement is US$76.25 million and comprises the following:

i.	Policy and regulations	-	US$10.95 million
ii.	Water resources assessment and knowledge	-	US$52.50 million
iii.	Protection and conservation	-	US$10.60 million
iv.	Institutional capacity	-	US$2.20 million

10.8.2 Funding Sources

Domestic Resources

Domestic resources cover capital and recurrent expenditure. The strategy for capital investments will be to:

i. Increase the government allocation for investments to the water resources sub-sector;
ii. Develop appropriate financing mechanisms (e.g. basket funds-SWAp) for efficient and prioritised channelling of funds according to national plans;
iii. Establish a Water Development Fund as one of the sources for financing infrastructure;
iv. Allocate at least 1% of the cost of new investments in water supply services for water resources management;
v. Enhance the abstraction and use charges of water resources for economic purposes as well as for effluent discharge.

External Financing

Specific external financing sources to be relied on to leverage financing of the water resources management interventions include:

Loans and Grants: Official Development Assistance (ODA) will be very useful in building the enabling environment, institutional strengthening, and access to information.

Private Finance: Involvement of the private sector where this would result in a more efficient and cost-effective development and management of the water resources.
Regional and international financing initiatives: Scale-up the mobilisation of foreign resources e.g. NEPAD, African Development Bank, Africa Enterprise Challenge Fund and Infrastructure Consortium.

Other Innovative Financing Mechanisms

i. Utilise the capital market in the country to tap the required private as well as public resources such as bonds for infrastructural construction;
ii. Explore transboundary water charges, benefits and cost sharing of the trans-boundary catchments under the national and international water management institutions;
iii. Explore the Blue Fund for concessional and preferential funding of trans boundary water resources infrastructure such as improved water and waste treatment, and constructing small dams.

Ultimately, a mixture of strategic, public and commercial benefits from infrastructure will make for a variety of financing models, often involving hybrid forms combining the different financing types.

10.9 Monitoring and Evaluation - Performance Framework

The water resources management infrastructure plan is underpinned by a performance/results framework to measure success of the strategic objectives, key results areas, outcomes, outputs and projects that will be defined in furtherance of the vision of making Ghana a high income country within the 30-year planning period.

Table 10.10 is the Water Resources Sector Specific Monitoring Framework with the strategic areas that would contribute to making Ghana a high-income country. Each objective has an intervention logic or the underlying rationale for the investment being proposed, the key objective indicators with specific baseline values and targets.

Table 10.10: Results Monitoring Matrix of the Water Resources Infrastructure Plan

<table>
<tr><td colspan="3">Focus Area 1: Improved water resources
One of the reasons for the creation of the Ghana Infrastructure Plan is to develop, manage and secure long-term water resources to support Ghana's long-term food security and other key developmental needs.</td></tr>
<tr><td colspan="3">Objective 1.1: Enhanced benefits of the existing water resources infrastructure

Intervention Logic: Ghana is well endowed with freshwater resources but very little is currently used for well-being and growth. Furthermore, fresh water regimes have been modified resulting in shrinking of the resources, and affecting water supply. The key challenges will be how to effectively distribute the resources to decrease losses to meet the growing demands of all water uses/users, and to introduce innovations to improve water use efficiency by all water users. Therefore, the water resources infrastructure agenda should not solely focus on the development of new infrastructure. Efficiency gains and benefits from the management, rehabilitation and optimisation of existing infrastructure forms a critical part of filling the water availability and requirement gaps identified.</td></tr>
<tr><td>Objective Indicator</td><td>Progress Indicators/Milestones</td><td>Planned Projects/Interventions</td></tr>
<tr><td>1.1.1 Use/withdrawal of water resources increased.
Baseline (2018) 80m³ per/cap/yr
Target (2047) 1025m³ per/cap/yr</td><td>1.1.1 Volume of clean water withdrawn and used for households, irrigation and industries
1.1.2 Number of existing water storage facilities rehabilitated</td><td>1.1.1 Map, make a dynamic inventory system and rehabilitate existing storage facilities.
1.1.2 Design and implement measures in water use efficiency
1.1.3 Apply intermediate reuse and recycling of water resources
for all storage options.</td></tr>
<tr><td colspan="3">Objective 1.2: Develop additional water resources through discovery and expansion of new sources.
Intervention Logic: Climate change and climate variability is skewing precipitation patterns and making the natural flow of water into river channels highly variable. Population growth and urbanisation have also set heavy demands on land, water and other natural resources, besides introducing competing water uses and pollution. The issues are how to reduce the quantitative pressures in order to have sufficient water resources to meet increasing water requirements (which in many cases increases by 100%–600%) and also manage water resources systems under variable conditions and for conflicting uses. Diverse water resources infrastructure is recommended due to the diversity of water resources needs. Investment in new high volume cost effective water storage facilities would prove very useful.</td></tr>
<tr><td>Objective Indicator</td><td>Progress Indicators/Milestones</td><td>Planned Projects/Interventions</td></tr>
<tr><td>1.2.1 Total water requirement met.
Baseline (2018) 5.13 billion m³
Target (2047) 48 billion m³</td><td>1.2.1 Number of multipurpose water storage facilities developed

1.2.2 Number of degraded wetlands/ floodplains restored</td><td>1.2.1 Develop multi-purpose conservancy facilities to increase storage capacities
1.2.2 Investigate and develop hydrogeological and groundwater base
1.2.3 Invest in additional resources from rainwater and flash flood harvesting.
1.2.4 Develop natural infrastructure "natural harvesters" such as wetlands, and floodplains.
1.2.5 Develop both national and transboundary inter basin water transfer/diversion infrastructure schemes</td></tr>
<tr><td colspan="3">Objective 1.3: Improved water quality and environmental protection.
Intervention Logic: The quality of freshwater resources is generally poor due mainly to human activities including illegal mining, poor industrial and household waste disposal, and improper agricultural practices. The result has been qualitative pressures that have deteriorated the ecological health of water resources. The key concern is to adopt sustainable practices that avoid damage to critical water resources and irreversible ecological processes. Therefore, infrastructure to restore, protect and conserve all water bodies and the natural environment for the purpose of ensuring that the resource is available in the right quality and quantity for continuous abstraction and utilisation is key.</td></tr>
<tr><td>Objective Indicator</td><td>Progress Indicators/Milestones</td><td>Planned Projects/Interventions</td></tr>
<tr><td>1.3.1 Improved water quality of all river basins</td><td>1.3.1 Number of buffer zones created</td><td>1.3.1 Promote clean products and their uses</td></tr>
</table>

Baseline (2018) Mean WQI = 52.5 (fairly good) **Target (2047) Mean WQI = 80 (good)**	1.3.2 Water quality monitoring reports produced	1.3.2. Use environmentally friendly methods and products in agriculture and industry 1.3.3 Design wastewater treatment facilities for treatment of industrial effluent and municipal sewage and wastewater for reuse 1.3.4 Establish and manage buffer zones to protect important and sensitive ecological areas and water sources from pollution and contamination

Source: Author's Construct

10.10 Risks and Mitigation Measures

Implementation of the Water Resources Management Infrastructure Plan will encounter a number of risks. The identified risks, assessment and the mechanisms to manage the risks are provided in Table 10.11.

T able 10.11: Risks and Mitigation Measures Matrix

RISK	RISK RATING	MITIGATION MEASURES
Assurance of full political will in investing in water resources management	H	Continuously provide decision-makers with concrete examples of approaches and potential responses from a broader political and sectoral scope, which covers development, financing, capacity-building and institutional reform.
Transforming water management institutions and key partners to deal with the anticipated changes	S	Capacity building activities and monitoring and evaluation mechanism included in the plan would be a mitigating factor.
Harmonising regulations and polices from conflicting and overlapping institutional mandates	S	Water management is most effective when based on collaborative governance. Legal and institutional framework should be sufficiently anchored at all levels to avoid some institutions operating in a "vacuum" or institutional sector responsibilities not clarified and sufficiently met.
Reaching a balance of stakeholder interests with respect to preparation of plans (intersectoral coordination and linkages)	M	Formalise an intersectoral coordination mechanism for cooperating partners.
Accessing reliable data and information	S	Consummate service agreements with relevant data management providers.
Involvement and commitment of stakeholders at all levels including transboundary	S	Cooperation of local and international partners is required. Thus, it is pertinent to pursue continuous dialogue that would bring relevant stakeholders on board.
Untimely and inadequate funding for a more sustainable future	H	A precondition of adequate financing for water resources is to fully appreciate the social and economic purposes that it serves. Also employ a blend of different funding schemes and financial risk management.

H=High, S=Substantial, M=Moderate, L=Low

Source: Author's construct

Chapter 11 Water Supply

11.1 Introduction

Access to safe and potable water supply is a basic necessity for healthy living. This has been emphasised in many development initiatives and goals globally. The lack of access to the utility in terms of its inadequacy or unreliability is considered one of the key threats to the total wellbeing of the population. The need, therefore, for a comprehensive and long-term plan to facilitate the effective development of water supply infrastructure to meet global and national development goals cannot be over emphasised. This is particularly important due to the growing imbalance in access to the utility between rural and urban dwellers with its direct adverse implication on the livelihood of the population. This framework outlines the overarching measures for strategic development of the country's water supply infrastructure over the plan period.

11.1.1 Vision and Goals

In line with set global and sector goals, the overarching vision is "to provide adequate, safe, affordable and sustainable water supply for all consumer categories by 2047".

The key goals include the following:

i. Adequate supply to meet the overall supply area demand;
ii. Appropriate system technology to meet required system service level of target supply area;
iii. Supply per capita conforms to expected per capita demand of the supply area;
iv. Efficient system operation to assure acceptable unit cost of water;
v. Efficient system management for optimum service delivery;
vi. Safe/quality water delivery to sustain expected benefits from the infrastructure development.

11.1.2 Rationale for the Framework

This framework seeks to provide linkages to plans and strategies adopted by the main statutory sector agencies, namely, Ghana Water Company Limited (GWCL), the Community Water and Sanitation Agency (CWSA) and the Water Resources Commission (WRC), aimed at achieving national goals set for development of the infrastructure and service delivery.

Among other indications, key rationales for the framework is the current and growing trend in rural-urban water supply access imbalance, suppressed demand even in most supply areas and the skewed planning and development of the infrastructure over the years. There is therefore the need for more comprehensive and long-term planning to provide a basis for more concerted effort towards development of the infrastructure and service delivery in the sector.

11.2 Strategy and Policy Linkage

This plan provides key linkages to statutory regulations and procedures. Key documentations of such policies and regulations considered in conjunction with other available agency-specific extracts are outlined below:

i. Regulations of GWCL;
ii. GWCL Manual and Guidelines on Operationalising and Implementing Projects;
iii. Water Resources Act, Act 1996;
iv. CWSA Act, 1998 (Act 564);
v. GWCL and CWSA Strategic Investment Plans;
vi. CWSA Design Guidelines;
vii. Water Safety Framework, CWSA;
viii. Project Operational Manual;
ix. District Operational Manuals;
x. Community Operational Manuals;
xi. Procurement Manual and Public Procurement Act.

Notwithstanding the above policies, the impact of other cross-sectoral policies and regulations cannot be overlooked to ensure that this plan is implemented to meet the set vision and goals. Relevant sectoral policies and regulations related to environmental management, social impact, economic policies and project financing frameworks are therefore very pertinent. Key documentations on such policies and regulations are highly recommended for consideration in conjunction with those outlined above in the application of this framework.

11.3 Institutional Structure of the Water Sector

Four key agencies/institutions with statutory mandate for various aspects of development and operation of infrastructure in the water sector are:

i. Ghana Water Company Limited (GWCL);
ii. Community Water and Sanitation Agency (CWSA);
iii. Water Resources Commission (WRC);
iv. Public Utilities Regulatory Commission (PURC).

Two sector agencies, namely GWCL and CWSA operating under the Ministry of Water Resources and Sanitation (MWRS) have statutory mandates for the development of water supply infrastructure in the country. The CWSA's mandate mainly entails facilitation of facility development, operation and maintenance monitoring with focus on small towns and rural communities, while the GWCL is focused on urban towns with mandate for both development and operation and maintenance of the systems.

These institutions with oversight supervision by the MWRS together with several stakeholders, governmental and non-governmental, have been responsible for development infrastructure in the sector over the years. These sector agencies and stakeholders have been categorised mainly for the purposes of this plan (Table 11.1). The categorisation is based on the key statutory mandate/functions and/or areas of operation to facilitate comprehensive identification for effective application of the plan.

Table 11.1: Sector Agency and Stakeholder Identification

Mandate/Operation Area	Major Agencies
Development Implementation	Ghana Water Company Limited (GWCL)
Regulatory	Water Resources Commission (WRC) Public Utilities Regulatory Commission (PURC)
Monitoring	Ministry of Water Resources and Sanitation (MWRS) Ghana Water Company Limited (GWCL) Community Water and Sanitation Agency (CWSA) Water Resources Commission (WRC)
Facilitating	Community Water and Sanitation Agency (CWSA)
Supervisory	Ministry of Water Resources and Sanitation (MWRS) Public Utilities Regulatory Commission
Planning	Ministry of Water Resources and Sanitation (MWRS) Ghana Water Company Limited (GWCL) Community Water and Sanitation Agency (CWSA) Water Resources Commission (WRC)
Facility Operation	Ghana Water Company Limited (GWCL) Private Operators
Development Partners	Local Authorities Non-Governmental Organisations Donor Agencies

Source: Author's construct

11.4 Existing Water Supply Systems and Facilities

11.4.1 Overview

Development guidelines adopted by the key sector agencies categorise existing water supply systems into the following system technologies:

i. Urban Water Supply System (UWSS);
ii. Peri-Urban Water Supply System (PUWSS);
iii. Small Town Water Supply System (STWSS);
iv. Limited Mechanised System (LMS);
v. Point Source System (PSS).

By their mandate, system developments under the CWSA have been Point Source Systems (PSS), Limited Mechanised Systems (LMS) and Small Town Water Supply Systems (STWSS) with a reported overall achieved regional coverage ranging from 64% to 76%. Of more relevance to the long-term plan under the agency is the STWSS which has total developments of 391 systems and a regional average of about 35 systems. With main focus on urban supplies, GWCL's developments and operations have been urban and peri-urban water supply systems with a countrywide total of 81 systems and an overall regional average number of installations of 8 systems.

Table 11.2: Overall Status of Existing Infrastructure

System Technology	Countrywide Development
PSS	28,718
STWSS	391
PUWSS	17
UWSSS	71

Source: GWCL and CWSA

11.4.2 Urban Water Supply System

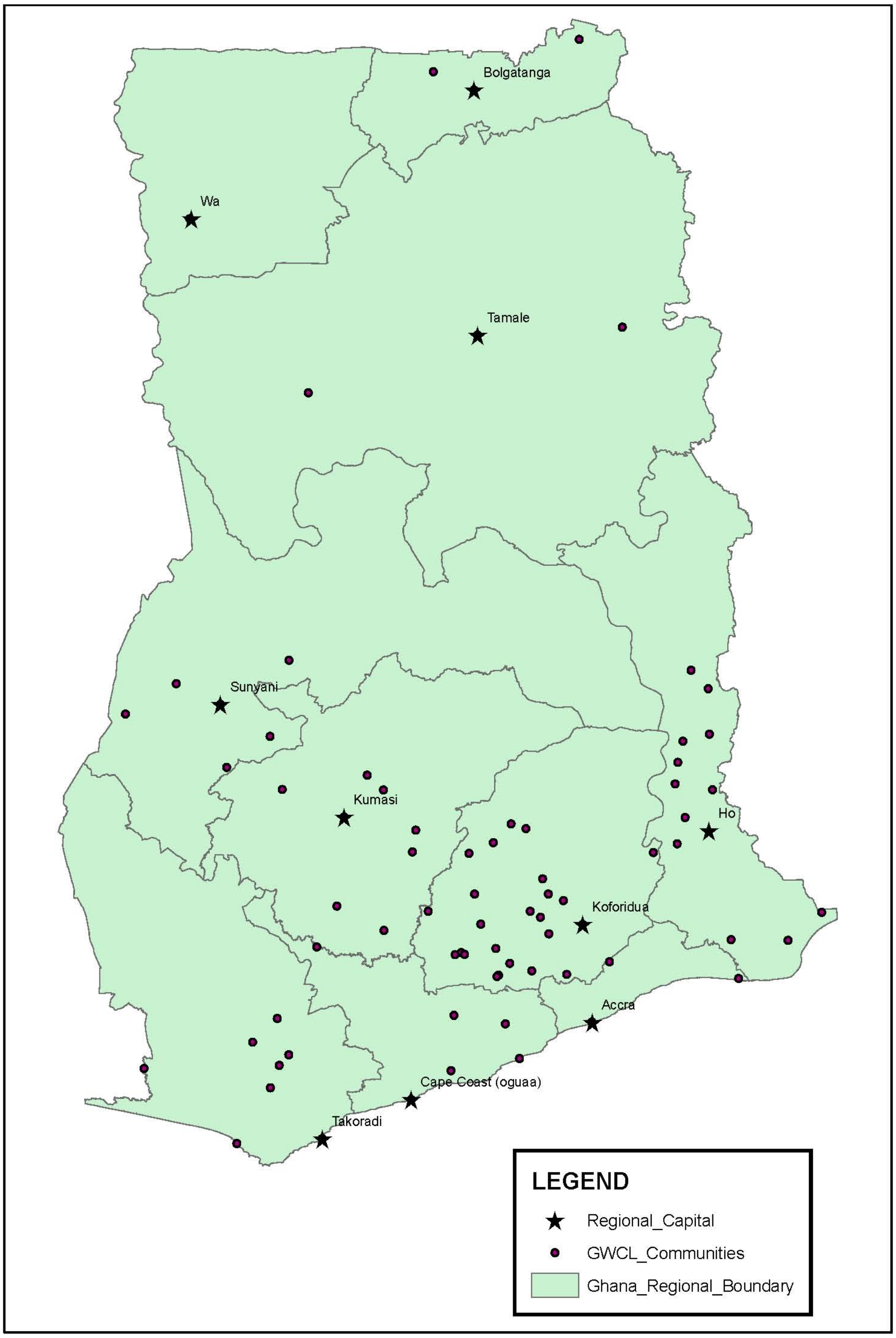
The Urban Water Supply System (UWSS) is the highest level technology for the provision of potable water in the sector. Such systems are developed to serve mainly highly urbanised communities with populations above 50,000. Most beneficiary communities of the UWSS therefore tend to be regional or district capitals or with very prominent local administrative status. A more recent development of UWSS based on desalination of sea water has been carried out in Accra, mainly to serve the Teshie area. Currently, there are 71 UWSS in operation in the country with an overall average of seven per region. Regional distribution of UWSSS is presented in Table 11.3 below. Figure 11.1 presents the spatial distribution of the existing UWSS.

Table 11.3: Spatial Distribution of UWSS

Region	No. of systems	Aggregated Installed Capacity (m^3/day)
Greater Accra	3	425,145
Ashanti	8	272,125
Brong Ahafo	6	21,292
Central	6	85,447
Eastern	23	23,361
Northern	3	24,120
Upper East	3	10,770
Upper West	1	1,672
Volta	11	31,581
Western	7	53,508
National Total	**71**	**949,021**

Source: GWCL

Figure 11.1: Spatial Distribution of Urban Water Supply Systems



Source: Author's construct based on GWCL data

11.4.3 Peri-Urban Water Supply System

The Peri-Urban Water Supply System (PUWSS) is the second level technology for provision of potable water in the sector. These systems are basically a hybrid of the UWSS and the Small Town Water Supply System (STWSS) and are developed to serve mainly urbanised communities with populations between 15,000 and 50,000. Most beneficiary communities of the PUWSS therefore tend to be small populations, district capitals or developed towns in the district. These systems have been developed for moderately high demand supply areas and are mostly based on multiple ground water sources or surface water with mostly direct run-of-river abstraction.

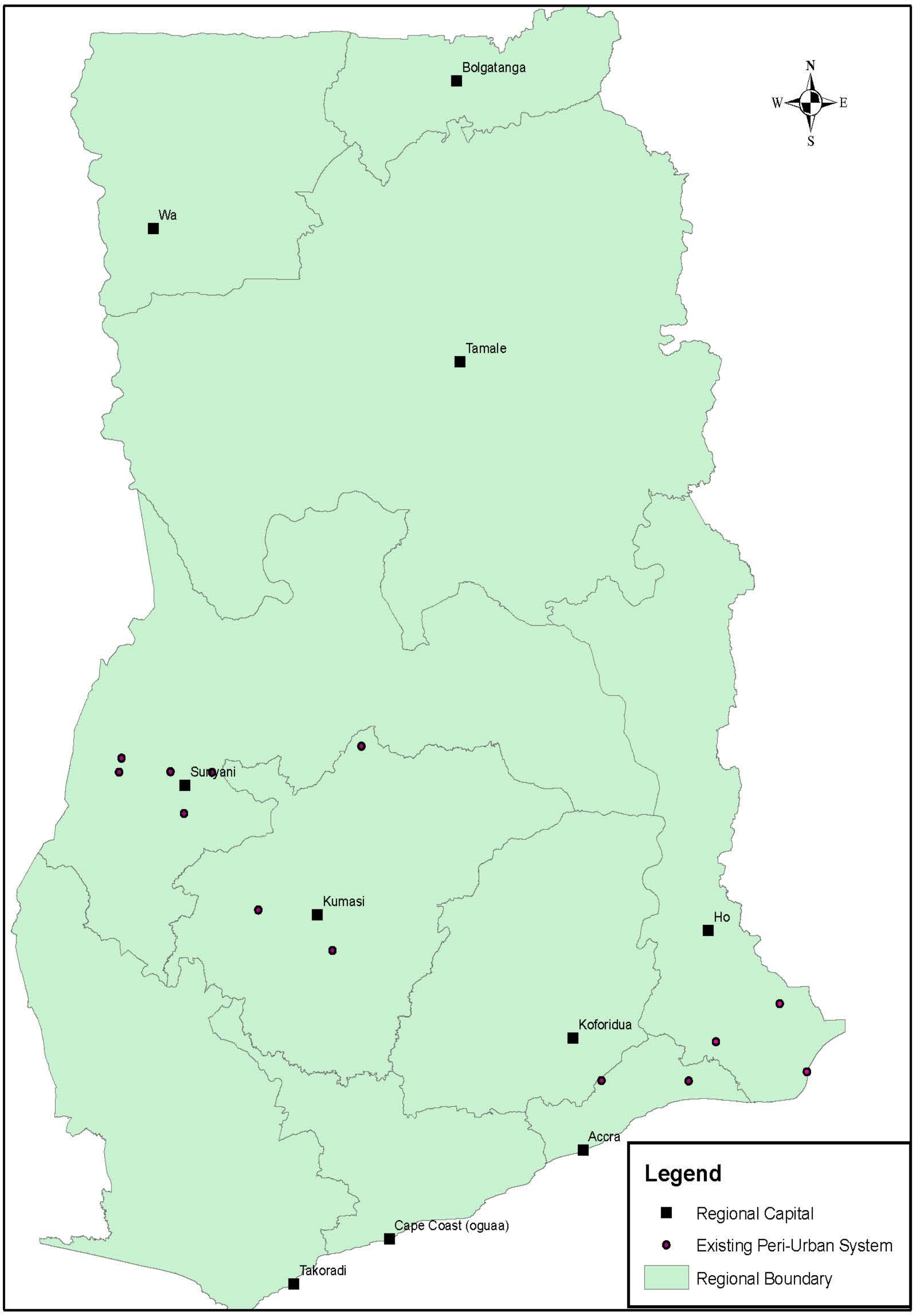
These systems have single or multiple town/community coverage and simple technology components, particularly for treatment facilities. The systems are managed by the GWCL when it is developed under their mandate. The community or private operator manages it when developed under the CWSA. Currently, there are a total of seventeen (17No.) PUWSS in operation in the country. Regional distribution of such systems is presented in Table 11.4 below. The spatial distribution of existing PUWSS is also presented (Figure 11.2).

Table 11.4: Spatial Distribution of PUWSS

Region	No. of systems	Aggregated Installed Capacity (m^3/day)
Greater Accra	4	3,840
Ashanti	3	2,880
Brong Ahafo	5	4,800
Central	0	0
Eastern	0	0
Northern	0	0
Upper East	0	0
Upper West	0	0
Volta	5	4,800
Western	0	0
National Total	**17**	**16,320**

Source: GWCL and CWSA

Figure 11.2: Spatial Distribution of Peri-Urban Water Supply Systems



Source: Author's construct based on GWCL data

11.4.4 Small Town Water Supply System

The Small Town Water Supply System (STWSS) is the third level technology for provision of potable water in the sector. These systems are developed to serve lowly urbanised communities with populations between 2,000 and 5,000. Most beneficiary communities of the STWSS therefore tend to be district capitals or fairly developed towns in the district. These systems have been developed for low to moderately high demand supply areas and are all based on multiple ground water sources. Few of them located in the middle belt of the country are based on surface water.

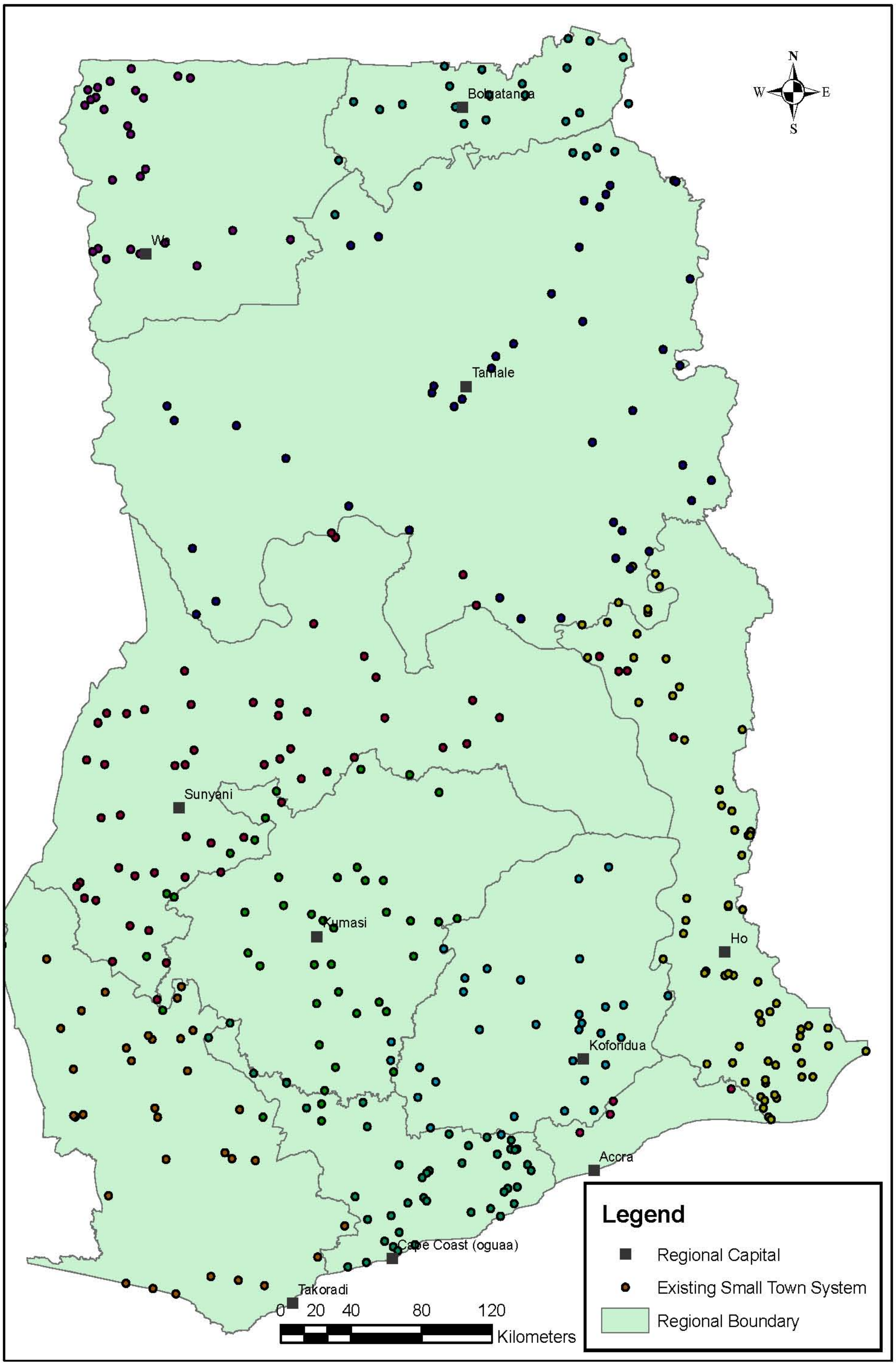
These systems have single town/community coverage and they are operated by simple technology. They are mostly managed by the community or a private operator under the CWSA which also has statutory mandate for facilitation of the system development. Currently, there are a total of 348 STWSS in operation in the country with an overall average of 35 per region (Table 11.5). A map of the spatial distribution of existing STWSS is presented (Figure 11.3).

Table 11.5: Spatial Distribution of STWSS

Region	No. of systems	Aggregated Installed Capacity (m^3/day)
Greater Accra	3	1,152
Ashanti	32	12,288
Brong Ahafo	54	20,736
Central	58	22,272
Eastern	32	12,288
Northern	50	19,200
Upper East	30	11,520
Upper West	30	11,520
Volta	56	21,504
Western	46	17,664
National Total	**391**	**150,144**

Source: CWSA

Figure 11.3: Spatial Distribution of Small Town Water Supply Systems



Source: Author's construct based on CWSA data

11.4.5 Point Source Water Supply System

The Point Source Water Supply System (PSWSS) is the lowest level technology for the provision of potable water in the sector. The PSWS systems are developed to serve mainly rural communities with a population below 2,000. Most beneficiary communities of the PSWSS therefore tend to be sparsely populated rural or developing communities in the district. These supply areas also tend to be dispersed satellite rural communities. These systems have been developed for low demand supply areas and are all based on ground water sources. The regional distribution of such systems is presented in Table 11.6.

Table 11.6: Spatial Distribution of Existing Point Source Systems

Region	No. of systems	Aggregated Installed Capacity (m^3/day)
Greater Accra	484	5,808
Ashanti	6,501	78,012
Brong Ahafo	3,301	39,612
Central	2,004	24,048
Eastern	2,919	35,028
Northern	4,412	52,944
Upper East	2,879	34,548
Upper West	1,832	21,984
Volta	2,521	30,252
Western	1,865	22,380
National Total	**28,718**	**344,616**

Source: CWSA

11.5 Existing Sources for Water Supply

11.5.1 General Overview

The availability/development of water sources has basically determined the feasibility and sustainability of any meaningful development of water supply infrastructure. Existing water supply systems across the various system technologies are based on one or a combination of the following water resources:

i. Groundwater from springs and boreholes;
ii. Rainwater;
iii. Surface water.

In spite of the above being the most prevalent sources, it is worth noting that in a recent initiative, sea water has been considered as an alternative source for development of a supply system to deprived areas. Reports on source developments for the various systems indicate that, beside the preference for some sources based mainly on the system technology being deployed, availability, yield and quality of the source have been the main criteria for selection of a resource for system source development. Table 11.7 presents the prevalence of the various source developments across the country.

Table 11.7: Outline of System Source Establishments

Source Type	Prevalent Source Location	Prevalent System Technologies
Groundwater from boreholes and Springs	Northern and Middle Belt of the country	PSS, STWSS and LMS
Rain water	Northern and Upper East Regions	LMS and STWSS
Surface water	Middle and Southern Belt of the country	UWSS

Source: Author's construct

11.5.2 Surface Water Sources

Two main types of surface water source developments, namely, direct abstraction sources and impounded sources, have been adopted for water supply systems across the country. These source systems have been developed mainly as sources for Urban Water Supply Systems (UWSS).

11.5.3 Ground Water Sources

The following are the main types of groundwater sources developed in existing water supply systems in the country:

i. Deep and relatively bigger diameter boreholes: These have mainly been adopted for mechanisation in UWSS, PUWSS and STWSS;
ii. Shallow and relatively smaller diameter boreholes: These have mainly been adopted for hand pump installation in Point Source Water Supply Systems (PSWSS).

The yields of existing groundwater sources in the sector vary extensively, while most are mainly abstraction estimates. This is mainly due to the fact that very limited post construction yield assessment is carried out as part of monitoring of the systems. Development guidelines in the sector however set the yield thresholds indicated in Table 11.8 for the development of these groundwater sources for various system technologies.

Table 11.8: Yield Thresholds of Groundwater Development

Groundwater Source	Yield Threshold (L/min)	Casing Diameter Range (mm)
Deep boreholes for mechanisation	85	150 – 300
Shallow boreholes for hand pump installation	10	100 – 125
Developed spring	85	N/A

Source: Author's construct

11.5.4 Rainwater/Run-off Impoundments

Existing direct run-off fed impoundments have been adopted as sources for mostly rural/small community water supply schemes, and are mostly located in the northern belt of the country. Information on these indicate that such developments have mainly been carried out in places where surface water potential is very low and also in areas where groundwater potential has also been found to be extremely low. Due to its operation as direct run-off interceptor/collector, these sources are highly prone to pollution from sanitary discharges, weedicides and chemical fertilizers, grazing cattle and direct human contact on run-off from the immediate catchment of the impoundment.

Although not one of the most adopted system sources, about 45 source systems have been constructed over the years. Most of these sources tend to be unsustainable due to its inherent development capacity limitation and high risk of pollution. With time, they are decommissioned and used as emergency sources while their supply areas are linked by transmission mains extended to neighbouring developed systems. The infrastructure plan therefore does not consider these sources as potential source developments for proposed interventions.

11.5.5 Sea Water Desalination

Although adopted for a recent development initiative to serve some areas in Accra, seawater has not been seriously considered as a source for water supply even to the coastal areas of the country. This has mainly been attributed to the fact that fresh water sources are reasonably available to meet demands in such areas and have not even been fully exploited. Added to the availability of fresh water, the associated high cost of harnessing sea water for water supply due to high power requirements and capital intensive technology, coupled with relatively low local expertise has always made the source a virtual non-starter in water system development initiatives. Therefore, the effective use of sea water desalination in target developments will be given lower priority.

11.6 Water Demand Projections

11.6.1 Population Categorisation

In order to facilitate estimation of water demand projections in conformance with guidelines adopted by the CWSA and GWCL, categorisation of derived populations was carried out. Guidelines adopted by the CWSA and GWCL indicate population categorisations, which are used as bases to estimate water demand and select appropriate system technology for the proposed development.

CWSA Population Categorisation

CWSA adopted design guidelines (Sector Guidelines – General, November, 2010) define the following population categorisation as bases for estimation of per capita consumption for design of adopted system technologies. The guideline also categorises the adopted population ranges into preferred system technologies as shown in Table 11.9.

Table 11.9: CWSA Categorisation

Category Description	Population Range	Recommended System Technology
Small Communities	75 to 2,000	Point Source Water Supply System
Small Community Category I	2,001 to 5,000	Limited Mechanised Water Supply System
Small Community Category II	5,001 to 15,000	Small Town Water Supply System
Small Community Category III	15,001 to 30,000	Peri-Urban Water Supply System
Small Community Category IV	30,001 to 50,000	Recommended System Technology

Source: Author’s construct based on CWSA data

GWCL Population Categorisation

With the sole mandate for development of UWSS, the guideline adopted by the GWCL rather categorises populations for estimation of per capita consumption only. The guideline adopts the population categories presented in Table 11.10.

Table 11.10: GWCL Adopted Population Categorisation

Category Description	Population Range
Urban Community Category I	> 50,000
Urban Community Category II	20,001 to 50,000
Urban Community Category III	10,001 to 20,000
Urban Community Category IV	5,001 to 10,001
Urban Community Category V	2,000 to 5,000

Source: Author’s construct based on GWCL data

Adopted Population Categorisation

Estimation of current population and projection over the planning horizons which are the main inputs for water demand assessments have generally followed the existing guidelines but harmonised into the categorisation presented below (Table 11.11).

Table 11.11: Adopted Population Categorisation

Category Description	Population Range	Recommended System Technology
Supply Community Category I	Up to 2,000	Point Source Water Supply System
Small Community Category II	2,001 to 15,000	Small Town Water Supply System
Small Community Category III	15,001 to 50,000	Peri-Urban Water Supply System
Small Community Category IV	Above 50,000	Urban Water Supply System

Source: Author’s construct

11.6.2 Water Demand Estimation

In line with standard practice, demand estimation as part of the utility development planning shall cover the following:

i. Domestic consumption, based on per capita requirements covering all service level provisions;
ii. Non-domestic consumption, covering all expected socio-economic activities;
iii. Provision for water used at headworks and system operation and maintenance requirements, particularly for UWSS;
iv. Provision for acceptable system physical losses;
v. Application of appropriate factors for consumption/demand variation.

An outline of the bases for the estimation of the various demand components is presented in Table 11.12 below.

Table 11.12: Rationale for Demand Components Estimation

Demand Estimation Parameter	Basis for Estimation	Rationale for the Parameter
Domestic consumption	Two service levels Direct House Connection Public Standpipe	To assure adequate service to the different consumer categories
Non-domestic demand	Covering: Institutional demand Commercial demand Industrial demand Recreational demand	To cater for expected socio-economic development over the planning horizons
System Losses	Unavoidable losses in the system	To cater for water loss as part of operation and maintenance activities
Water used in system management	Requirements for effective operation of the particular system technology	To cater for operation and maintenance requirements of the system
Demand variation factor	Peak daily demand factor	To cater for seasonal variations of water demand

Source: Author's construct

In order to facilitate the application of this framework, per capita consumption parameters to guide estimation of water demand for development of the various system technologies over the adopted planning horizons (Table 11.13). The parameters cater for the various demand estimation factors outlined above, aggregated into per capita consumption factors to provide over-arching bases for the planning.

Table 11.13: Outline of Per Capita Consumption

Demand Horizon		**2018**				
		Per Capita Demand Estimation				
Pop. Range	System Technology	Aggrega-ted Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day		l/c/day		l/c/day
<2,000	PSS	22	10	2	1.2	29
2,000 - 15,000	STWSS	33	10	3	1.2	43
15,000 – 50,000	PUWSS	55	20	11	1.2	79
>50,000	UWSS	110	28	31	1.2	169

Demand Horizon		**2022**				
		Per Capita Demand Estimation				
Pop. Range	System Tech Classification	Aggregated Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day				l/c/day
<2,000	PSS	22	10	2	1.2	29
2,000 - 15,000	STWSS	36	10	3	1.2	47
15,000 – 50,000	PUWSS	63	19	12	1.2	90
>50,000	UWSS	123	27	33	1.2	187

Demand Horizon		**2026**				
		Per Capita Demand Estimation				
Pop. Range	System Technology Classification	Aggregated Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day		l/c/day		l/c/day
<2,000	PSS	22	9	2	1.2	29
2,000 - 15,000	STWSS	40	9	3	1.2	53
15,000 – 50,000	PUWSS	68	17	12	1.2	95
>50,000	UWSS	132	24	32	1.2	197

Demand Horizon		**2030**				
		Per Capita Demand Estimation				
Pop. Range	System Technology Classification	Aggregated Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day		l/c/day		l/c/day
<2,000	PSS	22	8	2	1.2	29
2,000 - 15,000	STWSS	45	8	3	1.2	59
15,000 – 50,000	PUWSS	74	15	11	1.2	102
>50,000	UWSS	146	22	32	1.2	213

Demand Horizon		2034				
		Per Capita Demand Estimation				
Pop. Range	System Technology	Aggregated Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day		l/c/day		l/c/day
<2,000	PSS	22	7	2	1.2	29
2,000 - 15,000	STWSS	47	7	3	1.2	60
15,000 – 50,000	PUWSS	80	14	11	1.2	109
>50,000	UWSS	156	19	30	1.2	224

Demand Horizon		2038				
		Per Capita Demand Estimation				
Pop. Range	System Technology	Aggregated Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day				l/c/day
<2,000	PSS	22	6	1	1.2	29
2,000 - 15,000	STWSS	51	6	3	1.2	65
15,000 – 50,000	PUWSS	88	12	11	1.2	118
>50,000	UWSS	169	17	30	1.2	239

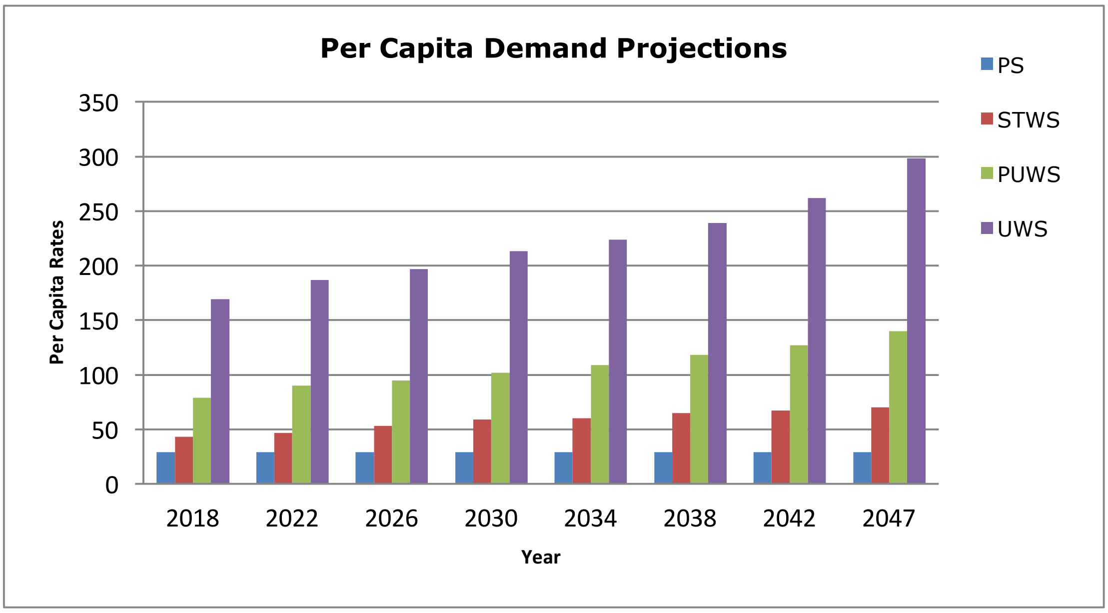
Demand Horizon		2042				
		Per Capita Demand Estimation				
Pop. Range	System Technology Classification	Aggregated Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day		l/c/day		l/c/day
<2,000	PSS	23	6	1	1.2	29
2,000 - 15,000	STWSS	53	6	3	1.2	67
15,000 – 50,000	PUWSS	95	11	11	1.2	127
>50,000	UWSS	189	16	30	1.2	262

Demand Horizon		2047				
		Per Capita Demand Estimation				
Pop. Range	System Technology Classification	Aggregated Per Capita Demand	Losses %	Losses Per Capita	Demand Peak Factor	Total Per Capita Demand
		l/c/day		l/c/day		l/c/day
<2,000	PSS	22	5	1	1.2	29
2,000 - 15,000	STWSS	56	5	3	1.2	70
15,000 – 50,000	PUWSS	106	10	11	1.2	140
>50,000	UWSS	218	24	31	1.2	298

Source: Author's construct

Projected growth of per capita demand over the planning horizon is presented in Figure 11.4 below.

Figure 11.4: Projections of Per Capita Demand



Source: Author's construct

Summary of Regional Water Demand Projections

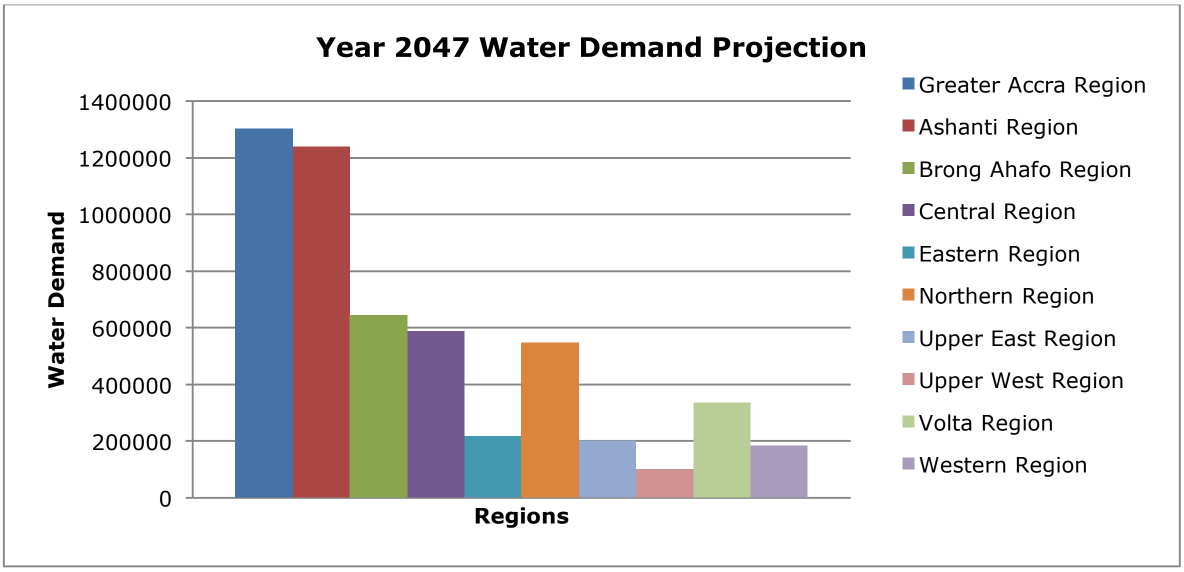
The summary of regional demand projections is presented in Table 11.14 below. A graphical representation of projected regional population distribution for 2047 is provided in Figure 11.5:

Table 11.14: Summary of Regional Water Demand Projections

Region	Baseline	Projected Demand (m³/day)						
	2016	**2018**	**2022**	**2026**	**2030**	**2034**	**2038**	**2047**
Greater Accra	413,310	432,541	519,925	612,566	700,493	794,933	911,964	1,302,237
Ashanti	441,339	465,493	576,662	655,687	727,280	840,721	930,676	1,238,384
Brong Ahafo	156,483	163,709	201,242	239,948	287,111	339,206	418,910	644,755
Central	204,545	217,423	250,846	287,563	333,194	374,326	425,995	589,160
Eastern	171,685	178,971	204,437	232,924	273,203	304,848	335,331	460,272
Northern	200,514	212,313	242,644	274,917	311,444	362,420	405,483	546,874
Upper East	57,326	58,710	85,908	96,349	107,796	124,491	146,084	201,323
Upper West	42,330	43,954	49,105	53,045	58,800	65,915	74,146	99,474
Volta	125,959	132,335	151,085	175,572	197,556	217,155	246,242	334,654
Western	88,920	92,532	88,571	100,012	111,806	126,229	142,466	182,830
Total	**1,902,411**	**1,997,981**	**2,370,425**	**2,728,583**	**3,108,683**	**3,550,244**	**4,037,297**	**5,599,963**

Source: Author's construct

Figure 11.5: Water Demand Projection for Year 2047



Source: Author's construct

11.7 Infrastructure Gap Analysis and Targets

11.7.1 Overview

An infrastructure gap analysis was carried out as a basis for the assessment of target developments to meet set development goals. For areas already covered by existing water supply systems, the analysis was based on projected water demand against existing system capacities. Key derivatives from the analysis were:

i. System Provision/Development Gap;
ii. Systems Supply and Water Demand Gap.

The former covered supply areas assessed by inappropriate systems together with areas without systems based on adopted population categorisation. Demand gap assessment mainly considered demand shortfall in the supply area based on the capacity of the existing system. Overall summary of output of gap assessments made is presented Table 11.15 below.

Table 11.15: Regional Summary of Gap Analysis

Region	Baseline (2016)				Year 2018 Horizon			
	Estmated Coverage Gap		*Average % Coverage Gap*		*Estimated Coverage Gap*		*Avearge % Coverage Gap*	
	Community (No.)	*Demand (m^3/d)*	*Community (No.)*	*Demand (m^3/d)*	*Community (No.)*	*Demand (m^3/d)*	*Community (No.)*	*Demand (m^3/d)*
Greater Accra	24	197,668	16.0	38.5	20	241,974	13.7	41.6
Ashanti	547	144,517	34.2	74.2	509	166,322	29.4	75.5
Brong Ahafo	238	44,387	17	33.5	215	71,474	14.5	46.4
Central	154	53,220	20.1	30.1	132	66,098	17.6	34.2
Eastern	254	88,822	17.3	55	234	93,580	16	54.2
Northern	302	64,787	12.4	24.2	291	74,184	12	27
Upper East	146	23,525	30.1	35.7	144	26,558	29.5	40.1
Upper West	130	4,451	16.5	11.8	129	6,089	16.4	15
Volta	248	31,045	16.5	20.1	230	37,566	15.1	24.4
Western	229	32,841	13	28.6	228	35,434	12.8	30.8

Source: Author’s construct

11.7.2 Outline of Required Developments

Scoping and scheduling of required interventions derived from the access gap analysis are based mainly on the following objectives derived from the overall goals of the plan.

Table 11.16: Regional Summary of Gap Analysis

Objective	Rationale	Implementation Horizon
Universal coverage and provision of the utility	Ensuring provision of appropriate system technology as required by the adopted supply area population categories.	Up to Year 2030
Equitable coverage	Ensuring adequate supply to all consumer categories in the target area	Up to Year 2047

Source: Author’s construct

Required infrastructure developments over the various horizons to meet the set goals have been derived from the gap analysis carried out. These have been categorised into the following two modes of developments:

i. Upgrading of existing systems to higher system technologies;
ii. Expansion of existing systems to meet project demands.

Collated summaries of required infrastructure developments in each region for the various planning horizons are presented (Tables 11.17, 11.18, 11.19 and 11.20).

arget Infrastructure Developments (2018-2022)

16 Horizon				2018 Horizon								2022 Horizon				
seline Status				Target System Development				Target System Upgrading				Target Syst. Development				Targ
	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS
4	3	51	1	48	3	0	0	0	2	0	0	0	0	0	0	0
01	29	0	0	0	48	1	0	0	38	0	1	0	56	3	0	0
01	49	0	0	200	31	0	1	0	46	0	3	160	39	1	1	0
04	46	0	0	150	8	0	0	0	32	0	0	120	12	3	0	0
19	64	0	0	100	41	1	0	0	69	0	0	80	56	7	0	0
12	40	0	0	350	37	0	0	0	13	0	0	280	49	8	0	0
79	25	3	3	150	47	3	0	4	32	0	0	120	47	0	0	0
32	24	0	0	150	29	0	0	0	26	0	0	120	30	0	0	0
71	67	0	0	100	24	0	0	0	24	1	0	80	35	18	0	0
55	57	6	2	200	41	7	0	0	31	0	1	160	52	3	1	0
669	**404**	**60**	**6**	**1448**	**309**	**12**	**1**	**4**	**313**	**1**	**5**	**1120**	**376**	**43**	**2**	**0**

s construct

arget Infrastructure Developments (2026-2030)

2026 Horizon								2030 Horizon						
rget System Development				Target System Upgrading				Target System Development				Target System Upgradi		
	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STWS	PU
	0	0	0	0	3	0	0	0	12	0	1	0	4	4
	62	4	0	0	58	0	1	0	65	7	0	0	58	3
3	43	1	0	0	51	2	1	102	48	0	0	0	66	0
	13	0	0	0	29	0	3	77	13	1	0	0	24	0
	56	1	0	0	92	0	0	51	59	7	0	0	87	0
4	52	11	0	0	63	0	0	179	51	11	0	0	50	2
	44	0	0	0	43	3	1	77	36	1	0	0	44	1
	27	0	0	0	15	0	0	77	33	0	0	0	22	0
	34	0	0	0	51	0	0	51	33	2	0	0	50	23
3	50	0	0	0	52	2	0	102	52	10	0	0	77	0
6	**381**	**17**	**0**	**0**	**457**	**7**	**6**	**717**	**402**	**39**	**1**	**0**	**482**	**33**

s construct

'arget Infrastructure Developments (2034-2038)

	2034 Horizon										2038 Horizon			
	Target System Development				Target System Upgrading				Target System Development				Target Syster	
	PS	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STV
	0	12	0	0	0	4	0	0	0	12	0	0	0	4
	0	63	1	1	0	70	11	3	0	61	0	0	0	70
	104	46	0	0	0	78	0	2	86	49	0	0	0	68
	86	16	0	0	0	24	0	0	72	18	0	0	0	24
	104	49	1	0	0	87	1	0	86	32	0	0	0	82
	86	53	0	0	0	72	1	0	72	53	0	0	0	72
	52	7	1	0	0	45	1	0	43	10	1	0	0	48
	86	23	0	0	0	22	0	0	72	18	0	0	0	21
	52	38	0	0	0	1	0	0	43	41	0	0	0	66
	86	29	0	0	0	65	1	2	72	27	2	0	0	21
	657	**336**	**3**	**1**	**0**	**468**	**15**	**7**	**547**	**321**	**3**	**0**	**0**	**476**

s construct

'arget Infrastructure Developments (2042-2047)

			2042 Horizon								2047 Horizon			
	Target System Development				Target System Upgrading				Target System Development				Target System U	
	PS	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STWS	PUWS	UWS	PS	STWS
	0	12	0	0	0	3	4	0	0	12	0	0	0	4
	0	65	20	0	0	66	0	1	0	64	9	0	0	98
	72	54	0	0	0	81	0	1	60	47	15	0	0	62
	60	10	0	0	0	24	0	0	50	8	6	0	0	24
	72	28	1	0	0	82	0	0	60	26	20	2	0	68
	60	55	0	3	0	72	0	0	50	49	6	0	0	68
	36	10	0	0	0	57	2	0	30	12	0	0	0	52
	60	24	0	0	0	17	0	0	50	26	5	0	0	26
	36	39	0	0	0	60	0	1	30	39	0	0	0	65
	60	18	0	0	0	34	0	2	50	30	5	0	0	50
	456	**315**	**21**	**3**	**0**	**495**	**6**	**5**	**380**	**313**	**66**	**2**	**0**	**517**

'’s construct

11.8 Systems Management Performance

11.8.1 Reducing Non-Revenue Water

Non-revenue water (NRW) has for a long time stood above 50 percent of water produced in urban water systems in Ghana. In spite of the many interventions (both direct and indirect) in the past decade, NRW continues to assume a sizeable magnitude of urban water production. Thus, the strategy presented herein is based upon several initiatives to fully address system input; billed consumption; accuracy of information; network integrity; leakages on consumers' premises; and public behaviour.

Sustainable Urban Planning and Development

The overaching strategy for reducing NRW will be based on re-engineering of existing human settlements to meet sustainable city principles. This will include land use classification, active urban regeneration and slum upgrading. The foregoing will improve planning, development and management of water infrastructure, leading to a reduction of NRW, especially in the distribution mains in densely populated urban centres.

System Zoning

Another step in reducing NRW shall be the accurate delineation of the hydraulic system, which is divided into zones and subzones where necessary. A survey shall be conducted to map out the boundaries of all systems unto GIS and properly define such boundaries. Such mapping activity shall comprise capturing all physical assets (water treatment units; transmission and distribution mains; appurtenances; and customer premises) unto GIS with a high degree of accuracy. Following the survey (mapping), physical zoning shall be achieved by ensuring that each water treatment plant supplies a well-defined area (or zone). Where an area has more than one supply source and the two sources have contiguous networks, isolation valves shall be installed to hydraulically separate the two systems. This shall be done in a way that does not compromise on the ability of the networks to transfer water to each other.

Metering

The metering initiative aims to increase the confidence in the numbers used in the NRW calculation and it will employ the top-down and bottom-up approaches. The "top down" approach shall be to meter the systems from the supply source to the zonal areas. As a matter of policy, all bulk meters installed shall have telemetric functions; measure at least one of flow and pressure; measure with electromagnetic or ultrasonic principle; and have flexible options for power supply. The "bottom up" approach starts from the customer level, an improved service and measurement on zonal level. Thus the approach aims to increase current customer metering ratio to 100% within 5 years, as a matter of policy only smart meters shall be installed within the period and going forward.

Improved Billing

The bottom up approach to metering discussed above shall address the accuracy of billed authorised consumption. To further improve the accuracy of billed authorised consumption, and to make the billing process more effective and accurate, GWCL has begun the implementation of a new electronic billing system. This new system when fully implemented will remove arm-chair meter reading; remove manual and multiple entry points for meter reading; and improve monitoring of meter reading activities.

Leakage Management

The term leakage is used loosely to generally refer to all forms of losses of water (volumes) from the physical water system. Leakages may occur as overflows on reservoirs and storage tanks; on mains (transmission and distribution); and on service connections (including those on customer premises). These may occur as visible leaks, which eventually get reported and resolved within a specified timeframe; or as background leaks (invisible) which are difficult to detect. As part of leakage management, both visible and background leakages will be addressed as they occur on mains, service connections and tanks.

Pressure Management

The top-down approach to managing leakage in the urban systems is the overall management of pressure within the network. Thus, for any system, optimum pressure shall range between 20mwc and 80mwc. This will guide the design, operation and maintenance of all zones to be demarcated during the implementation of the system zoning strategy aforementioned.

Active Leakage Control

Periodic physical inspection of the full span of all transmission mains will be instituted. For any particular transmission main, the inspection shall involve physically checking all valves and joints for leakage and minor leaks that may be difficult to detect along the span of the main. This will be done at least once a year for new installations; twice a year for installations between 5 to 15 years old; and three times or more depending on the age and frequency of repairs on the line. This inspection shall be carried out from the point of final treatment (clear well) to the point where the line terminates into distribution.

Speed and Quality of Repairs

By policy, all reported leaks within the distribution network will be repaired within 48 hours. The solution that will be pursued is a well-structured management of supply of logistics to ensure that each district of GWCL is well equipped to repair leaks in time.

Capacity Building

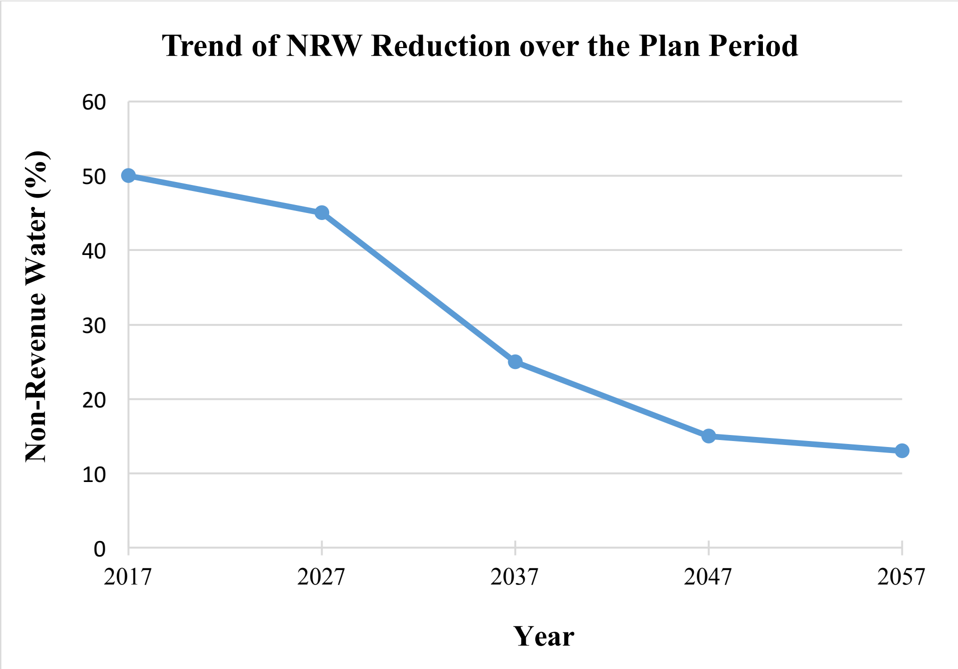
To fully and effectively implement all the strategies outlined, there is the need to improve the capacity of GWCL to deal with the issues. Firstly, building the capacity of the human resource to deal with NRW is paramount. Tooling and retooling is key if all these strategies are to be realised.

Research

Understanding the NRW phenomenon, and providing local solutions require careful study and elaborate research on the various systems. To this end, there will be collaboration with the relevant academic institutions to draft and implement research proposals aimed at refining current strategies, and coming up with novel ideas in the area of NRW reduction.

A graphical representation of the target for NRW for the plan period is provided in Figure 11.6 below.

Figure 11.6: Non-Revenue Water Target



Source: Author's construct

11.8 Financial Requirements

The estimation of indicative costs for the proposed water supply infrastructure is based on analyses of completed and on-going investments of similar nature and complexity. Table 11.21 shows the typical component configuration and key works components of water supply infrastructure.

Table 11.21: Systems and Works Configuration of Water Supply Infrastructure

System Technology	Typical Component Configuration	Key Works Components
Point Source	• Relatively small diameter borehole • Borehole apron/platform • Hand-pump • Ancillary facilities	• Borehole drilling and construction • Hand-pump supply and installation • Construction of borehole platform
Small Town Water Supply Peri-Urban Water Supply	• Relatively larger diameter borehole • Borehole platform • Submersible pump and accessories • Treatment Plant • Transmission and Distribution mains • Storage Tank • Ancillary facilities	• Borehole drilling and construction • Borehole mechanisation • Pipe laying • Construction of treatment plant units • Construction of storage tank • Construction of buildings
Urban Water Supply	• Surface water source • Intake • Electro-mechanical installations • Transmission and Distribution mains • Storage Tank • Ancillary facilities	• Source works and intake construction • Electro-mechanical installations • Construction of Conventional Treatment Plant • Pipe laying • Construction of storage tank • Construction of buildings

Source: Author's construct

An estimated total investment of $9 billion is required to carry out the required infrastructure developments over the plan period (Tables 11.22 and 11.23).

Table 11.22: Financial Requirements for Target Infrastructure Development (US$ m)

System Technology	2018 - 2021	2022 - 2025	2026 - 2029	2030 - 2033	2034 – 2037	2038 – 2041	2042 - 2046	2047	Total
PS	10.0	7.7	6.2	4.9	4.5	3.8	3.1	2.6	**42.8**
STWS	408.9	504.8	511.4	535.1	427.3	411.5	389.1	397.0	**3,585.1**
PUWS	26.4	495	499	471	480	509	530	0	**3,010.4**
UWS	29.9	59.9	0.0	29.9	29.9	0.0	89.8	59.9	**299.3**
Total	**475.2**	**1,067.4**	**1,016.6**	**1,040.9**	**941.7**	**924.3**	**1,012**	**459.5**	**6,937.6**

Source: Author's construct

Table 11.23: Financial Requirements for Target Infrastructure Upgrading (US$ m)

System Technology	2018 - 2021	2022 - 2025	2026 - 2029	2030 - 2033	2034 – 2037	2038 - 2041	2042 - 2046	2047	Total
PS	1.2	1.0	0.8	0.6	0.6	0.5	0.4	0.3	**5.4**
STWS	136.5	14.6	195.1	196.8	185.6	189.1	200.6	208.9	**1,327.2**
PUWS	0.7	38.3	4.6	19.8	9.9	2.0	4.0	29.7	**109**
UWS	62.9	83.8	73.3	83.8	73.3	21.0	73.3	157.1	**628.5**
Total	**201.3**	**137.7**	**273.8**	**301**	**269.4**	**212.6**	**278.3**	**396**	**2,070.1**

Source: Author's construct

Chapter 12 Integrated Waste Management

12.1 Introduction

The development of an integrated and sustainable waste management system is essential for the creation of an equitable, healthy and well planned society. In the past several decades, various interventions have been undertaken by sector players, particularly the Ministry of Local Government and Rural Development (MDGRD) and the Metropolitan, Municipal and District Assemblies (MMDAs) that impact on development of environmental sanitation. These bodies played a key role in supporting city and town councils to provide basic environmental sanitation services by centrally procuring and distributing vehicles and equipment for solid and liquid waste management activities. Portions of public lands acquired through the process of compulsory acquisition were readily made available for construction of waste treatment infrastructure.

Subsequent to enactment of the Local Government Act (Act 462) in 1990 and related institutional reforms, the councils that had been transformed into MMDAs were encouraged to invite private sector participation as a means to increase sector financing and introduce efficiency in the delivery of services, while the public sector played a facilitative role as part of an overall strategy to meet the ever increasing demand for services, particularly in the urban areas.

Currently, the private sector drives delivery of waste collection services and is gradually making inroads to provide treatment infrastructure for both solid and liquid waste. Incidentally, the private sector investments to improve waste management in the country are limited in scope, and they are not guided by any comprehensive plan to ensure integrated and sustainable delivery of needed environmental sanitation infrastructure and services. The need for comprehensive framework to facilitate the effective development of an integrated waste management system to meet global and national development goals cannot be overemphasised.

12.1.1 Vision and Objectives

The vision of this sector is to provide integrated and sustainable waste management and sanitation infrastructure and services that ensure a healthy living environment for all and support agriculture and industrial development.

Based on the vision, the following strategic objectives and related actions are defined as key elements of the plan to achieve integrated waste management in Ghana:

i. Sustainable waste minimisation/reduction, reuse, recycling and recovery by adopting interventions that include source separation, composting, waste to energy;
ii. Innovative and affordable technologies for accelerated delivery of household sanitation facilities to reduce overdependence on public onsite sanitation systems;
iii. Treatment and safe disposal of waste through provision of adequate infrastructure based on sustainable technologies to reduce environmental impact;

iv. Integrated planning to promote provision of shared infrastructure for sustainable waste management;
v. Sustainable system for waste data gathering, reporting and performance monitoring;
vi. Awareness raising and capacity building in support of waste management initiatives;
vii. Effective enforcement through sanctions to ensure compliance with regulations;
viii. Adequate budgeting and financing of waste management infrastructure and services.

12.2 Policies and Institutional Framework

12.2.1 Available Sector Policy

Currently, available sector policy documents and guidelines include the following:

i. National Environmental Sanitation Policy (NESP1999 and revised April 2010);
ii. National Environmental Sanitation Strategy and Action Plan (NESSAP, Sept. 2010);
iii. Strategic Environmental Sanitation Investment Plan (SESIP, April 2011);
iv. Medium Term GSGDA II;
v. Manual for Preparation of District Waste Management Plans (June 2002);
vi. Monitoring Systems for Environmental Sanitation Services (January 2003);
vii. Strategic Framework for the Development of Capacity of Environmental Health and Management in Ghana (August 2001).

12.2.2 Other Relevant Policies

The consideration of waste as material in transition and therefore a useful resource for the production of energy (through biogas and combustion of dried sludge), compost and treated water, etc., has linkages with national policies on energy, agriculture and water as indicated in Table 12.1.

Table 12.1: Other Sector Related Policies

Sector Policy	Attributes	Remarks
National Energy Policy	Supports conversion of municipal, industrial and agricultural waste into energy to contribute to energy security.	Guidelines and procedures for in-feed access to national grid from waste to energy plants exist but require review.
Agricultural Sector Development Policy	Supports production of organic solid waste composting to support plant growth and protection.	No explicit strategies and actions to promote production and use of FS/septage organic fertilizer. National policy and legislation on bio-fertilizers is necessary.
National Water Policy	Supports abstraction, treatment and supply of inland water resources (ground and surface) for domestic, commercial and industrial uses.	No clear policy on water derived from reuse as a resource. Water derived from reuse could be made available to Ghana Water Company Ltd (GWCL) as raw water. GWCL mandate does not cover Independent Water Producers.

Source: Author’s Construct based on Various Policies

12.2.3 Key Legislative Instruments

Key legislative instruments that support policy and provide avenues for enforcement include the following:

i. The Constitution 1992, Section (41k) 1992;
ii. The Criminal Code, 1960 (Act29) Section 296 and 297;
iii. Local Government Act, 1993 (Act 462);
iv. Environmental Sanitation Bye-Laws (2003);
v. The National Building Regulation, 1996 (L.I 630);
vi. Water Resource Commission Act, 1996 (Act 522);
vii. Environmental Protection Agency Act, 1994 (Act 490);
viii. Ghana Investment Promotion Council Act, 2013 (Act, 865).

In spite of their existence, enforcement by regulatory agencies including the EPA has been weak. MMDA bye laws do not allow adequate sanctions for recalcitrant offenders; and MMDAs themselves are sometimes the worst offenders. Enforcement can only be effective when there is adequate political will and support from Government. The complementary roles of the judiciary and law enforcement agencies in ensuring enforcement and compliance with environmental sanitation rules and regulations is critical. That notwithstanding, increasing advocacy and monitoring by civil society and the electronic media appear to have a positive impact on the effort towards better enforcement.

12.2.4 Financial Management Framework

The framework that guides MMDAs in their financial management of resources is based on:

i. Financial Administration Act, 2003 (Act 654);
ii. Financial Administration Regulation, 2004 (LI 1802);
iii. Financial Memoranda for Metropolitan, Municipal and District Assembly of 1961, revised in June 2004;
iv. The District Assemblies Common Fund Act, 1993 (Act 455) with updated guidelines;
v. Ghana Audit Act, 2000 (Act 584);
vi. Local Government Service Act, 2003 (Act 656);
vii. Public Procurement Act, 2003 (Act 663);
viii. Internal Audit Agency Act, 2003 (Act 658);
ix. Internal Revenue Act, 2005 (Regulation of Business, Act 684).

The framework gives further direction to MMDAs in exercising their mandate as provided in the Local Government Act, 1993 (Act 462) and the National Development Planning System Act, 1994 (Act 480).

12.2.5 Institutional Setup

Several institutions have different roles and responsibilities for waste management. Generally, key public sector institutions play facilitative and regulatory roles, while the private sector provides the needed services under the supervision and management responsibility of the MMDAs. A summary of the roles and responsibilities of key sector institutions is presented in Table 12.2.

Table 12.2: Summary of Roles and Responsibilities

Institution	Role/Responsibility
Ministry of Sanitation and Water Resources (MSWR)	Policy and overall sector coordination, monitoring and development guidance. Acts through the Environmental Health and Sanitation Directorate (EHSD) and the Regional Environmental Health Offices.
Ministry of Energy (MOE)	Related policy to promote waste to energy initiatives and facilitates access to the national grid.
Ministry of Food and Agriculture (MOFA)	Policy on bio fertilizers to protect plants and ensure food security. The Ministry currently acts through the PPRSD.
Environmental Protection Agency (EPA)	Functions based on the Environmental Protection Agency (EPA) Act, 1994 (Act 490) include (a) provision of environmental standards and safeguards to protect the environment; (b) administering permitting and certification procedures for all activities with potential environmental impact; and (c) prosecution of any operator that causes environmental damage.
Regional Coordinating Council (RCC)	Regional planning and coordination of the activities of respective MMDAs in the region. The Council performs this function through the Regional Planning Coordinating Unit (RPCU) of the RCC.
Metropolitan and Municipal Assemblies (MMAs)	Perform legislative, deliberative and executive functions of the Government through the Local Government Act, 1993 (Act 462). In compliance with the NESP, the MMAs have responsibility for implementing sector related activities in line with established service standards.
Private Sector	Services provision including containment, collection, treatment and reuse of waste material. Increasingly, services are provided under PPP arrangements.
Ghana Investment Promotion Centre (GIPC)	Responsibility to encourage and promote investments in Ghana by providing for the creation of an attractive incentive framework and a transparent, predictable and facilitating environment for investments based on Act 865 (GIPC Act, 2013).

Source: Author's Construct

12.2.6 Policy Implications for Infrastructure Delivery

Environmental sanitation services are to be appropriately planned and designed to suit the demand of different population groups: rural, small towns, urban, industries, commercial areas and urban poor[62]. The recently endorsed National Climate Change Policy- Focus Area 4 also requires building climate resilient infrastructure by incorporating climate-resilient codes into the design of basic infrastructure to significantly reduce vulnerability to climate change risks. In addition, review of the existing institutional arrangements is necessary to adequately respond to expected needs.

The relevant targets provided by the NESP are presented in Table 12.3. The table indicates 100% solid waste collection in the five major cities by 2020 and in the other municipalities/cities by 2025. In addition, up to 90% of all communities shall be provided with primary separation facilities and services by 2035. The NESP also targets up to 90% coverage of all rural communities.

[62] National Environmental Sanitation Policy, 2010

Table 12.3: Minimum Targets for Waste Management

Description	Year				
	2010	**2015**	**2020**	**2025**	**2035**
	Solid Waste Collection and Transport				
Five largest cities	*75%*	*90%*	*100%*		
Other municipalities/districts		*60%*	*75%*	*100%*	
	Services/ facilities for primary separation at HH, community, public and commercial areas				
All Communities	*20%*	*25%*		*70%*	*90%*
	Home-Latrine Coverage (Rural)				
All Rural Communities	*15%*	*35%*		*70%*	*90%*

Source: NESP, 2010 and NESSAP, 2010

12.3 Current State of Liquid Waste Management

Liquid waste streams include grey water and black water (human excreta/septage) from domestic and non-domestics sources and dwellings. Such wastes contain mainly organic materials, nutrients and pathogens and therefore require adequate treatment before discharge into the environment.

12.3.1 Generation and Collection

Large volumes (about 40 – 60 litres/capita) of greywater are generated each day from domestic and industrial activities and mostly disposed of in nearby drains. Only about 3.9 percent of the population of Ghana (3.6 percent Urban, 0.3 percent Rural) has access to sewerage systems and generates about 61,500 cu. m of sewage a day[63]. Tema is the only metropolis with a comprehensive sewerage system serving about 38% of the total metropolitan population[64]. Accra, the national capital has a sewerage system covering only about 6 percent of the metropolitan population[65].

Kumasi, the second largest metropolis has a limited sewerage system covering the 4BN Barracks, Komfo Anokye Teaching Hospital and the Kumasi Golden Tulip/City Hotel. A decentralised simplified sewerage system at Asafo serves about 20,000 people living in 120 tenement housing blocks. Over 90 percent of the urban, and 65 percent of the rural population use various types of domestic and public on–site sanitation facilities including household VIP, KVIP, Pour flush, Aqua-privy latrines, Ecological Latrines, Water Closet/Flush toilet with septic tanks, etc., and generate about 38,000 cu. m of septage/feacal sludge each day (based on a per capita generation of 1litre/day[66]. Overall access to improved sanitation is only about 15 %[67].

[63] Multiple Indicator Cluster Surveys (MICS), 2011
[64] National Environmental Sanitation Strategy and Action Plan (NESSAP), 2010
[65] Accra Sewerage Improvement Project (ASIP) Appraisal Report, 2016
[66] EAWAG/Water Research Institute (WRI), 1998
[67] Joint Monitoring Programme (JMP), 2015 Updated

Table 12.4: Distribution of Toilet Facilities in Rural Communities

Type/Technology/Facility – Improved	Rural %
Flush to piped sewer system	0.3
Flush to septic tank	1.3
Flush to pit (latrine)	0.5
VIP	21.6
Pit latrine with slab	19.6
Composting toilet	0.0
Type/Technology/Facility – Unimproved	
Pit latrine without slab/open pit	21.2
Bucket	0.4
Open defecation	35.2

Source: Multiple Indicator Cluster Surveys (MICS), 2011

In urban areas, septage/faecal sludge are mostly collected from the onsite sanitation facilities and transported by private cesspit truck operators. Metropolitan/Municipal Assemblies have limited trucks for such purpose. In order to adequately regulate their activities, the private operators are being encouraged to regularise their membership with the Liquid Waste Service Providers Association under the Environmental Services Providers Association (ESPA).

Table 12.5: Type of toilet facilities in urban communities

Toilet facility used by household	All regions -2010	Urban communities (%)
No facilities (bush/beach/field)	19.3	9.3
W.C.	15.4	24.9
Pit latrine	19	12.9
KVIP	10.5	12.8
Bucket/Pan	0.7	1.2
Public toilet (WC/KVIP/Pit/Pan etc.)	34.6	38.4
Other	0.4	0.5
Total	100	100
Number surveyed	5,467,054	3,049,366

Source: GSS, 2010 Population and Housing Census; National Analytical Report, 2013

12.3.2 Treatment and Disposal

Over the years, the MMAs have not been able to keep up with their mandate to provide, operate and maintain adequate waste treatment infrastructure and services in accordance with the Local Government Act (1993). The result is increasing discharge of untreated liquid wastes (septage and sewage) in the urban built environment. In the Greater Accra Metropolitan Area (GAMA), for example, less than 10% of the total quantity of septage and sewage generated is treated and safely disposed of as shown in Figure 12.1. The situation is even worse in other MMDAs outside GAMA. In urban areas, most of the existing treatment infrastructure are non-functional. Out of the existing 44 municipal and satellite wastewater treatment plants (including 7 Faecal Sludge and Septage Treatment Plants- FSTPs) across the country, only 7 were reportedly functional[68].

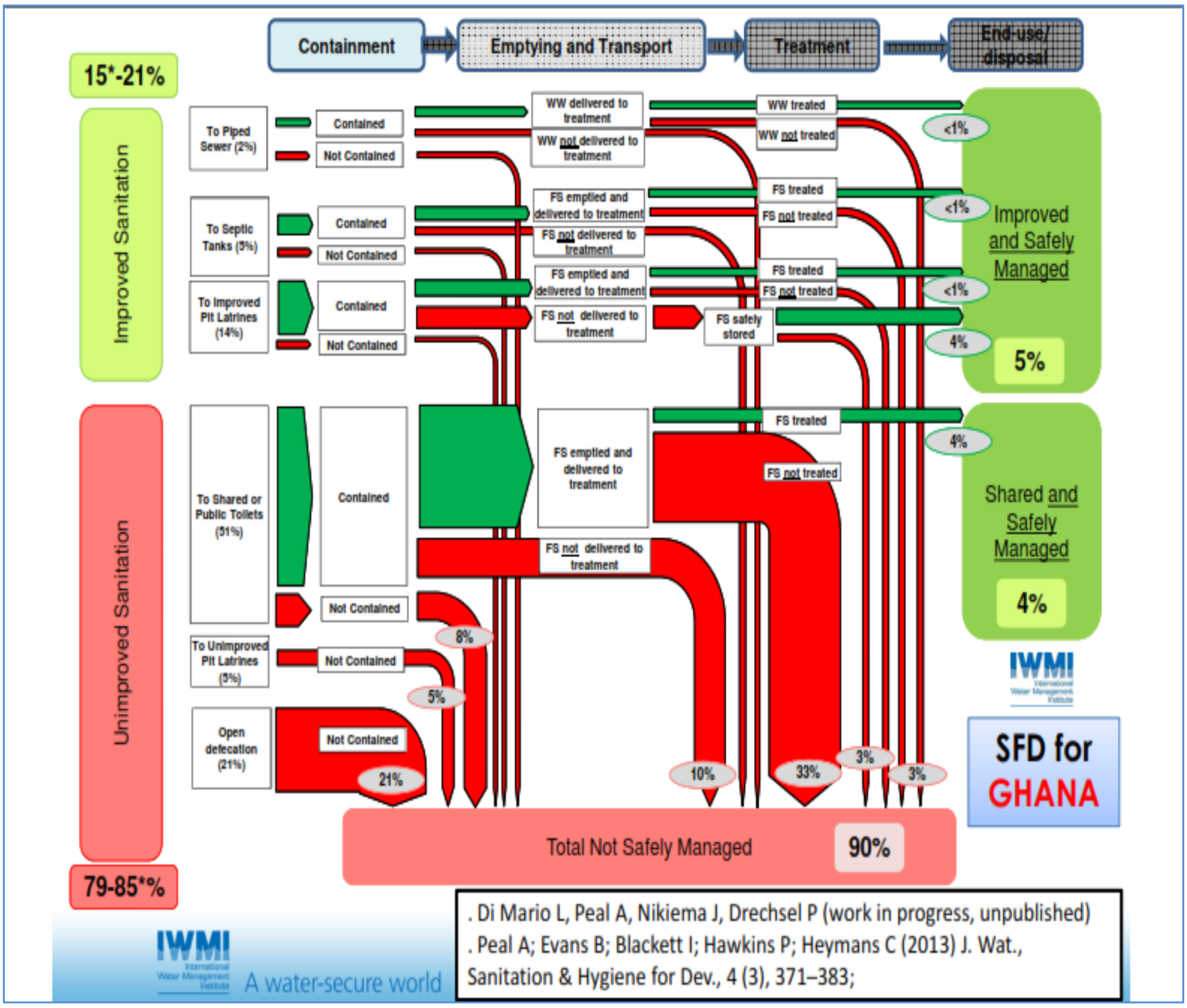
[68] National Environmental Sanitation Strategy and Action Plan (NESSAP), 2010

In rural areas, a few satellite treatment facilities that include communal septic tanks and soak pits exist for sewage but are mostly in a state disrepair. Available facilities for septage treatment include dug out pits and trenches that are covered with soil material after being filled up, open land disposal at designated sites and direct application on farms, among others.

Recent effort to improve treatment capacity has been concentrated in Greater Accra and include the following:

i. Rehabilitation and expansion of the Accra Sewage Treatment Plant (Mudor UASB Sewage Treatment Plant) up to 18,000 cu m total installed capacity;
ii. Construction of three (3) septage/faecal sludge treatment facilities with a total installed capacity of 3,400 cu. m per day at Mudor and Adjen Kotoku;
iii. Construction of two (2) pilot plants for septage/faecal sludge treatment with total installed capacity of less than 100 cu m per day at Ashaiman and Tema Nungua Farms;
iv. Construction of the Legon Sewage Treatment Plant (waste stabilisation ponds) with installed capacity of 6,500 cu. m per day to treat sewage from Legon, Achimota and their environs.

Figure 12. 1: Septage/Sewage Flow Diagram



Source: IWMI, 2014

12.3.3 Recycling and Reuse

The existing sector policies favour recycling and reuse of wastewater to derive and maximise economic benefits in support of sustainable operation and maintenance of treatment infrastructure. Expected benefits include revenue streams from activities related to waste-to-energy (production of electricity), production and use of compost fertilizers, treated effluent for irrigation and construction works, bio-fuel for industrial applications, etc.

Recycling and reuse practices in urban areas is gradually gaining prominence and is mainly driven by the private sector. Within the GAMA, for example, the existing five (5) septage and one (1) sewage treatment facilities together have capacity to produce in excess of 160 tonnes per day of organic fertilizers, and in the process deliver over 20,000 m^3 of treated effluent as end products.

On the contrary, in rural areas, the traditional practice of improving soil condition of farmlands through direct land application of untreated faecal sludge/septage for crop production is rife. Benefits derived include expected limited use of artificial fertilizers to improve crop yield. Table 12.6 presents some selected wastewater treatment facilities in the country.

Table 12.6: Selected Municipal and Satellite Wastewater Treatment Plants in Ghana

Location of System	Type of Facility	Year	Management Responsibility	Financing for O&M	Condition
			Accra		
Sewage Treatment Plant, Legon	Waste Stabilisation Pond	2015	AMSD/AMA	Tariff	Newly constructed and functional
ACARP Leachate, Septage/FS Treatment Plant	UASB - MBR	2016	UASB - MBR	ACARP/ MLGRD	Expected completion by Dec. 2016
Mudor Septage/FS Treatment Plant	UASB-Trickling Filter	2016	Sewerage Systems Ghana Limited (SSGL)	SSGL-MLGRD	Expected completion by Dec. 2016
Slamson FS Treatment Plant	Dewatering-Polymers	2016	Slamson	Slamson-MLGRD	Under construction
Safisana Co-composting Plant	Co-composting	2016	Safisana GH. Ltd.	Tariff and product sale	Expected operation by Dec. 2016
IWMI Co-composting Plant	Co-composting	2016	IWMI	Product sale	Expected full operation by Dec. 2016
Accra Central Sewerage Scheme	Con./Sewer Outfall(Sea)	1973	AMA	Sewer Tariff/ Government Subvention	Low-connection. Under rehabilitation
	UASB-Trickling Filter/Secondary Clarifier/Sludge Beds	2000		Government Subvention	Under rehabilitation
37 Military Hospital	Trickling Filter/Sedimentation	1972	Ministry of Defence/MOH	Government Subvention	Broken down but still in use
University of Ghana (UG)	Trickling Filter + drain field	1967	Health Services, UG	Government Subvention	Damaged Filter
Achimota School	Trickling Filter/Waste stabilisation ponds	1968	Ghana Education Service	Government Subvention	Damaged Filter Encroachment

Location of System	Type of Facility	Year	Management Responsibility	Financing for O&M	Condition
Burma Camp	Trickling Filter + Waste Stabilisation Pond	1972	Ministry of Defence	Government Subvention	Damaged Filter
MATS, Teshie	Trickling Filer + Drain field	1972	Ministry of Defence	Government Subvention	Damaged Filter
Labone Estates	Activated Sludge	1974	PWD	Sewer Tariff/ Government Subvention	Damaged Filter
Ministries (Accra Beach)	Activated Sludge	1972	PWD	Government Subvention	Damaged
State House	Activated Sludge	1974	PWD	Government Subvention	Damaged
Mental Hospital	Trickling Filter	1971	MOH/PWD	Government Subvention	Damaged
Accra High School	Activated Sludge	1970	GES/PWD	Government Subvention	Damaged
Roman Ridge	Imhoff Tank	1973	PWD	Government Subvention	Damaged. Reconstructed in 2004/Additional trickling filter bed
Dansoman Estates	Communal Septic Tanks	1975	SHC/AESC Hydro	Ministry of Works and Housing/Govt.	Septic tanks in use. Need rehabilitation
Korle Bu Teaching Hospital	Imhoff Tank + Trickling Filter	1954	MOH/PWD	Government Subvention	Rehabilitated 1990
Presec School	Stabilisation Pond	1976	GES/PWD	Government Subvention	Damaged, need rehabilitation/refitting
Teshie/Nungua Estates	Trickling Filter	1977	SHC/AESC Hydro	MWH/ Government	Damaged, need Reconstruction
Trade Fair Site, Labadi	Trickling Filter	1972	PWD	MWH/ Government	Damaged, need Reconstruction
Labadi Beach Hotel	Packaged Plant	1992	Beach Hotel Ltd	Hotel Tariff	Functional
Golden Tulip Hotel	Packaged Plant	1993	Golden Tulip Hotel	Hotel Tariff	Functional
Teshie-Nungua (Fertilizer)	FSTP	1994	AMA-WMD	AMA	Decommissioned
Achimota Septage Treatment Plant	Waste Stabilisation Ponds	1990	AMA-WMD	Tariff/WMD	Decommissioned
			Kumasi		
Kumasi Teaching Hospital/City Hotel/4BN Barracks	Trickling Filter (1956-1962); Oxidation Pond	1956	KATH/KMA	Ministry of Health/ Government Subvention	Choked/punched sewers/silted up pond. Reconstruction required
University Campus (KNUST)	Trickling Filter	1967	Health Services (KNUST)	Government Subvention	Damaged trickling filter/pump station
Ahinsan/Chirapatre	Communal Septic tank/filter bed rehabilitation	1975	AESC Hydro/SHC	Community	Communal Septic tanks out of use
Kwadaso Low cost Housing	Waste Stabilisation Ponds (WSP)	2002	KMA	KMA	New community WSPs
Asafo	Simplified sewerage/waste stabilisation pond (WSPs)	1994	KMA/Contractor	KMA	Functional. Expanded to cater for KATH
Asokore-Mampong Buobai	FSTP	2002	KMA	KMA	Decommissioned. Encroachment of

Location of System	Type of Facility	Year	Management Responsibility	Financing for O&M	Condition
					buffer zone/filled primary anaerobic ponds
Oti/Dompoase Landfill	Leachate, Septage & Faecal Sludge Treatment Plant	2004	KMA	KMA	In operation but non-functional
			Tema		
Planned Communities & Industrial Estates	Chemical Treatment (1996 -, Aerated Lagoons)	1973	Tema Development Corporation	Tariff/TMA	Damaged Pumping stations, Chemical plant and choked sewers. Rehabilitation and new aeration needed
Tema Septage Treatment Plant	Waste Stabilisation Ponds	2002	TMA	Tariff/TMA	Operational but dysfunctional

Source: Author's construct

12.4 Current State of Solid Waste Management

12.4.1 Generation and Collection

In Ghana, the main sources of generation of municipal solid wastes are households (about 30 percent) and commercial places including markets, lorry parks and other public places (about 40 percent). The other sources include factories, construction and mining, institutions (schools, colleges, and health facilities), hotels and restaurants. In addition, the agricultural sector produces large quantities of organic waste that include crop waste residue, animal waste, straw and stubble after harvesting, etc.

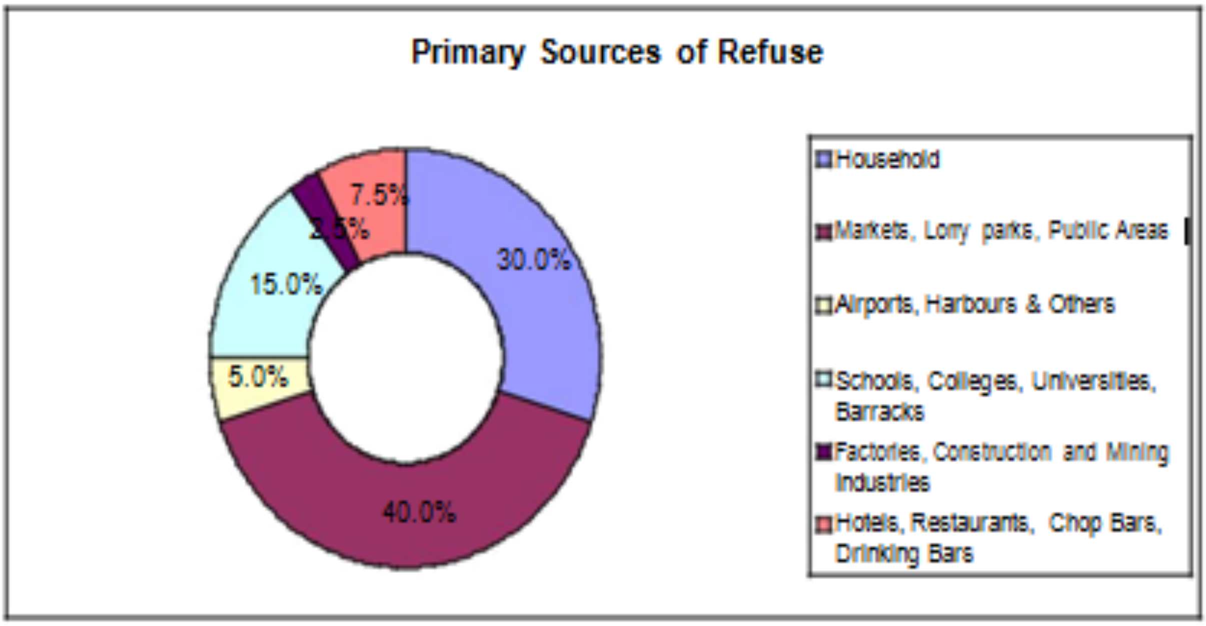
Municipal Solid Waste

While the generation rates of municipal solid waste vary across the country, and based on an average rate of 0.47 kg/person/day and the 2017 projected population, about 13,558 tons of solid waste is currently generated each day in Ghana. Reportedly, the average generation rates for Metropolitan, Municipal and District Assemblies are 0.63kg/person/day, 040kg/person/day and 0.28kg/person/day, respectively, compared with the regional average of 0.51 kg/person/day[69].

The average composition of domestic waste in Ghana is 61% organics, 14% plastics, 6% metals and glass, 6% inert, 5% paper, 5% miscellaneous, and 3% textiles, leather and rubber. Over the last three decades, there has been a significant increase in plastics from 3% (1989 -1999) to over 8% (1999-2009) according to the 2010 NESSAP report, implying the need for serious attention. Generally, with an average moisture content of about 50% and favourable carbon-nitrogen ratio, domestic solid waste is conducive for composting. The other sources include factories, construction and mining, institutions (schools, colleges, and health facilities), hotels and restaurants as indicated in Figure 12.2.

[69] K. Miezah et al, 2015

Figure 12.2: Sources of Solid Waste Generation



Source: NESSAP, 2010

Only a little over 50% of the population has access to collection services. The remaining population employ unacceptable disposal methods like burning, dumping in open public spaces and burying on compound. Domestic and communal collection services are mainly provided by the private sector using vehicles and equipment that include compaction trucks, motorised tricycles, boarded push carts, wheel barrows, skip loaders/roll on roll off trucks, and skips, etc. Effort to improve on collection capacity by increasing vehicular fleet is met with challenges as most of the vehicles are highly depreciated and are in a state of disrepair.

The MMDAs are unable to provide adequate financial resources to meet increasing demand for services; and have hardly taken full advantage of the likely economic benefits of reuse and resource recovery. They are also confronted with challenges that include increasing threat of discharges from mining/other industrial activities and use of wetlands & water courses as disposal sites, among others.

Agricultural and Industrial Wastes

Agricultural waste production is estimated at more than 4.2 million tonnes per year[70]. The waste mainly consists of crop waste residue from harvesting and post-harvest losses, animal waste, straw and stubble after harvesting, among others. During crop harvesting, about 60 to 70 % of the total agricultural biomass is produced as waste. Crop residues such as maize cobs, rice husks, palm branches, shells and nut serve as potential sources of fuel and are partly collected for the purpose.

Limited data is available on the types and quantities of industrial wastes generated in Ghana. However, such wastes can be classified as toxic and non-toxic waste produced by

[70] Quartey & Chýlková, 2012

heavy and light industrial concerns mainly located within industrial enclaves in the major urban centres.

E – Waste (Electrical and Electronic Equipment Waste)

E-waste (defined by the National E-Waste Strategy 2011 as obsolete, end-of-life, discarded or intended/required to be discarded appliances that use electrical energy) contains both valuable as well as harmful materials, which require special handling and recycling methods. In 2009, about 215,000 tonnes (per capita of 9kg Electrical and Electronic Equipment Waste (WEEE)) was imported into Ghana, of which about 50% reached the collection system[71].

Generation of e-waste and other hazardous wastes appears to be increasing, particularly in the major urban areas where over 87% of the total quantity of WEEE is generated. Urban dwellers tend to store their WEEE for lesser periods than their counterparts in rural areas, because of the presence of formal and informal collectors who offer money for WEEE.

12.4.2 Treatment and Disposal

The major urban areas like Tema, Kumasi, Tamale and Sekondi-Takoradi have been provided with sanitary landfill facilities with varying capacities. Most of the facilities are becoming crude dumpsites due to poor operation and maintenance practices. Currently, the eleven MMAs in the Greater Accra Metropolitan Area use the Tema landfill facility located at Kpone for municipal solid waste disposal at a rate that far exceeds the design capacity and therefore threatens the lifespan of the facility.

There are hardly any properly designed and constructed solid waste disposal sites in small towns and rural communities. Crude dumping without any site management practice is the predominant mode of disposal in the small towns and rural communities across the country. The environmental and socio economic implications of such practices cannot be over emphasised.

Agricultural waste is mostly disposed of on farmlands mainly through burning to clear the land for the next farming cycle and use as animal fodder; and to a limited extent through mulching and composting for reuse in the agricultural production processes. The energy potential of the waste is hardly tapped for other useful purposes. Infrastructure for WEEE disposal are non-existent. However, a number of organisations and individuals provide disposal services through burning or burial, mostly at landfills or dumpsites.

12.4.3 Recycling and Reuse

A number of privately owned municipal solid waste composting and recycling facilities exist in some of the major urban centres like Accra, Kumasi and Tema. Generally, the facilities have limited capacity and therefore have little impact in terms of effort to achieve integrated waste management.

Majority of WEEE recyclers are the informal recyclers (scavengers and dismantlers) who manually dismantle and separate fractions and recover valuable materials like copper, iron, aluminium and printed wiring boards for sale to local industries as inputs for

[71] SBC e-Waste Africa Project Report, 2011

production or to private businesses for export. Their operations result in emission of toxic substances that adversely impacts on their health and the environment at large.

12.5 Challenges of Waste Management

The key challenges confronting the waste management sector are presented as follows:

i. Increasing waste levels associated with a growing economy and related life-style changes: The population of Ghana has been increasing since independence, and almost doubles every 30 years with expansion of the Ghanaian economy and living standards. This has resulted in an increase in the quantity of waste generated, particularly in the urban communities;

ii. Increasing indiscriminate disposal of plastic waste: As a result of the changes in life styles including food packaging, generation of plastic waste has been increasing over the years. Increasingly, such plastic waste is mainly disposed of indiscriminately as there are no adequate programmes available for sustainable management of such waste;

iii. Reuse is not mainstreamed through provision of appropriate incentives: This is not done to derive related social and economic benefits. As such, advantage is not taken of the full potential of reuse with regard to employment opportunities and partial cost recovery;

iv. Inadequate provision of collection, treatment and disposal facilities: Local government authorities (MMDAs) that have direct responsibility for managing waste are unable to provide adequate infrastructure to cope with the ever increasing quantities of waste;

v. Threat of use of wetlands and water courses as disposal sites: Increasingly in urban communities, land scarcities resulting from the ever increasing population limit the opportunity to have adequate land space for treatment and final disposal of collected waste. Waste managers and individuals therefore resort to use of wetlands and water courses for disposal, ostensibly as a means to reclaim land but with dire environmental consequences;

vi. Increasing threat of discharges from mining/other industrial activities: In recent years, the menace of illegal mining has been rife. Such mining and other industrial activities tend to discharge wastes indiscriminately to pollute the environment, thereby flouting EPA regulations for industrial discharges;

vii. Increasing disease burden from environmental ill health including lack of appropriate household-level facilities: The lack of programmes and facilities that support proper and sustainable waste management practices at the household and community levels, result in environmental ill health and increased disease burden of communities;

viii. Vulnerable and physically challenged needs unmet: Needs of the vulnerable and physically challenged are hardly met in the delivery of waste management services.

12.6 Strategic Approaches for Development

12.6.1 Waste Generation by Income Level

The comparative generation rates for the different income groups of countries as classified by the World Bank are presented in Table 12.7 below.

Table 12.7: Per Capita Waste Generation by Income Level [72]

Income Level	Waste Generation Per Capita (kg/capi a/day)		
	Lower Boundary	Upper Boundary	Average
High	0.70	14	2.1
Upper Middle	0.11	5.5	1.2
Lower Middle	0.16	5.3	0.79
Lower	0.09	4.3	0.60

Source: World Bank, 2012

[72] As of July 2016, the World Bank classification method defines low-income economies as those with a GNI per capita of $1,025 or less in 2015; lower middle-income economies are those with a GNI per capita between $1,026 and $4,035; upper middle-income economies are those with a GNI per capita between $4,036 and $12,475; and high-income economies are those with a GNI per capita of $12,476 or more.

12.6.2 Alternative Approaches for Solid and Liquid Wastes Management

A number of alternative approaches towards development of the sector are defined and assessed in Tables 12.8 and 12.9.

Table 12.8: Alternative Approaches for Solid Waste Management Development

Solid Waste Management Improvement			
Alternative	**Collection/Transportation**	**Treatment/Resource Recovery**	**Assessment/Remarks**
I	Complete privatisation No waste minimisation No source separation Partial cost recovery	Increased privatisation Adoption of sustainable technologies Limited emphasis on recycling/reuse benefits Partial cost recovery	Increased government subsidies due to partial cost recovery along the SWM value chain. Increased sector financing due to increased private investments. Economic benefits of recycling/reuse not maximised. Approach considered unsustainable.
II	Complete privatisation Waste minimisation Source separation Full cost recovery	Increased privatisation Adoption of sustainable technologies Increased emphasis on recycling/reuse benefits Full/Partial cost recovery	Limited government subsidies to support treatment and disposal, where necessary. Increased sector financing due to increased private investments. Maximised economic benefits of recycling/reuse. Awareness programmes needed on waste minimisation and resource recovery. Approach considered sustainable.
III	Partial privatisation Partial source separation Partial cost recovery	Increased public investments Adoption of sustainable technologies No emphasis on recycling/reuse No cost recovery	Increased government subsidies due to partial or no cost recovery along the SWM value chain. Limited sector financing due to limited availability of private investments. Economic benefits of recycling/reuse not maximised. Awareness programs needed on waste minimisation and reuse. Approach considered unsustainable.

Source: Author’s Construct
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Table 12.9: Alternative Approaches for Liquid Waste Management Development

Liquid Waste Management Improvement			
Alternative Approach	**Collection/Transportation**	**Treatment/Reuse**	**Assessment/Remarks**
I	Limited conventional sewers + Privatised cesspit haulage Partial cost recovery	Complete privatisation Limited emphasis on reuse benefits. Partial cost recovery. Adoption of conventional technologies.	Increased private investments in on-site household sanitation systems that are costly and with likely undesirable impacts in the long term. Increased government subsidies. Technologies require high investment capital. Approach considered unsustainable.
II	Extensive simplified/ small bore sewers + Privatised cesspit haulage Full cost recovery	Complete privatisation Emphasis on reuse benefits. Full/partial cost recovery. Adoption of innovative and sustainable technologies.	Limited private investments in on-site household sanitation systems. Limited or no government subsidies. Technologies require limited investment capital. Awareness programmes needed for increased reuse. Approach considered sustainable.
III	Extensive simplified/ small bore sewers + Privatised cesspit haulage Partial cost recovery	Partial privatisation Limited emphasis on reuse benefits. Partial cost recovery Adoption of sustainable technologies.	Limited private investments in on-site household sanitation systems. Increased government subsidies. Technologies require limited investment capital. Approach considered unsustainable.

Source: Author's Construct

12.6.3 Expected Outcomes and Targets

Expected Sanitation Outcomes

i. Affordable and sustainable household and public sanitation facilities and appropriate technologies for 100% access provided;

ii. Adequate infrastructure for conveyance, treatment and disposal including reuse (sewage and septage) are provided. One hundred percent (100%) coverage of improved sanitation (sewerage and on-site) by 2033 and 2041 for urban and rural communities, respectively as shown in Table 12.10.

Table 12.10: Expected Targets for Sanitation

	Urban		Rural	
Year	**Sewerage (%)**	**Improved On-site Technology (%)**	**Sewerage (%)**	**Improved On-site Technology (%)**
2021	5	40	1	30
2025	10	45	2	35
2029	20	60	5	50
2033	30	70	10	60
2037	40	60	15	65
2041	50	50	20	80
2045	60	40	30	70
2047	70	30	30	70

Source: Author's Construct

Expected Solid Waste Management Outcomes

i. Facilities and services for source separation and minimisation of waste (95%) are provided on individual, institutional, commercial, etc., premises;
ii. Infrastructure for collection and transportation of municipal waste (100%) are provided;
iii. Infrastructure for effective management of MEEW (100%) are provided;
iv. Infrastructure for waste treatment and disposal shall be provided based on Table 12.11:

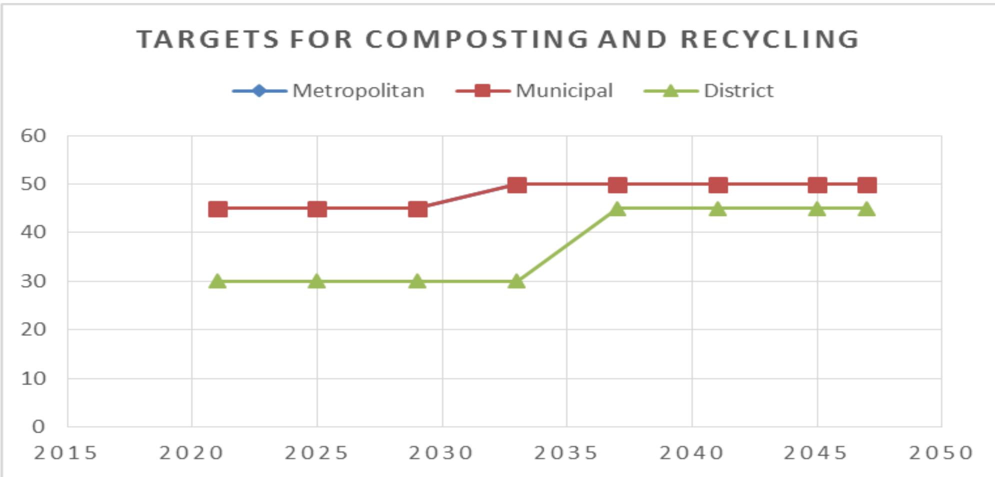
Table 12.11: Expected Targets for Solid Waste Management

Category	Solid Waste Treatment Infrastructure Development Targets (2047)		
Metropolitan	Landfill - 35%	Recycling/Composting Facility-50%	Incineration/W2E -15%
Municipal	Landfill/Controlled Dump- 40%	Recycling/Composting Facility-50%	Incineration/W2E -10%
District	Controlled Dump - 55%	Recycling/Composting Facility-45%	

Source: Author's Construct

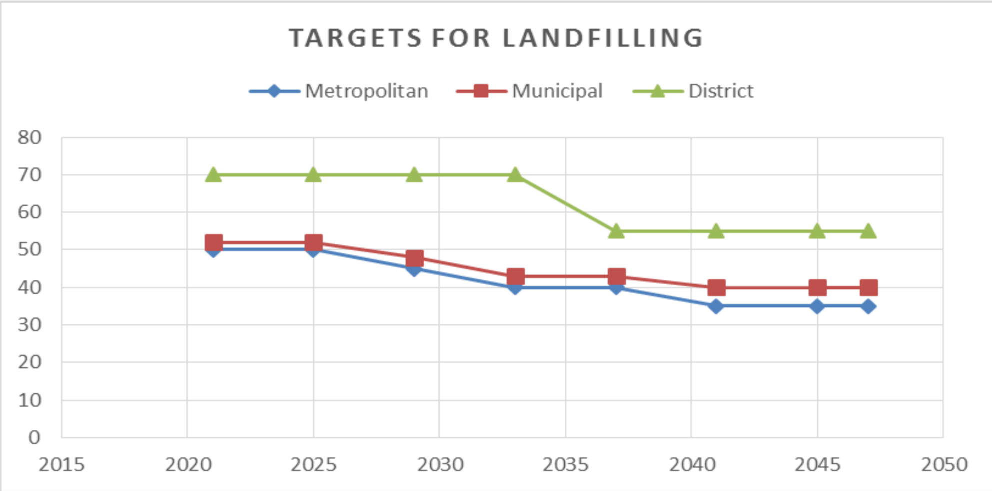
Figures 12.3, 12.4 and 12.5 indicate the various targets for composting and recycling, landfilling, and waste to energy respectively.

Figure 12.3: Expected target for Composting and Recycling



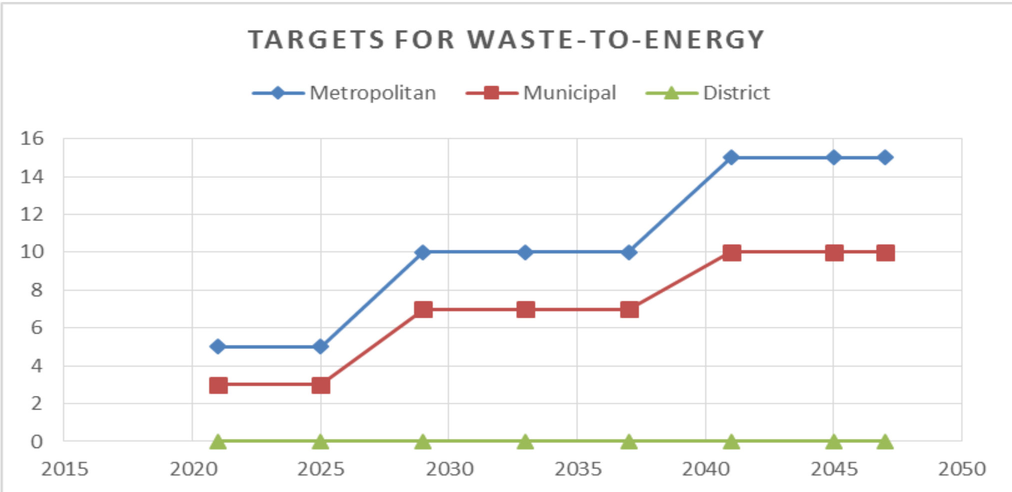
Source: Author's Construct

Figure 12.4: Expected target for Landfilling



Source: Author's Construct

Figure 12.5: Expected target for Waste-to-Energy



Source: Author's Construct

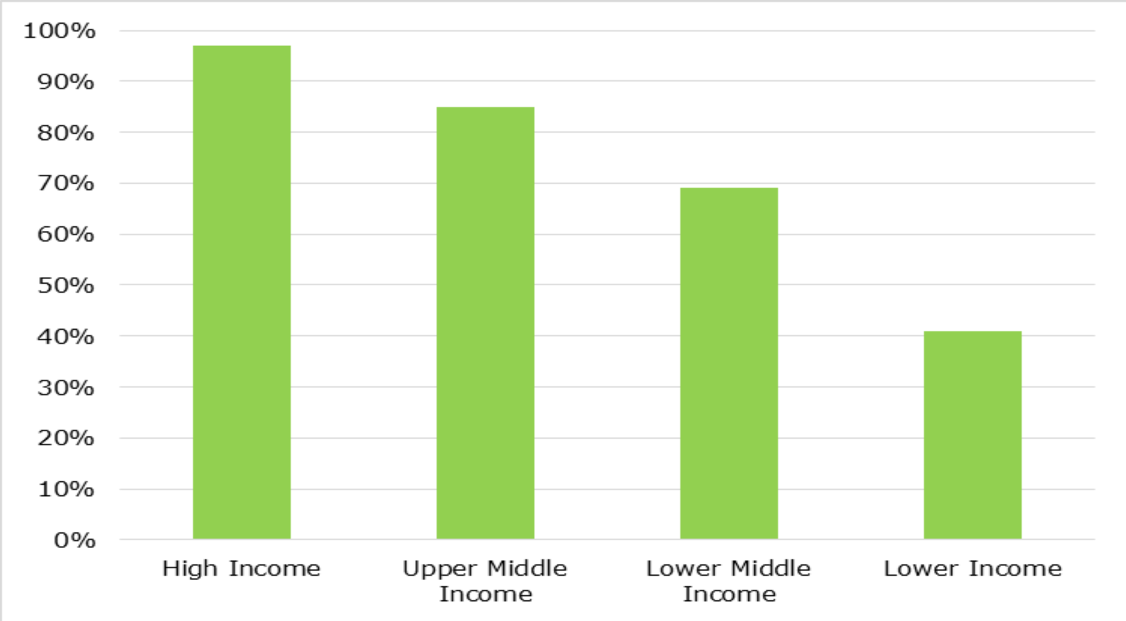
12.6.4 Design Norms and Assumptions

Solid Waste Management

Within the context of the NESP and NESSAP, and in keeping with the vision and objectives of the GIP, the following are relevant assumptions and design norms adopted for the projections:

i. Infrastructure for collection are planned for 100% collection by 2047 and beyond, consistent with the collection rates for high income countries as envisioned (Figure 12.6).

Figure 12.6: Waste Collection Rates



Source: Hoornweg & Bhada Tata, World Bank, 2012

ii. Organic content of solid waste reduces over the 30 year plan period as income status improves, while the proportion of recyclables like paper, plastic and metal rather increases. Global estimations as published by the World Bank are indicated in Table 12.12.

Table 12.12: Waste Composition by Income

CURRENT ESTIMATES						
Income Level	**Organic (%)**	**Paper (%)**	**Plastic (%)**	**Glass (%)**	**Metal (%)**	**Other (%)**
Low Income	64	5	8	3	3	17
Lower Middle Income	59	9	12	3	2	15
Upper Middle Income	54	14	11	5	3	13
High Income	28	31	11	7	6	17

Source: Hoornweg & Bhada Tata, World Bank, 2012

The following waste compositions are adopted for the waste generation projections and estimation for treatment requirement cost based on the economic development and urbanisation envisioned for the Metropolitan, Municipal and Districts:

Table 12.13: Adopted Waste Composition based on Economic Development

Description	[73] Percentage composition ("Organics"/ "Paper, Plastics, Metals and Glass"/ "Rest")		
	2018 – 2029	**2030 - 2041**	**2042 – 2047**
Metropolitan	61% /14% / 25%	54% / 33% / 13%	28% /55% / 17%
Municipal	61% / 14% / 25%	54% / 33% / 13%	28% / 55% / 17%
District	61% / 14% / 25%	61% / 14% / 25%	54% / 33% / 13%

Source: Various (including Miezah et al., 2015, World Bank 2012)

iii. Landfilling, recycling and composting, and incineration account for about 45%, 33% and 22% of the total waste load disposed of in high income countries, compared with the corresponding proportions of about 97%, 2% and 1% in low income countries (Table 12.14).

Table 12.14: Municipal Solid Waste Disposal (Million Tonnes)

High Income		**Upper Middle Income**	
Dumps	0.05	Dumps	44
Landfills	250	Landfills	80
Compost	66	Compost	1.3
Recycled	129	Recycled	1.9
Incineration	122	Incineration	0.18
Other	21	Other	8.4
Low Income		**Lower Middle Income**	
Dumps	0.47	Dumps	27*
Landfills	2.2	Landfills	6.1
Compost	0.05	Compost	1.2
Recycled	0.02	Recycled	2.9
Incineration	0.05	Incineration	0.12
Other	0.97	Other	18

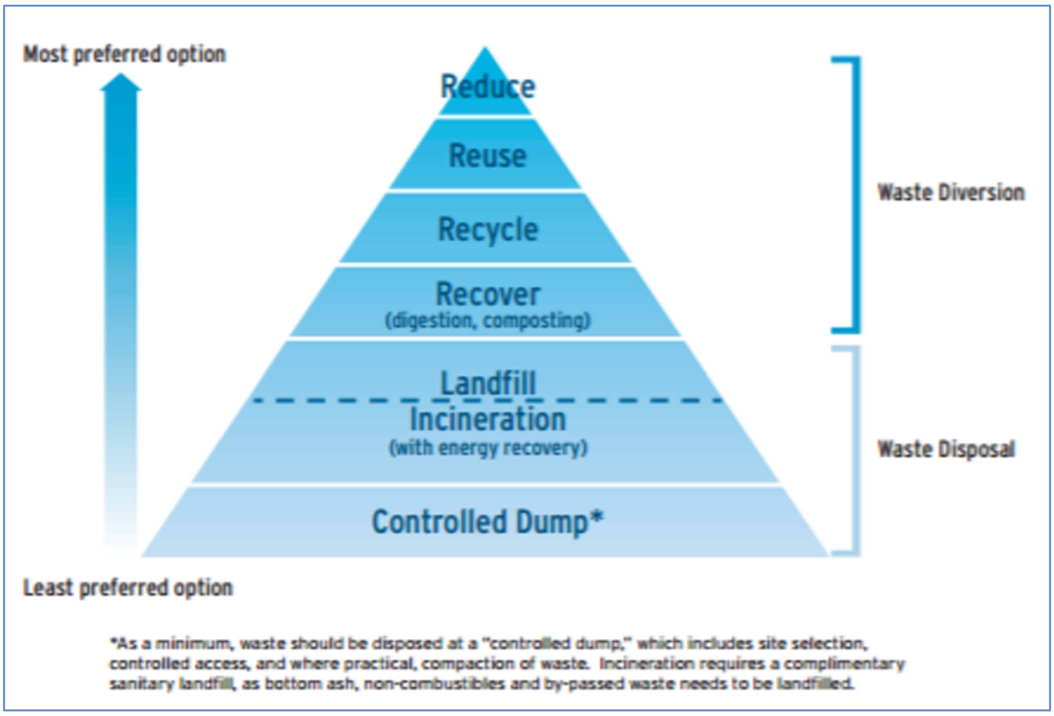
**The value is relatively higher due to the inclusion of China*

Source: Hoornweg & Bhada Tata, World Bank, 2012

iv. Solid waste management hierarchy places emphasis on waste minimisation, reuse and resource recovery in preference to landfilling, dumping and incineration.

[73] The waste fractions adopted for 2018 – 2029 are from nationwide survey conducted in 2015 by Miezah et al. The waste fractions adopted for Metropolitan and Municipal Assemblies for the periods of 2030 – 2041 and 2042 – 2047 are for upper middle income and high income countries, respectively, as published by Hoornweg & Bhada Tata (World Bank, 2012**)**, whiles those for Districts are 2015 survey figures for 2030-2041 and upper middle income fractions for 2042 - 2047.

Figure 12.7: Solid Waste Management Hierarchy



Source: Innovations to tackle inorganic waste in Texel, 2015

v. Per capita generation rates are assumed as follows, considering the envisioned economic growth of the country within the planning horizon as shown in Table 12.15:

Table 12.15: Per capita generation rate with planning horizon

Description	[74]Per capita generation (kg/c/day)		
	2018 - 2029	**2030 – 2041**	**2042 - 2047**
Metropolitan	0.63	0.75	1.20
Municipal	0.40	0.63	1.20
District	0.28	0.40	0.63

Source: Miezah et al., 2015

vi. Waste minimisation programmes to include provision of household level containers and composters for source separation and domestic level composting.

vii. Appropriate vehicles and equipment with adequate capacity to be provided for sustainable and improved collection and conveyance at the household and community levels.

viii. Facilities to be provided at the household level shall take into account housing types and income level to ensure sustainable use and maintenance.

ix. Waste treatment infrastructure shall be provided with the minimum lifespan shown in Table 12.16:

[74] Per capita waste generation adopted for 2018 – 2029 is from nationwide survey conducted in 2015 by Miezah et al.
Per capita waste generation adopted for Metropolitan Assemblies for the period 2030 – 2041 and 2042 – 2047 are the lower boundary of the generation rate of upper middle income countries, and the average per capita waste generation for upper middle income countries, respectively as published by the World Bank 2012.

Table 12.16: Minimum lifespan of Waste Infrastructure

Description	Lifespan (Years)
Semi Centralised Landfills/Controlled Dumps	15 to 25
Composting/Recycling Facility	15 to 25
Waste to Energy Facility	25

Source: Author's Construct

x. Proportion of E-waste is assumed as a percentage of total municipal waste load.
xi. Separate infrastructure shall be provided for managing agricultural waste streams in order not to over burden available municipal solid waste management facilities.
xii. Industrial wastes shall be treated on-site (on their premises) by industrial concerns in accordance with EPA standards before discharge into the environment.

Liquid Waste Management

Per capita generation rates are assumed as indicated in Table 12.17.

Table 12.17: Per capita Liquid Waste Generation

Description	Litre per capita per day
Sewage	60.0
Septage	1.0

Source: Author's Construct

i. Sewer Networks comprising simplified and small bore sewers of minimum length of 5.0m per person shall be provided, particularly in urban communities with minimum 5,000 inhabitants.
ii. Treatment Infrastructure shall be provided as shown in Table 12.18.

Table 12.18: Treatment Infrastructure

Description	Number of People Served
Centralised Sewage Treatment	200,000 – 250,0000
Centralised Septage Treatment	350,000 – 500,000

Source: Author's Construct

iii. Decentralised (satellite) treatment systems to be provided for smaller sized communities.
iv. Maximum benefits to be derived from reuse.
v. Facilities for household sanitation shall be mainly based on water dependent technologies that include low volume flush systems. All technologies shall be tested and approved by an appropriate certifying body for acceptance and use.

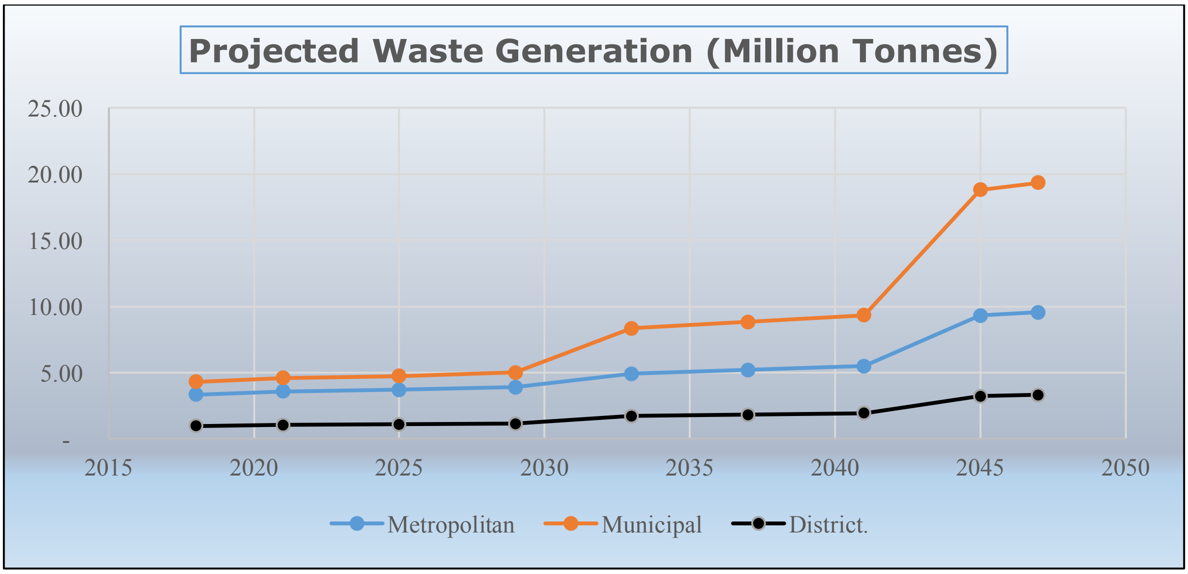
12.7 Projections and Infrastructure Requirements

12.7.1 Municipal Solid Waste Management

Generation

It is projected that about 32 million tonnes of municipal solid waste would be generated per annum by end of the 30-year planning horizon 2047 (See Fig. 12.8).

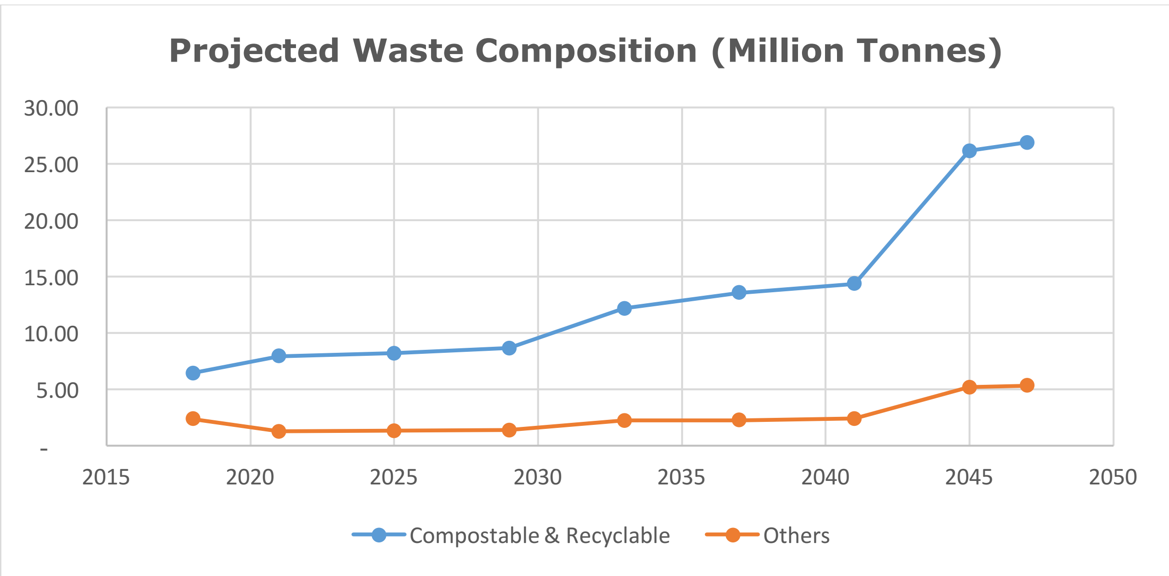
Figure 12.8: Projected Solid Waste Generation (2018-2047)



Source: Author's Construct

The municipalities would generate the most waste over the planning period. Compostable and recyclable fractions of the waste generated is expected to increase over the period; from about 6.5 million tonnes to 27 million tonnes per annum by 2047 as shown in Figure 12.9.

Figure 12.9: Projected Waste Fractions (2018-2047)

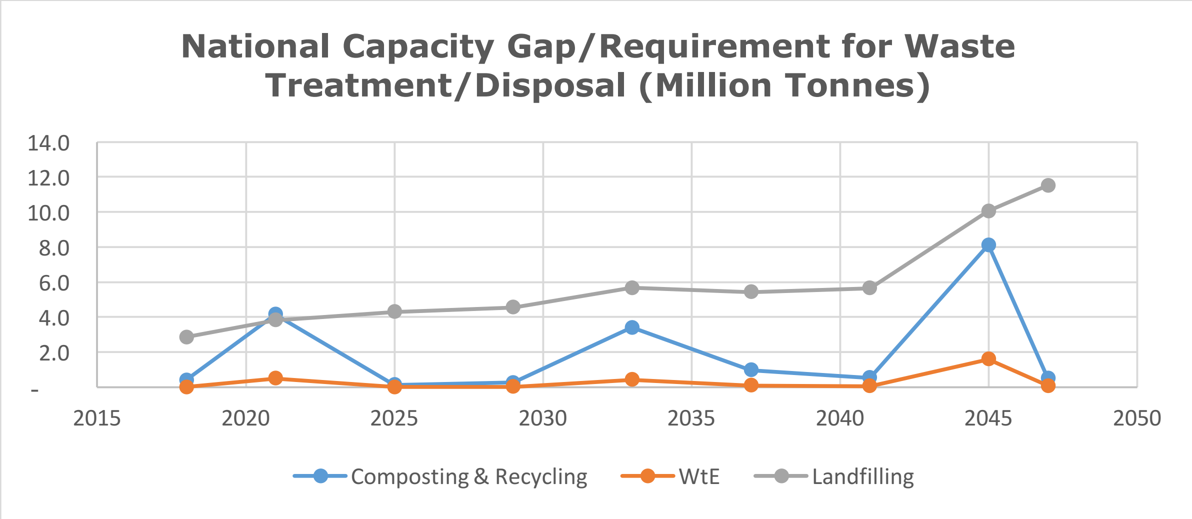


Source: Author's Construct

Treatment and Disposal Requirement

All treatment technologies applied to solid waste would generate residue that requires disposal in a landfill in addition to the inert waste fraction. In this regard, about 15% of the waste to be treated is assumed as residue for landfilling. Waste-to-Energy treatment would take the least tonnage of projected solid waste generated based on the targets as shown in Figure 12.10.

Figure 12.10: Treatment/Disposal Capacity Requirement



Source: Author's Construct

Land Area Requirements

By 2047, it is projected that about 9 sq. km of land area per annum would be required for landfilling (Table 12.19). Due to increasing rate of urbanisation and the resulting scarcity of land for final waste disposal, it may be desirable to secure lands in outlying areas of urban clusters within metropolitan and municipal areas for future use.

Table 12.19: Land Area Requirements for MSW Disposal

	Land Area Requirements (km²)			
Year	**Metropolitan**	**Municipal**	**District.**	**Total**
2018	0.96	1.23	0.28	2.47
2021	1.03	1.32	0.30	2.65
2025	1.06	1.36	0.31	2.72
2029	1.12	1.43	0.33	2.88
2033	1.41	2.39	0.50	4.29
2037	1.49	2.52	0.52	4.54
2041	1.57	2.67	0.55	4.79
2045	2.66	5.37	0.92	8.96
2047	2.73	5.53	0.95	9.21

Source: Author's Construct

Transfer Stations

Transfer stations of 300 tonnes per day minimum capacity shall be provided within 20 km travel distances to support collection and transfer of solid waste from the generation points to the treatment and disposal sites.

12.7.2 Municipal Liquid Waste Management

Generation

Projections suggest that about 1,669,414 m³/day of sewage and 11,538 m³/day of septage would be generated in the urban communities by 2047 (Table 12.20). Septage generation would decrease from about 22,350m3/day to 11,500m³/day in 2047 due to the expected shift from onsite systems to off-site system (sewerage).

Table 12.20: Urban Wastewater Generation

Description		Liquid Waste Generation (m^3/day)	
	2018-2029	**2030-2041**	**2042-2047**
Sewerage	35,058 – 268,215	268, 215 – 1,020,823	1,020,823 – 1,669,414
Septage	22,301-22,351	22,351-17,014	17,014-11,538

Source: Author's Construct

In the case of rural communities, sewage generation is expected to increase to 106,309m^3/day while septage generation declines to 14,700m^3/day in 2047 (Table 12.21). Generally, as the country reaches over 90% urbanisation in 2047, it is expected that there would be a shift from use of on-site sanitation systems to off-site (sewerage) systems across the country.

Table 12.21: Rural Wastewater Generation

Description		Liquid Waste Generation (m^3/day)	
	2018-2029	**2030-2041**	**2042-2047**
Sewerage	2,390 - 36,106	36,106 - 79,228	79,228 – 106,309
Septage	14,700-15,044	15,044-5,282	5,282-4,134

Source: Author's Construct

Collection and Treatment Capacity Requirement

The infrastructure requirement for collection based on the targets and projections made is presented in Table 12.22. A total of about 149,000 km length and 8,660km length of sewers are required for urban and rural communities, respectively by 2047. In addition, a little over 4 million facilities in urban areas and about 853,000 facilities in rural areas will be required to meet on-site sanitation needs by 2033 nationwide.

Table 12.22: Projected Collection Infrastructure Gap

Year	Projected Quantity of Sewer lines Required			Projected Quantity of On-Site Sanitation Facilities Required	
	Urban Population (Km-length)	**Rural Population (Km-length)**		**Urban Population (No.)**	**Rural Population (No.)**
2021	14,223	511		1,275,074	518,301
2025	5,414	590		457,893	48,097
2029	12,594	1,707		1,157,154	243,991
2033	16,501	2,217		1,180,079	42,208
2037	20,717	1,260			
2041	25,500	117			
2045	26,073	2,257			
2047	27,976	-			
Total	**148,998**	**8,659**		**4,070,200**	**852,597**

Source: Author's Construct

12.7.3 Agricultural Waste

Table 12.23 presents the projected production of agricultural wastes based on available figures for crop production in year 2008, estimated growth rates and anticipated crop waste residue to product ratios according to the Ministry of Food and Agriculture (MOFA).

Table 12.23: Projected Crop Residue over Plan Period

Crop Type	Estimated Waste Residue (x1000 Tonnes)		
	2018-2029	**2030-2041**	**2042-2047**
Maize	32,499	98,624	178,345
Sorghum	18,061	54,811	99,117
Cocoa	13,787	41,841	75,662
Millet	9,454	28,691	51,882
Oil Palm Fruit	4,403	13,361	24,161
Rice	7,150	21,697	39,236
Coffee	6,825	20,711	37,452
Coconut	3,954	11,999	21,699
Sugarcane	252	765	1,383
Total	**96,384**	**292,500**	**528,937**

Source: Author's Construct projected from MOFA data

Agricultural waste shall be adequately managed to derive related reuse benefits as necessary. The energy potential and nutrient value of such wastes shall be exploited to support industrial and agricultural production.

12.8 Financial Requirements

A total investment of USD 31.1 billion will be required to achieve the objectives and set targets for integrated waste management by 2047 (Table 12.24).

Table 12.24: Estimated Financial Requirements for Integrated Waste Management

Planning Period	Required Investment in Infrastructure (US$ m)					Total
	Liquid Waste Management	Solid Waste Management				
		Compost + Recycling	Waste to Energy	Landfilling	E Waste Recycling	
2018 – 2021	1,157.8	646.7	288.1	467.4	323.3	**2,883.3**
2022 – 2025	517.3	19.3	8.5	301.4	9.6	**856.1**
2026 – 2029	858.6	38.4	16.9	318.7	19.2	**1,251.8**
2030 – 2033	1,304.4	760.9	273.2	888.5	380.5	**3,607.5**
2034 – 2037	1,253.3	865.1	347.2	1,318.4	432.6	**4,216.6**
2038 – 2041	3,023.6	139.4	48.0	1,186.7	69.7	**4,467.4**
2042 – 2045	2,278.4	2,341.4	1,149.7	2,578.4	1,170.7	**9,518.6**
2046 – 2047	1,452.8	144.3	54.4	2,589.0	72.2	**4,312.7**
Total	**11,846.2**	**4,955.5**	**2,186.0**	**9,648.5**	**2,477.8**	**31,114.0**

Source: Author's Construct

12.9 Proposed Financing Strategy

The strategy for sector financing will be based on the following principles:

i. Complete adoption of the "polluter pays principle," ensuring full cost recovery for collection and transportation, and partial cost recovery for treatment, reuse and disposal infrastructure and services.
ii. Part of the revenues derived from service charge and tariff payments by beneficiaries and reuse benefits will be applied to fully cover operation and maintenance costs.
iii. Private sector direct investments in infrastructure and services will be made through various contracts that include BOOT, BOT, BOO, etc., to substantially increase sector financing. Due diligence will be exercised by the relevant public sector institutions in the award of related contracts to ensure value for money.

Chapter 13 Drainage, Flood Control and Coastal Protection

13.1 Introduction

Floods, be it coastal (surge flood), pluvial (surface flood) and/or fluvial (riverine flood), can have devastating effects on communities by causing significant damage to homes and economic activities. They can also cause severe destruction of energy, transport, water and communication infrastructure which impacts negatively on the local economy. In recent years, fluvial, or river flood in particular, which occurs when excessive rainfall over an extended period of time causes a river to exceed its capacity, has become a perennial problem in Ghana, especially for those settlements along waterways. According to the National Disaster Management Organisation (NADMO), floods have accounted for nearly 65% of the disasters in the country.

The hydrological transformation of rainfall into runoff by a catchment is significantly modified by land use changes such as urbanisation. However, hydrological consequences of land use policies are rarely considered to the level they deserve in the country. Due to rural-urban migration and competition for land for residential development, water courses, wetlands and low-lying areas become places of settlements. The occupation of wetlands and low-lying areas as well as increased roof and paved areas aggravates the rate of runoff which has adverse impact on recharge and discharge of ground water system. The resultant high rainfall-runoff concentration puts pressure on existing low capacity drainage channels and subsequently cause flooding. The development of strategies to improve the general drainage system of the country and ensure that flood risk awareness and forecasting using modern tools is pursued, is critical to prevent loss of lives and property.

13.1.1 Vision

The vision, therefore, is to improve drainage, and reduce the risks of flooding and coastal erosion on people, the economy, environment and society.

13.2 Overview of Ghana’s Drainage and Flood Control Situation

13.2.1 The Drainage System of Ghana

Ghana’s drainage system is dominated by the Volta River basin which covers nearly 70% of the country’s area. The rest of the country is drained by several smaller rivers such as the Pra, Tano, Ankobra, Bia, and a number of small coastal streams. All the rivers in the country flow generally southward, emptying into the Gulf of Guinea along the southern coast. Approximately one half of the drainage area of all rivers in Ghana lies outside the country with the Volta river system accounting for nearly all of it.

The Bia River originates within the country and flows into Ivory Coast on the west. The Tano has its source within the country, but flows along the border with Ivory Coast in the last 76 km of its course. The Volta flows from outside into Ghana and finally to its outfall into the Gulf of Guinea. The Todzie, Aka and Belikpa rivers also have parts of their upper catchments outside the country. The rest of the river basins are entirely within Ghana as shown in Figure 13.1.

Figure 13.1: Drainage Map of Ghana

Source: Maps of World, 2013

13.2.2 Overview of Flooding in Ghana

Some cities where floods have occurred in recent times are Accra, Tamale, Cape Coast, Takoradi, Kumasi, Koforidua, Bolgatanga and Ho. This has attracted national attention in recent times. The causes of flooding in these urban cities are similar in nature. Ghana's south-eastern coast has suffered from the negative impacts of climate change, especially sea level rise, resulting in the destruction of coastal infrastructure in urban areas and small fishing villages. In addition, climate change has threatened the sustainability of important cultural and historical resources, hindered coastal tourism development, and affected the socio-economic life of the local population especially around Keta, Ada, Accra, Nkontompo and Shama. Building climate resilience in the country's infrastructure has weak links between the national policy framework and district-level planning directives. In effect, the capacity of the coastal ecosystem to cope with natural phenomena is negatively affected. Other causes of flooding can be attributed to the following:

i. Over reliance on direct conveyance of runoff through channels instead of integrated flood management, which includes source controls such as detention and retention ponds and management of anthropogenic forces in catchments;
ii. Poor waste management resulting in the dumping of solid waste in open drains;
iii. Climate change resulting in the severe weather conditions that continue to intensify in the years to come;
iv. The impact of water storage and stream flow regulation of upstream countries that share common water resources with Ghana;
v. Poor engineering design and management of drains.

13.3 Institutional Structure of the Drainage Subsector

13.3.1 Classification of Drains

Primary drains

These are drains designed for high hydraulic capacity channels that mostly run along natural stream courses. They are capable of carrying within their banks the run-off likely to result from the highest rainfall intensities in their catchments that may be expected to occur on an average once in 25 years.

Secondary drains

The secondary drains are designed for medium hydraulic capacity channels that are capable of carrying within their banks the run-off likely to result from the rainfall intensities that may be expected to occur on an average once in 15 years. These drains discharge into the primary drains.

Tertiary drains

The tertiary drains which lie along service lanes and roads in developed areas (residential and market areas) discharging into primary or secondary drains are designed for a return period of two to five years.

13.3.2 Role of Institutions in Drainage and Flood Control Activities

Table 13.1 shows the activities of the various state and parastatal organisations involved in planning and implementation of drainage systems and coastal management in the country.

Table 13.1: Existing Roles of State and Other Organisations in Drainage/Flood Control Activities

Activity	Organisation	Type of Drain
Physical Planning	Town and Country Planning Department (Land Use and Spatial Planning Authority) State Housing Company (SHC) Tema Development Corporation (TDC)	Secondary and Tertiary Drains
	Other Private Developers	Tertiary Drains
Project Formulation	Hydrological Services Department (HSD) Ghana Highway Authority (GHA), Department of Urban Roads (DUR) and Department of Feeder Roads (DFR)	Primary, Secondary and Tertiary Drains
	Metropolitan, Municipal and District Assemblies (MMDAs) Ghana Meteorological Agency (GhMET) Water Resources Commission (WRC) Research Institutions NADMO	Tertiary Drains
Design	HSD, GHA / DUR / DFR	Primary, Secondary and Tertiary Drains
	SHC/TDC Private Large Scale Developers	Secondary and Tertiary Drains
	Others (SSNIT, SIC, Banks etc.)	Tertiary Drains
Construction	HSD	Primary and Secondary Drains
	GHA/DUR/DFR	Secondary and Tertiary Drains
	SHC/TDC	Secondary and Tertiary Drains
	Private Large Scale Developers	Tertiary Drains
	MMDAs	Tertiary Drains
Maintenance	MMDAs with the support from HSD	Primary and Secondary Drains
	MMDAs with the support of DUR	Tertiary Drains
Environmental, Waste Management and Sanitation	MMDAs, MLGRD, Ministry of Sanitation and Water Resources, MESTI, EPA	Primary, Secondary and Tertiary Drains
Research	Universities, Building and Road Research Institute, CSIR (WRI, Soil Research)	Research into Primary, Secondary and Tertiary Drains
Finance and Economic Planning	Ministry of Finance (MoF) MMDAs	Primary, Secondary and Tertiary Drains
Coordination	Individual coordination by organisations No coordinating agency for effective implementation of existing system	

Source: Author's construct

13.4 Existing Drainage, Flood Control and Coastal Stability Plans

13.4.1 Drainage Master Plans

A Drainage Master Plan is an important tool used to identify remedial storm water quality and flood risk management projects. It guides new land development projects to be consistent with regional/national drainage and flood control needs. It also provides valuable input and helps with the identification and acquisition of rights-of-way for future capital improvements along stream/river basins and areas for preservation. It further aims at managing urban area development and stimulating economic growth to reduce poverty by reducing flood risks.

The initial drainage master plan schemes prepared in the country consist predominantly of open U-shaped or rectangular concrete lined drains and open trapezoidal shaped drains. For the future development of drainage master plans, there is the need to focus on channel systems, which provide permanent underground waterways that restore water quality and recharge the natural environment in order to solve the enormous problems currently associated with open dirt or concrete channels. Using the available recent topographic maps, and satellite images coupled with stream/land profiles surveys, drainage master plans could be prepared more accurately. Watercourse profiles, soil characteristics, permeability of land areas and likely land-use are the inputs used together with the hydrology of the drainage basin to develop the master plan. Also, the development of the masterplan requires the input of various state agencies such as Land Use and Spatial Planning Authority (LUSPA), road agencies, research institutions and universities.

A key challenge to the preparation of drainage master plan is the integration of contingency plans to reduce climate-related risks at local levels. There must be multi-stakeholder consultations, effective communications and integration of community knowledge. Table 13.2 indicates the drainage master plans developed for some urban centres in Ghana. In some cities, the master plans and the necessary drainage designs have been completed but implementation of drainage/flood control improvement works have been very slow.

Table 13.2: Existing Drainage Master Plans for Urban Centres

Year	City	Initiating Ministry	Project	Prepared by	Area of Coverage
1963	Tema	Communication and Works	Drainage Master Plan for Tema	NEDECO ,The Hague- Holland	Communities 1-12
1963	Accra	Communication and Works	Overall drainage master plan for Accra	NEDECO ,The Hague- Holland	Main water courses within Accra Central
1967	Accra	Communication and Works	Overall drainage master plan (Addendum)	NEDECO ,The Hague- Holland	Additional areas to cover the Ministries, Christianborg and Central Town
1991	Accra	Local Government and Rural Development	Feasibility interventions for flood mitigation in Accra	Mott Macdonald	
1995	Accra	Local Government and Rural Development	Review and Update of 1991 Drainage Master Plan	SNC Lavalin	Centred on the development of the Odaw stream and its tributaries
1998	Accra	Local Government and Rural Development	Urban Environmental Sanitation Project. Accra Drainage Improvement works	SNC Lavalin	Centred on the development of the Odaw stream and its tributaries
2006	Tema	Local Government and Rural Development	Second Urban Environmental and Sanitation Project. Preparation of Drainage Master Plan, Preliminary Detailed Engineering Designs.	MDC and Mott Macdonald, UK	Communities 5,6, 18,19,20,25 and Ashiaman, Tema Newtown and TOR Area
2002	Tamale	Water Resources Works and Housing	Preparation of Tamale drainage master plan	Twum Boafo and Partners, Ghana. Dalhandasa of Egypt	Tamale Central Business Area
1998	Kumasi	Local Government and Rural Development	Second Urban Environmental and Sanitation Project. Preparation of Drainage Master Plan, Preliminary Detailed Engineering Designs.	Watertech	Central Business Area of Kumasi
2014	Ho	Department of Urban Roads	Preparation of drainage master plan for Ho Municipality	KE&T Consult Accra	Ho Central with emphasis on drains crossing major roads

Source: Author's construct

13.5 Flood Management Practices

13.5.1 Non-Structural Measures

The World Meteorological Organisation Associated Programme on Flood Management (WMO-APFM) provides the following examples of non-structural measures:
Development of integrated land and water planning policies, including:

i. Catchment management policies;
ii. Re-zoning of flood plains; and
iii. Development of appropriate legislation;
iv. Flood risk assessment;
v. Assessment of social acceptability risk;
vi. Flood forecasting and early warning;
vii. Public awareness and emergency preparedness; and

viii. Use of economic tools, such as compensation and insurance.

13.5.2 Structural Measures

Even though WMO-APFM provides the combination of structural and non-structural measures for flood management, the nation's flood management practices are skewed towards the structural measures. The structural measures involve the construction of designed artificial waterways to remove, transport, detain or retain floods to bring relief to the flood prone areas. These structures include the following:

i. Creating an artificial reservoir behind a dam across a river in order to retain or detain flood;
ii. Improving and regulating a suitable natural depression;
iii. Diverting part of the peak flow to another river or basin, where such diversion would not cause appreciable damage; and
iv. Constructing a parallel channel by-passing a particular town or reach of the river prone to flooding.

The engineering methods of flood protection works which do not reduce the flood flow but reduce spilling include the following:

i. Embankments which artificially raise the effective river bank and prevent spilling;
ii. Channel and drainage improvement works, which artificially reduce the flood water level so as to keep the same confined within the river banks and thus prevent spilling.

The following sections show the form of structural measures currently practised in Ghana. A way forward is to bring on board the effective management of floods by the combination of the two measures prescribed by WMO-APFM.

Channelisation of Rivers

Channelisation of rivers involves improving the extensive meandering problems of rivers to enhance their carrying or conveying capacities. This includes activating channels and training rivers into shorter courses. The Akora River in Agona Swedru, Odaw Stream in Accra, and the lower Kakum River at Kwapro in Cape Coast are good examples of channelisation. In order to channelise a river, it must be allowed certain freedom to flow along the right of way to pass its flood waters and silt load within its natural waterway. Hence, the dynamic nature of rivers should be appreciated and preventive measures planned accordingly during channelisation.

Channel Improvement (Desilting)

Channel improvement involves the enhancement of the hydraulic conditions of river channels by desilting, dredging, lining etc., in order to enable the river carry its discharges at lower levels or within its banks. This approach has often been advocated but it has been adopted on a very limited scale because of its high cost and other constraints.

The Korle Lagoon Dredging Project started very well in 1976/77 with Ghana Government budgetary support. In 2000/2004, it continued under a co-financing arrangement between the government of Ghana and international funding agencies in the form of bilateral and multi-lateral suppliers' credit and buyers' credit. In 2015-2017, it was continued by a local construction firm on Government' support but the work is still not completed. In order to sustain the Korle Lagoon Dredging Programme, waste management in the basin should be considered a priority.

Reservoirs

Reservoirs can moderate the intensity and timing of the incoming flood. They store the water during periods of high discharges in the river and release it after the critical high flow condition is over, so as to be ready to receive the next wave. Their effectiveness in moderating floods depends on the reservoir capacity available at the time for absorbing the flood runoff and their proximity to the likely damage centre. They are operated with a carefully planned regulation schedule which takes into account both the safety of the dam and related structures and the safe carrying capacity of the lower reaches of the river in their present condition.

Reservoirs are more effective for flood management because apart from the incidental moderation available for any type of storage on a river, specific flood space is earmarked, as in the case of Akosombo and Kpong dams across the Volta, and the Weija dam on the Densu River. In order to improve the efficiency of the reservoirs and improve the operation schedules for providing incidental or specific flood moderation effects, arrangements for inflow forecasts should be made.

Detention Basins

Detention basins are usually formed by utilising natural depressions, swamps and lakes by improving their capacity to store water. This is achieved by the construction of encircling embankments and providing suitable devices for regulating the release of water. Since the land under the marshes or low depression may hardly require much compensation and rehabilitation measures, these methods are relatively inexpensive. There are several detention basins on the Mamahuma stream in Accra and the Gyorwulu stream in Ashiaman. These detention basins were originally developed for water storage for agricultural purposes. With the expansion of the city, they have virtually become water bodies within the city and so they must be reinforced and protected. The current practice of filling up the ponds with water for estate developers poses a great threat as it can result in flooding, therefore it should be avoided.

Drainage Improvement

Surface water drainage constraints resulting from the inadequacy of natural or artificial waterways to carry storm water discharge within a reasonable period of time can cause flooding. Therefore, improving the discharge capacity of the existing drainage system by constructing new channels is recommended as part of an integrated flood management programme in the country. Even though governments over the years continue to provide funds for the implementation of drainage improvement schemes in Ghana, the level of funding is inadequate. Since the preparation of the first drainage master plan in 1963 and subsequent updates up to 2016 (over 50 years), only about 23% of the primary drainage improvement works have been carried out in the capital city. The percentage of drainage improvement works completed in the other cities of the country is relatively lower. Table 13.3 below shows the major channels in Accra which have encountered major floods even though some level of channel improvement works have taken place.

Table 13.3: Major Channels in Accra

Major Channels	Communities	Total Channel Length (km)	Length Completed (km)	Remaining (km)
Odaw	Agbogbloshie, Circle, Avenor, Alajo, Abofu, Kisseman Abokobi, Danafa	30	7.3	22.7
Agbogbloshie	Sodom and Gomorra, Kantamanto	1.9	1.7	0.2
South Kaneshie	Abossey Okai	1.5	0.3	1.2
Mataheko	Mataheko	3.2	1.7	1.5
Nima	Asylum Down, Nima , Mamobi, Airport City	6.6	5.3	1.3
Kokomlemle	Circle, Kokomlemle	1.0	0.9	0.1
Mukose	Avenor, North Kaneshie	6	3	3
Onyasia	Alajo, Dzorwulu, Okponglo, East Legon	15	7	8
Osu Klottey	Osu, Cantonments	6.1	2.9	3.2
Kpeshie	Trade Fair, La, Giffard, Burma Camp	6.21	2.9	3.31
Korkordjor/ Tributaries	Kpeshie lagoon, Teshie, East Airport, East Legon	26	0	26
Kaneshie	Abossey Okai, Kaneshie, Bubiashie, Odorkor	5.3	2.4	2.9
Lafa	Awoshie, Santa Maria, Sowutom	13.5	0.5	13.0
Baale	Malam, Gbawe	12	0	12
Total		**104.31**	**28.6**	**75.71**

Source: Author's construct

Watershed Management

Watershed management measures include developing and conserving the vegetative and soil covers and also undertaking structural works like check-dams, detention basins, and diversion channels etc. In watershed management of upper catchment areas, land treatment through afforestation and grass land development practices should be supplemented by structural works for retarding the water velocity and arresting silt.

Water Resources Commission (WRC) has the responsibility for watershed management in the country. Areas covered nationwide are very small and more rigorous attempts should be made to cover all flood prone areas in the country. There is the need to strengthen the involvement of local communities in the management of mangrove forests and wetlands by promoting cooperative management systems. Additionally, there is the need to enact appropriate legislations for the protection of forest wetlands and mangroves from degradation.

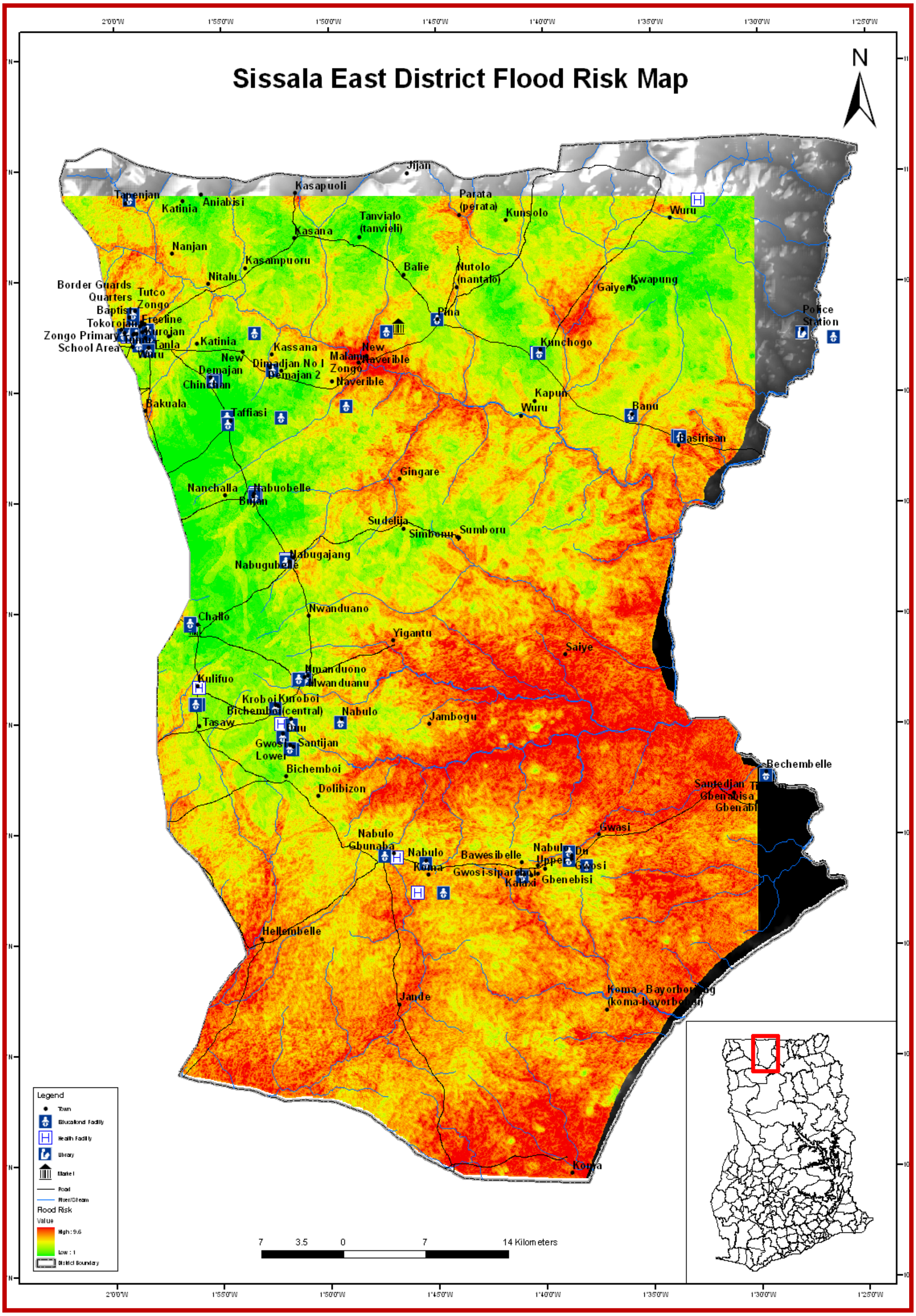
13.6 Development Strategy Framework for Drainage, Flood Control and Coastal Protection

13.6.1 Objectives

At the most basic level, the best defence against floods is to seek higher ground for high-value uses while balancing the foreseeable risks with the benefits of occupying flood hazard zones. The ultimate objective is the protection of lives and property from flood hazards. This objective will be pursued during the planning period by carrying out the following activities:

i. Preparation of flood directive document with the necessary legislation;
ii. Upgrading of the existing manual gauging sites to modern telemetric gauging sites;
iii. Preparation of flood risk assessment maps - an additional requirement for development and building permit approval;
iv. Observation of previous and present flood heights and inundated areas;
v. Statistical, hydrologic and hydraulic model analyses;
vi. Mapping inundated areas and flood heights for future flood scenarios;
vii. Long-term land use planning and regulation;
viii. Engineering design and construction of structures to control, delay/reduce or withstand flooding;
ix. Intermediate–term monitoring, forecasting, and emergency response planning;
x. Short–term monitoring, warning and response operation;
xi. Intensification of flood damage data collection on nation-wide basis and continuation of flood studies.

Figure 13.2: Sissala East Flood Risk Map



Source: Community Resilience through Early Warning (CREW) Project, UNDP/NADMO, 2016

13.6.2 Strategies for Reduction of Flooding in Northern Savannah Zone

Overview of Northern Savannah Ecological Zone

The Northern Savannah Ecological Zone (NSEZ) is drained by a large number of streams and rivers flowing southward with the Atlantic Ocean as the final discharge point. Due to its proximity to the Sahara Desert, the NSEZ is much drier than the southern areas of the country. There are two seasons: wet season between May and October and dry season between November and April. The average annual rainfall varies from 750 mm to 1300 mm[75]. The key constraints of managing and maintaining the drainage systems are:

i. Seasonal flooding issues during the rainy season in Northern Ghana;
ii. Population growth and urban development with insufficient drainage systems;
iii. Uncontrolled development of peri-urban settlements including building in waterways;
iv. Floods along the White Volta River due to heavy rainfall and spilling from upstream Bagre reservoir in Burkina Faso.

The Need for Water Resources Management System

There is the need to develop civil and cultural systems for water resources management to ensure the proper planning, evaluation, monitoring and funding of water resources projects that are coming up in the SADA zone, such as the creation of farm land banks[76]. The following activities should also be carried out:

i. Organise and reinforce consultations among countries sharing common water resources and in particular, the riparian countries of the Volta as well as all development partners interested and concerned with the development of water resources of the Volta basin;
ii. Harmonise the national policies relating to the management of the water resources of the Volta basin, through the adoption and enforcement of integrated water resources management throughout the basin;
iii. Replace vegetation by replanting of trees to minimise the rate of soil erosion and subsequent sediment transport into the rivers;
iv. Encourage sustainable soil conservation techniques in the form of contour ploughing;
v. NADMO needs to establish strong collaboration with VRA to facilitate the communication of dam releases from the Republic of Burkina Faso in order to increase early warning system in the zone.

13.6.3 Strategies for Reduction of Flooding in Urban Centres

Overview of Flooding in Urban Centres

Ghana has experienced several floods in urban centres. Notable among them are the urban floods in the Accra Metropolis, especially in the Odaw, Kpeshie, Sakumo and Densu river basins. In the Kumasi Metropolis, floods occur in the river basins of Sisan,

[75] Northern Savannah Ecological Zone- Concept Master Plan Report Draft Version, December 2016
[76] Technical Feasibility Studies on Investment in Land Development for Commercial Agriculture in the SADA Zone, 2014

Aboabo and Wiwi. Other urban centres such as Tamale and Takoradi experience floods in their central business areas due to the presence of major stream courses through those communities. The following are proposals for flood reduction in urban centres:

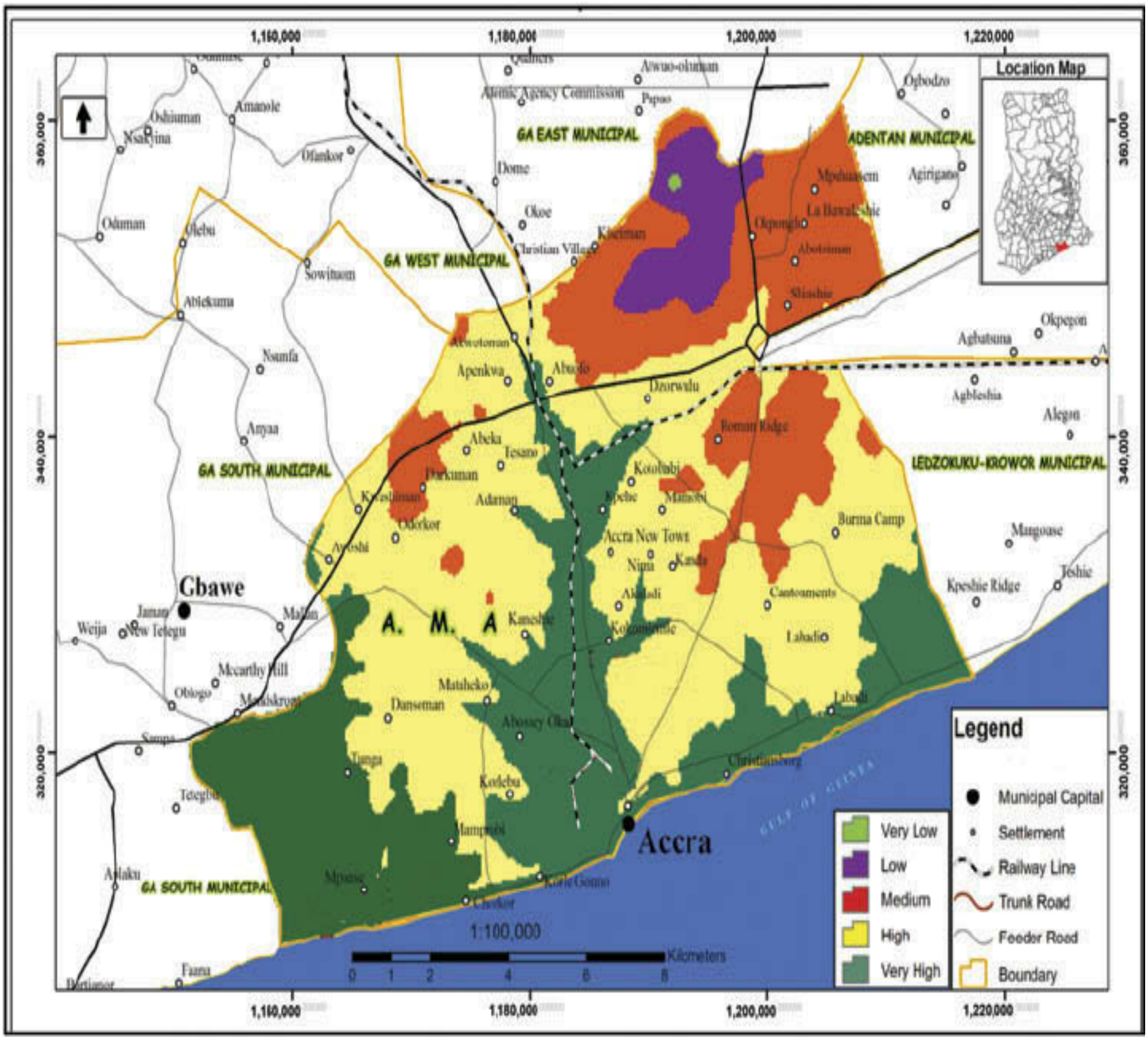
i. Carry out an assessment of the current drainage capacities in urban settlements and delineate the flood prone areas;
ii. Overlay the flood prone areas with the social and economic hotspots to guide the development of interventions;
iii. Prepare development plans for the urban communities as well as the hydraulic infrastructure and carry out cost-benefit analyses, and social and environmental impact assessments of each of the plans;
iv. Select the most attractive plans (socially, environmentally and economically) and plan their phase-wise implementation;
v. Develop an effective organisation to guide the implementation of the works;
vi. Develop an effective organisation to operate and maintain the flood management systems;
vii. Facilitate strong manpower training and development for drainage, flood management and other related issues.

Land Use Planning

Ghana has seen a tremendous shift of population from rural to urban centres in the past few decades. Urban areas have therefore come under pressure to provide housing and other infrastructure such as recreational areas, car parks, and more roads to accommodate the rapid population growth. Some urban centres have developed along streams and river systems. The effect of urbanisation on flooding is the increase in the volume of runoff and the shorter time of concentration as a result of inadequate channel improvement and high level of paved areas. Hence, the need to strengthen and enforce land use planning in urban centres cannot be overemphasised.

Land use planning should be developed taking into cognisance the flood risk map of the area. Figure 13.3 shows the flood risk map of Accra Metropolitan Area indicating areas of very low, low, medium, high and very high flood prone areas. There is the need to update this map to cover the entire Greater Accra Metropolitan Area (GAMA) and also prepare same for other cities and district capitals in the country.

Figure 13.3: Flood Risk Map of Accra Metropolitan Area



Source: Centre for Remote Sensing and GIS (CERSGIS), 2013

Covered and Underground Drainage Systems

Traditionally, open concrete channels are used widely in the urban landscape for drainage improvement even though they are considered unsafe. Besides the health and safety challenges, large open concrete channels take up vast areas of land and impact negatively on the amenities of the area. They encourage the deposition of solid waste into drains, leading to local floods in urban areas.

A way forward is to increase the provision of permanent underground storm sewers to replace the current open channels. This system will provide a unique measure for solid waste control to solve the enormous problems currently associated with open concrete channels. By replacing open drains with underground drainage systems, cities can now benefit from increased environmental amenities, greater recreational space and healthier conditions by using the vast tracts of land once given over to rapid flowing open concrete channels.

13.6.4 Strategies for the Reduction of Coastal Floods and Erosion Degradation

Overview of Ghana's Coastal Land

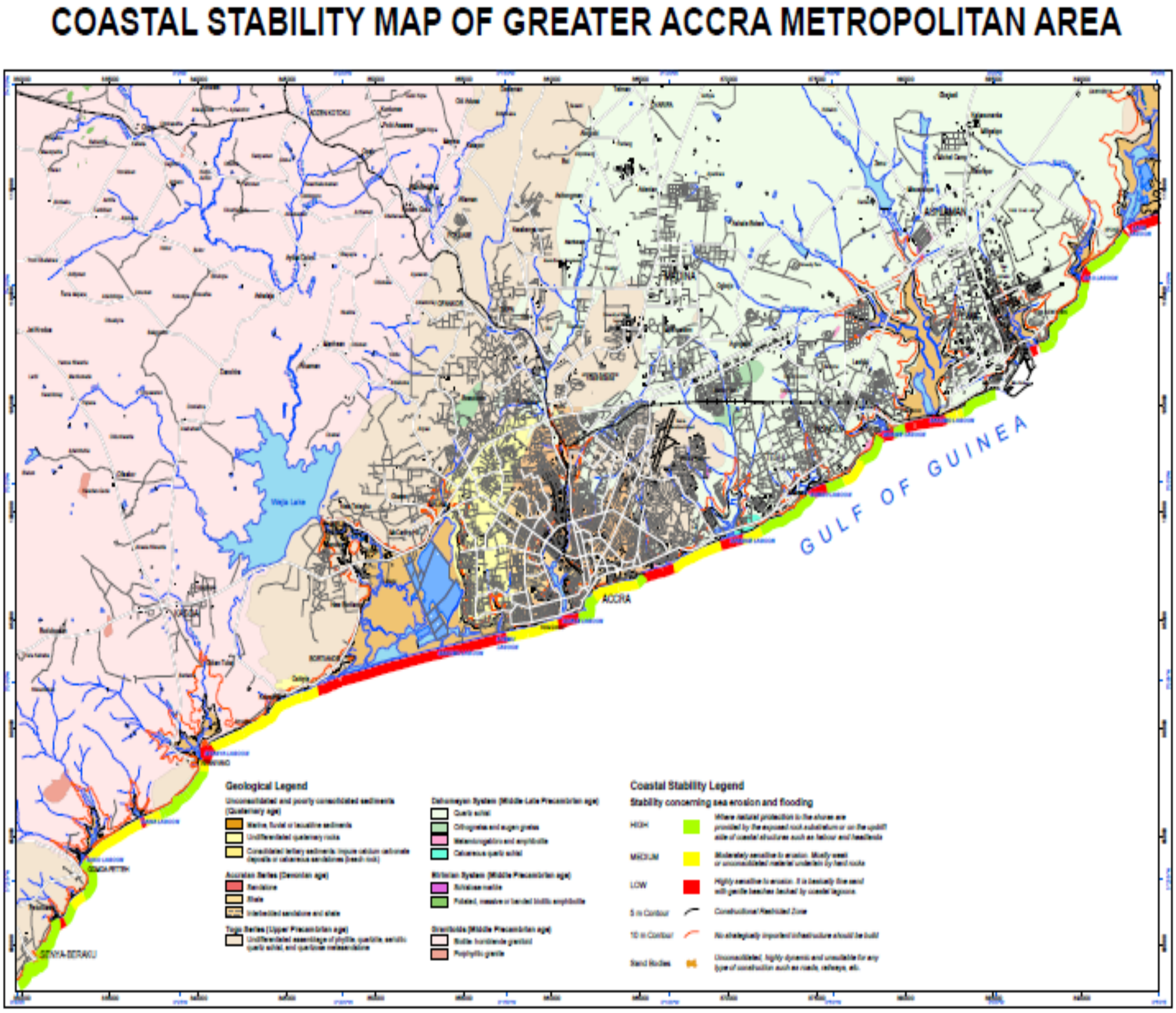
Ghana's coastal boundary stretches over 630 km and the composition of the coastline material ranges from rock to fine sand. Wave height along Ghana's coast is 1.0 m on the average and the tidal influx is diurnal. The eastern coastland ranging from Keta through Ada to Accra has experienced serious coastal degradation over the years, and still continues to be highly active. The western coastland experiences its most critical problems along the Shama to Ngiresia coasts. The rate of coastal erosion in the middle of the 1980s and also between 2001 and 2008 was between 7-10 metres per year in Keta and the Ada coastal fronts[77].

Figure 13.4: Map of Ghana showing areas of Coastal Erosion

Source: Hydrological Services Department, 2007

[77] Hydrological Services Department, 2007

Figure 13.5: Coastal Stability Map of Greater Accra Metropolitan Area



Source: Ghana-Germany Environmental and Engineering Project, Geological Survey Department and BGR Federal Institute of Geosciences and Natural Resources, 2005

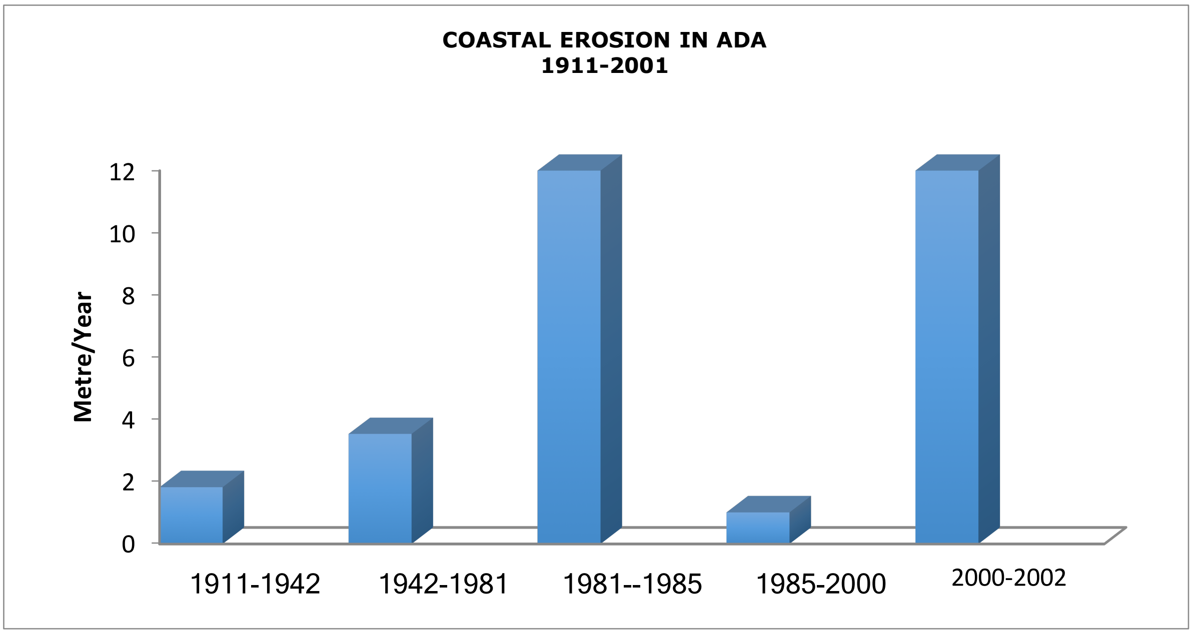
The coastal storms which sweep the coast often destroy homes, fishing boats, outboard motors, fishing nets and other fishermen's equipment. Such destruction underscores the vulnerabilities of many shorefront communities to coastal hazards due to changing climate and rising sea levels. The destruction that followed the events has necessitated the need to re-examine institutional arrangements in place to plan and respond to such hazards.

Nature of Coastal Flood Damage

The nature of coastal flood damage varies from coast to coast depending on coastal stability. Along the Keta coastline, the beach material composition is sand and due to the plunging nature of the wave action, erosion is rapid. The area is also low lying and prone to flooding from rainstorms. At high tides, the plunging tidal wave action combined with the general rise in lagoon water levels is responsible for the flood disasters in the area. At Ada, the coastal material composition is similar to that of Keta, however a new dimension is added by the action of the Volta River at the estuary. Closer examinations have revealed that the coastal erosion is extreme, particularly in drought years, when the sand bar outside the Volta River is closed due to the low velocity flow of fresh water from the river[78].

In the periods of low outflow from the Volta River the banks will close and the water flows out from the river in the easterly and westerly directions. The water flow in the westerly direction affects the coastal profile of Ada, as the wave motion is increased, when the primarily easterly littoral drift meets the out flowing water from the Volta**.** In this way, there is a clear explanation for the heavy erosion off Ada's coast in periods of droughts in Ghana and the resulting fresh water out flow from the Volta River. Figure 13.6 below shows the coastal erosion in Ada from 1911 – 2001.

Figure 13.6: Coastal Erosion in Ada (1911 – 2001)



Source: SIC Skagen Innovation Centre, 2007

Climate Change Impact on Coastal Erosion

Climate change vulnerability assessment studies in Ghana with support from the Netherlands Government Climate Change Studies Assistance Project (NCCSAP) for water resources and the coastal zone have revealed that in the last 30 years the temperature has risen by about 1ºC and the corresponding reduction in rainfall and stream flows were 20% and 30% respectively.

According to the studies, the impact of climate change on the coastal zone in the country is such that, a total of 1,110km² of land area may be lost as a result of a 1.0m rise of sea level due to the temperature rise. This will reflect in putting a population of about 132,200, mostly located along the East Coast, at risk. Important wetlands especially in the Volta Delta may be lost due to land erosion and inundation.

[78] SIC Skagen Innovation Centre, (2007)

Early Warning on Coastal Floods

Tidal events can be predicted with precision, and information on flooding risk can be provided to the coastal public, disaster and response agencies, district authorities and fishermen to better prepare for flooding events. The information could provide the framework for an early warning system. Fishermen and communities could be advised to move away from critical areas and also be able to move their boats and other equipment to safe areas. Coastal communities cannot afford to lose more lives in the midst of available precision tools for providing information and predicting floods.

Framework on Control of Coastal Floods

There is recognition of the fact that the country's most expensive investment is within the coastal zone and most importantly, more than thirty per cent (30%) of Ghanaians live on six per cent (6%) of coastal lands where climate change stressors, including flooding, sea level rise and coastal erosion wreak havoc with high frequency. A coastal programme together with institutional and legal framework should be among the priorities of government.

Required Policies on Coastal Floods

In order to develop and integrate coastal management policies and practices seamlessly, there is the need to establish a vision on coastal management in Ghana and a strategic coordination between institutions relevant to coastal management. Investments need to be made in coastal disaster risk reduction and resilience by strengthening disaster-resilience of critical infrastructure, such as sites of historical, cultural, heritage and religious places of importance.

There is the need to promote coordination among institutions, universities, research units as well as stakeholders to combat coastal erosion and flooding as well as establishing a national forum or coordination mechanism for coastal zone protection and planning. As a first step, contiguous coastal areas could begin working together on common issues such as coastal erosion and flooding. Act 462 and Act 480 provide legal backing for the establishment of joint development planning activities by District Assemblies.

Country Strategy and Policy Linkage

The main challenges identified include weak institutional capacity at the district and national levels; lack of political will and interest; inadequate funding; limited knowledge and information of local communities; and difficulty in integrating data across institutions and turf protection. There is the need for strategic coordination among institutions relevant to coastal management. This is required to ensure that coastal management issues are highlighted for consideration by District Assemblies. This will also strengthen their spatial planning functions. The issues confronting Ghana's coast are enormous and more complicated than a single agency can handle. Therefore, the country strategy should be focused on the following:

vii. Barriers to coordinated action against coastal erosion and flooding need to be removed;
viii. There is the need to set up an inter-agency group to focus on coastal management programmes in the country;
ix. There is the need to strengthen weak regulatory and planning frameworks;
x. There is the need to adopt integrated approach to solving coastal flood shocks requiring coordination among key stakeholders, including traditional authorities and civil societies;
xi. The focus should be on financing and investing in coastal protection and capacity-building programmes, including awareness and sensitisation and supporting the development of new coastal policies and regulatory frameworks;
xii. There is the need to educate communities on how to combat coastal erosion and adapt to climate change. Local governments and NGOs could play key roles in this direction.

13.7 Flood Forecasting Framework

13.7.1 Overview

Flood forecasting is the most non-structural measure gaining sustained global attention from planners and policy makers. Flood forecasting enables forewarning as to where a river is going to spill over into its flood plain, and to what extent and for how long. Its main tools consist of hydrological and hydro-meteorological data collection such as gauge, discharge, and rainfall data, their transmission from field stations to a central control room, formulation of forecasts and dissemination to various concerned agencies on daily basis.

Flood forecasting systems are real time operations, and must be backed by efficient administration systems. In order to meet the requirement of real-time data collection, automatic data transmission as well as flood forecast formulation, and expeditious data/ information dissemination is required.

The activity of flood forecasting comprises level forecasting and inflow forecasting. The level forecasts help the user agencies to decide mitigating measures like evacuation of people and shifting people and their movable property to safer locations. The inflow forecasting is being used by VRA, and the Bui Power Authority to optimise the operation of reservoirs for safe passage of floodwaters downstream as well as to ensure adequate storage in the reservoirs for meeting demand during non-rainy periods.

Flood forecasting should be handled by the Hydrological Services Department which already operates the network on river systems in the country, and in close collaboration with the Ghana Meteorological Agency which provides meteorological data support. The programme for flood forecasting in Ghana was recently commenced by the Water Resources Commission in conjunction with the Hydrological Services Department in a very small way. Presently, there are eight telemetric gauging stations installed in the Volta basin for flood forecasting. Out of the number, two are on the Oti River, two on the White Volta, one each on the Sissili, Kulpwan, Nasia and Nabogo Rivers, all in the Northern Savannah zone. Also, one wireless communication system has been installed in all the eight stations.

13.7.2 National Policy on Floods

It should be emphasised that the national policy on floods should focus on non-structural methods of flood control so as to reduce the recurring expenditure on flood relief. The country requires a policy to modernise all the gauging stations in order to ensure effective means of real time data communication between the forecasting stations and the base stations. The policy should make it imperative for all TV/radio stations to broadcast flood forecasts issued through teletext on their channels. A new policy needs to be formulated on coastal and flood plain settlement.

13.8 Addressing Accra and other Urban Centres Drainage Challenges

Urban stormwater management is receiving enormous attention due to changes in land use patterns resulting from population growth and urbanization. The increasing rate of commercial, residential and industrial development is putting pressure on drainage systems. Land and vegetation act as a natural filtration system during storms. Conversion of open space to impervious structures such as roads, buildings, and parking lots increases the volume of runoff and risk of downstream flooding.

In Accra, the Odaw River is the major drainage channel. The change in land use pattern of the Odaw basin has contributed to perennial incidence of flooding. Experience has shown that the most effective way of managing urban flood is not by constructing bigger drainage channels only since they only provide short to medium-term relief and therefore unsustainable. Instead, there is the need for an integrated urban stormwater management approach that utilises sustainable measures for preventing urban flooding.

The Vortex Valve Technology

Until recently, most municipalities in the United States relied on end-of-pipe solutions such as large detention tanks, deep tunnel storage systems, and high rate treatment facilities to combat urban flooding problems. These large, structurally intensive systems, however, are extremely costly to purchase and maintain. To alleviate these challenges, many are now looking to an alternative approach long relied on in Europe and the United Kingdom. Over 16,000 vortex flow controls, also known as vortex "valves", are installed around the world to manage water flow in stormwater storage schemes, stormwater sewers, combined sewers and wastewater treatment plants.

The Vortex Valve technology is an exceptional solution to control the discharge flow rate from stormwater drainage, detention, and infiltration systems to prevent downstream flooding during periods of heavy rainfall. These novel devices are useful for several types of applications. The city of Evanston, Illinois in the USA, has deployed 2,831 vortex valves to date for inlet control . The cost saving of the technology compared to the construction of alternative drainage channels is about 50 percent.

Today, vortex technology is used in thousands of drainage and sewerage applications all over the world. In the United Kingdom, new National Standards for Sustainable Drainage Systems (SuDS) place increased expectations for controlling the flow and quantity of surface water in new developments and vortex technology provides the perfect solution–

but its design and specification need careful consideration to meet the required standards effectively.

National Policy to Control Post-Development Runoff

Natural lands with vegetative cover ensures a balance of runoff flows during rainfall. When these lands are cleared for development, this balance is compromised and excessive erosion and run-off flow result. There is therefore the need for a national policy to control post-development runoff resulting from the construction of megaprojects such as real estates, shopping malls etc. that changes the drainage characteristics of the catchment.

The idea is to ensure that post-development runoff from the catchment does not exceed the pre-development runoff. This can be achieved by estimating the predevelopment runoff before the projects are commenced and comparing it with the post development runoff to inform the necessary controls to mitigate against excessive runoff.

The policy will require that developers will be responsible for building controls at their own expense to ensure that the post development runoff from the catchment into the drainage channels does not exceed the pre-development runoff. This is necessary to control flooding at source. As a result, developers will be compelled to avoid unnecessary paving of surfaces and adopt sustainable measures of reducing runoff including the creation of lawns where necessary.

Promotion of Permeable Paving Blocks

Permeable paving surfaces have been demonstrated as effective in managing runoff from paved surfaces. Permeable pavers provide a solid ground surface, strong enough to take heavy loads, like large vehicles, while at the same time they allow water to filter through the surface and reach the underlying soils, mimicking natural ground absorption.

This can be used in car parks, median strips etc. The goal is to control stormwater at the source, reduce runoff and improve water quality by filtering pollutants in the substrata layers. Besides controlling excessive runoff, the blocks can be produced commercially from recycled rubber tyres and has the potential of creating jobs in the economy as well as partly solving the country’s solid waste and environmental issues.

Awareness Creation on Rainwater Harvesting

It is important that rainwater harvesting be looked at not only as a means of providing more water for domestic uses in every home but also as a means of reducing flooding. To this end, the enforcement of the building code in regard to the provision of rainwater harvesting in especially new buildings as a pre-requisite to obtaining a building permit must be religiously upheld.

13.9 Institutional Arrangements for Flood Control and Coastal Protection Management

13.9.1 Proposed Responsibilities of Institutions

Even though most institutions have clear cut mandates, overlapping of activities occur in the management of drainage and flood control activities. It is therefore important to propose institutional arrangements for better coordination of the various activities in the management of drainage, flood control and coastal protection. There is also the need for a change in mainstreaming flood management by involving various universities and research institutions in the collection and dissemination of information on research findings on flood and climate risk in order to strengthen the resilience of urban, rural and coastal communities. Table 13.4 summarises the proposed responsibilities with regards to the institutions.

Table 13.4: Proposed Responsibilities for State Institutions in Drainage/Flood Management

Institution	Proposed Responsibilities
Hydrological Services Department	Collection of flood damage data. Formulation and execution of programmes for flood management measures. Preparation of drainage master plans. Act as a centre for coordination of all drainage and flood related programmes as well as link up all drainage master plans with the LUSPA and District Planning Units. Act as a centre for the hydrological network establishment and data collection and analysis. Act as a centre for the monitoring and development of all coastal erosion works
GHA, DUR, and DFR	The Ghana Roads Departments should execute their core responsibilities of design and construction of all roadside drains and refer all road crossing drainage issues to the Hydrological Services Department for advice on waterway requirement.
Ghana Meteorological Agency (GhMET)	Lends meteorological data support to the Hydrological Services Department for handling flood forecasting issues. Develops rainfall models for water resources engineering works as well as increase capacity for early warnings on storms.
Land Use and Spatial Planning Authority (LUSPA)	Development of National Infrastructural Plans taking into account the prepared drainage master plans, water resources management plans, utility plans and to plan housing development and communities to ensure proper buffer zones along waterways and protection of wetlands for flood storage
Ministry of Local Government (MLGRD)	Implementation of flood and drainage management plans and act as main agency in the maintenance of flood and drainage control works. To enforce bye-laws to prevent encroachment on waterways and also sand winning at the beaches and river beds
Environmental Protection Agency (EPA)	Focus on its core responsibility of ensuring environmental safety components of flood control and drainage projects
Volta River Authority (VRA)	Maintains its core mandate of providing power and to use its facility for flood mitigation. It should also liaise with the Hydrological Services Department for flow data and also champion transboundary water issues in the regulation of floods
National Disaster Management Organisation (NADMO)	To continue to address contingencies resulting from hydro-metereological events such as floods and other natural disasters as mandated by its Act of Parliament 1996, ACT 517 and amended by Act of Parliament 2011 (ACT 927)
Forestry Commission	To link up with the Land Use and Spatial Planning Authority for proper planning in terms of maintaining vegetation along drainage channels and water bodies
Waste Management Department	Intensify liquid and solid waste disposal, cleansing of streets and drains, public open places, periodic maintenance of primary and secondary drains sides and open public places
Universities and other Research Institutions	Initiate and bring on board research findings of factors which affect floods such as climate-vulnerability, flood early warning systems and disseminate information for comprehensive policies for flood risk management and preparation of contingency plans.

Source: Author's construct

13.9.2 Way Forward

Stakeholder Engagement

An essential aspect of drainage, coastal protection and flood management schemes is the creation of effective stakeholder engagements to discuss and understand flood risk related problems. This offers the platform to actively participate in the planning and implementation of initiatives related to the promotion of integrated flood management.

Education of the public regarding the importance of avoiding settlement in wetlands, coastal lands prone to erosion, and having early season farming in flood plains, is also needed. A public awareness and education campaign programme by NADMO needs to be developed and implemented.

Preparation of Drainage Master Plans and Flood Forecasting Systems

Given the continuous physical and spatial changes to rivers and surrounding areas, flood risks should be monitored regularly through the development and updating of river basin master plans. HSD and MLGRD need to intensify the preparation of drainage master plans. HSD and WRC need to intensify the preparation of comprehensive communication strategies to disseminate information on flood forecasts and early warning systems. Workshops need to be organised for District Assemblies as part of awareness creation in the management of coastal, urban and rural floods.

Institutional Capacity Building

There is a need for capacity building and training in drainage and coastal flood management in institutions such as HSD, GhMET, GHA, MLGRD, WRI and other state organisations. In developing spatial plans, there is the need to integrate flood disaster risk reduction measures. There should be effective implementation of duly approved strategies for solid waste collection including plastic waste in the country.

There is a strong need for the establishment of a National Hydrology Authority that will be solely responsible for the planning of the drainage systems, inland and coastal flood management as well as hydrological data collection, analyses and dissemination of information and flood forecasting systems. HSD should be strengthened to carry out the preparation of drainage and coastal plans.

National Policy on Coastal and Flood Plain Settlements

A growing number of communities are currently under risk of flooding due to the rapid urbanisation and population growth. Therefore, in order to address contingencies resulting from extreme hydrological events due to threatening climate change scenarios, a new policy needs to be implemented on coastal and flood plain settlements. Laws are required to stimulate the regional and district authorities to assess the hydrological conditions of the country's current and future water systems and to indicate whether areas are suitable for residential facilities, agriculture etc.

In order to achieve long-term positive impacts from interventions, contingency planning at the grassroots level, in addition to any national frameworks should be a key component of climate compatible development. Community members' unique roles can boost project success and sustained resilience if they are mainstreamed into effective national policy. Harnessing local resources, knowledge and skills should form the baseline of research and project formulation.

Transboundary Initiatives in Flood Management

Most of the initiatives that have taken place on trans-boundary water resources management have not effectively addressed the negative impact of floods in the Northern Savannah Zone. The joint cooperation should be on the management of the shared river basins for the mutual benefits of the concerned countries.

Improvement in Flood Data Collection

Many flood management studies suffer from a lack of data, which can lead to very costly structural failures or wrong decision in planning. There is therefore the need to invest in data collection since this can pay off in the form of more reliable structural and non-structural flood management investment.

Effective Climate Risk Communication

Effective risk communication is of topmost priority for reducing existing constraints that inhibit adaptation of policy development and contingency plans with respect to flood management. Risk communication at the location where the event occurs promotes local ownership of the issues and solutions.

Adaptation Measures to address Flood Risk and Climate Change

Total protection against flooding in flood prone areas cannot be guaranteed as the required investment would not be cost effective. Adaptation measures to address climate change and flood risk will enhance capacity in early warning systems for both coastal and urban floods. In the case of coastal floods, these measures include shoreline protection, beach nourishment, coastal mangrove protection, and preventing construction of immovable structures within shorelines subject to inundation. For urban floods, adaptation measures include avoiding development in waterways, flood-proof building construction and resettlement of emerging peri-urban slum areas.

13.9.3 Financial Investment

Financial resources used for drainage, coastal and northern savannah zone flood management, though very limited, are largely obtained from government sources with very little inflows from external sources. Thus, there is a huge gap in the level of funding required for the sector. Government therefore needs to beef up its investment in the sector, and seek support from private sources through Public Private Partnerships (PPP) and the introduction of drainage funds as the main contributors to this process.

A total investment of $42.7 billion is required to carry out the implementation of drainage, flood control and coastal protection activities during the planning period (Table 14.5).

Table 13.5: Financing Plan for Drainage, Flood Control and Coastal Protection Activities

Item Description	Benefits	Unit Cost ($m)	Total Cost ($m)
1,100 km of primary drains constructed/rehabilitated	Increase drainage capacities to enhance flood conveyance in order to protect lives and property and reduce poverty	0.020/m	22,000.00
2,500 km of secondary drains constructed/rehabilitated	Increase drainage capacities to enhance flood conveyance in order to protect lives and property and reduce poverty	0.007/m	17,500
2,556 ha of flood retention ponds constructed/rehabilitated	Maintain significant flood upstream to attenuate flood downstream and thereby protect lives and property to reduce poverty	0.5/Ha	1,278.00
450 No. of early flood warning stations constructed/rehabilitated	Warn vulnerable communities against flood in order to protect lives and property and reduce poverty	0.3200/station	144.00
10 No. of regional capital drainage master plan prepared	Increase drainage capacities to enhance flood conveyance in order to protect lives and property and reduce poverty	0.40/region	4.00
216 No. of district capital drainage master plans prepared	Increase drainage capacities to enhance flood conveyance in order to protect lives and property and reduce poverty	0.3/district	64.8
216 No. of district flood risk maps prepared	Increase drainage capacities to enhance flood conveyance in order to protect lives and property and reduce poverty	0.01/district	2.16
20 No. of lagoons of 1,000,000m^3 volume of silt dredged	Retain significant flood water when flood coincides with high tide in order to protect lives and property	0.000067 /m^3	1,340.00
120 km of coastal zone protection	Ensure coastal disaster risk reduction and resilience in order to protect lives and property and reduce poverty	0.003/m	360.00
	Total Estimated Cost		**42,692.96**

Chapter 14 Irrigation Infrastructure

14.1 Introduction

In recent times, climate change has made rain-fed agriculture less productive and unsustainable. In Ghana, where majority of the populace depends on agriculture for their livelihoods, irrigation development provides insurance for sustainable agricultural production. Approximately 49% of Ghanaians live in rural areas and depend largely on agriculture for their livelihoods. Agricultural growth is therefore significant to poverty reduction as it can facilitate and drive national economic growth. However, agriculture in the country remains essentially subsistence, rain-fed, and production has not kept pace with population growth leading to food self-insufficiency levels, especially rice and vegetables.

Although irrigation development facilitates poverty reduction and boosts economic growth, the irrigation sub-sector in Ghana remains underdeveloped with only 11.6% of its potential developed. Just about 5% of the area developed for irrigated agriculture falls under public irrigation schemes. This is because investment into public irrigation development has not been adequately pursued. It is therefore imperative that singular focused commitment is made towards irrigation development. This will help sustain food production and consequently, improve incomes and reduce poverty.

14.1.1 Vision

The overarching vision is to "harness the natural resources of water and land to produce enough food to achieve national food and nutrition security, as well as increase foreign exchange through exports by 2047." Irrigation is expected to be a catalyst to drive the development agenda of the agriculture sector due to its potential to speed up economic growth and transformation.

14.2 Irrigation Policy and Institutional Reforms

The Ghana Irrigation Development Authority (GIDA) has the mandate to lead irrigation development in Ghana through policy formulation and implementation of strategies and regulations. However, until recently the irrigation sub-sector has been plagued by ad-hoc government-led strategies and programmes. The sustainable use of irrigation infrastructure has been one of the concerns of policy-makers in the sector. A National Irrigation Policy (Strategies and Regulatory Measures) document promulgated in 2010 by GIDA sought to identify key problem areas that needed to be tackled to ensure accelerated and sustained irrigation development.

GIDA is currently repositioning itself through restructuring and modernisation. It involves a revision of the Authority's mandate and a shift from direct involvement in irrigation implementation and management to the role of sub-sector planner, facilitator, regulator, advisor, supervisor and public service provider. As part of the restructuring, GIDA is implementing irrigation public-private partnerships (PPPs) which provides platforms for private sector participation in irrigation development, operation, management and maintenance. It also includes re-tooling and re-equipping the Authority and training to improve the capacity of staff to deliver the new mandate. The exercise is expected to prepare the Authority adequately to deliver the irrigation development needs of Ghana now and beyond.

The National Irrigation Policy is under review by a team of consultants in view of the change in the Authority's mandate as a result of the modernisation and restructuring of Ghana's irrigation sub-sector. Many institutions collaborate with GIDA in the different stages of project implementation. Table 14.1 stipulates the roles and responsibilities of collaborating partners in the irrigation sub-sector.

Table 14.1: Roles and Responsibilities of Collaborating Institutions

Item	Institution	Role	Responsibility
1	Ghana Irrigation Development Authority	Lead Agency	Lead agency in all irrigation activities in the country. Management of headworks, main canals and bulk water supply
2	MoFA	Collaborating Agency	To provide agricultural inputs/ensure that GIDA benefits from all support services under its remit
3	Financial Institutions: MOFEP, Development Partners (JICA, IFAD, CIDA, WORLD BANK, AfDB etc.)	Collaborating Agency	Funding for new construction and rehabilitations
4	NGOs and Local Banks, Local Government Authorities	Collaborating Agency	Funding for projects and credit to farmers
5	Water User Associations (WUA)	Collaborating Agency	Management of small on-field infrastructure
6	Beneficiary communities, chiefs and Lands Commission	Collaborating Agency	Release of land to undertake projects
7	Environmental Protection Agency	Collaborating Agency	Provision of environmental permits
8	Media	Collaborating Agency	Public education on irrigation
9	Consultants	Collaborating Agency	Studies, design and construction
10	Water Resources Commission	Collaborating Agency	Granting of permits for water abstraction for irrigation
11	Ministry of Local Government and Rural Development	Collaborating Agency	To promote adherence to standard water management practices by individual irrigators and community managed schemes
12	Ghana Investment Promotion Centre	Collaborating Agency	Promote investor participation in irrigation through PPP arrangements
13	Registrar Generals Department	Collaborating Agency	Registration of WUA's
14	Ministry of Trade and Industry	Collaborating Agency	Linkage to foreign markets and investors

Source: Author's construct

14.3 Current Status of the Irrigation Sub-Sector

Ghana has a total land area of 23.9 million hectares. Out of this number, the cultivable land area is estimated to be 13.6 million hectares. The irrigable potential is 1.9 million hectares but only 221,000 hectares (11.6%) have been developed by both public and private sectors, leaving over 88% of the potential untapped. The level of irrigation development in the country is rather negligible compared to international coverage and even corresponding figures for other developing Sub-Saharan African countries.

In Ghana, irrigation infrastructure is categorised into formal, informal and commercial. Presently only about 11,000 hectares of the irrigable land is funded by the public or formal sector. Small scale informal irrigation accounts for 189,000 hectares while commercial irrigation accounts for the remaining 21,000 hectares. There are 56 public irrigation schemes distributed throughout the various regions of Ghana.

14.3.1 Informal Irrigation

This may be defined as irrigation practised by individuals who cultivate an area of up to about 0.5 hectares or more by using simple structures and equipment for water storage, conveyance and distribution. Capital investments are relatively very small and are provided from the farmer's own resources. Currently, informal schemes that do not depend on public infrastructure for their water supplies account for the bulk of irrigation in Ghana. In most cases, manual fetching of water with watering cans and buckets is dominant, while motorised pumps and hoses are also used along streams and reservoirs. This category of irrigators has not received adequate attention from GIDA in the past although it is much larger than the formal arrangements. This is because the mandate of GIDA was limited to public irrigation schemes.

Informal irrigation may also comprise traditional and community initiated schemes which are typified by the cultivation of about 2,000 hectares of shallots and other vegetables in the south-eastern coastline of Ghana, cultivation around the hundreds of small reservoirs in the north, in inland valleys, groundwater irrigation e.g. near Bawku and irrigated urban and peri-urban agriculture. Although there is little data on the overall extent of informal irrigation in the country, it was established that around Kumasi alone, there are at least 12,700 smallholders irrigating 11,900 hectares in the dry season, which is close to the area currently functioning under formal irrigation in the whole of the country. A particular concern affecting many urban and peri-urban farmers is the lack of reliable land tenure and safe water sources in and around the cities.

14.3.2 Formal Irrigation

Formal irrigation may be defined as one that is reliant on some form of permanent irrigation infrastructure funded by the public sector. The development of formal irrigation schemes in Ghana dates back to the 1960s. In 2003, GIDA had 22 irrigation schemes under its jurisdiction covering about 14,700 hectares of which 60% were developed and about 9,000 hectares actually put under irrigation. However, currently under the formal irrigation sector, GIDA has 56 irrigation schemes covering about 12,000 hectares as indicated in Table 14.2. On many of the schemes, the rates of utilisation are low due to poor operation and maintenance of the facilities and also due to frequent electrical power disconnection.

Table 14.2: Formal Irrigation Schemes

No.	Schemes	Potential Area (ha)	Area Developed (ha)	Area Irrigated (ha)	Irrigation Type	Target Crop
1	Ashaiman	155	155	77	Gravity-type	Rice and vegetables
2	Dawhenya	450	450	200	Gravity & pump	Rice/ vegetables
3	Kpong	3452	3028	2786	Gravity-type	Rice and vegetables
4	Weija	220	220	220	Pump-type	Vegetables
5	Weta	950	880	880	Gravity-type	Rice/ vegetables
6	Aveyime	120	60	60	Gravity & pump-type	Rice
7	Kpando Torkor	356	40	40	Pump-type	Vegetables
8	Mankessim	260	17	17	Pump-type	Vegetables
9	Okyereko	111	81	81	Gravity & pump-type	Rice
10	Subinja	121	60	60	Pump-type	Vegetables
11	Tanoso	115	64	64	Pump-type	Vegetables
12	Sata	56	34	25	Gravity-type	Vegetables
13	Akumadan	1000	120	120	Pump-type	Vegetables
14	Anum Valley	140	89	52	Gravity & pump-type	Rice
15	Amate	203	101	0	Pump-type	-
16	Dedeso	400	20	0	Pump	Vegetables
17	Kikam	27	27	0	Gravity & pump	Rice
18	Bontanga	800	450	390	Gravity	Rice and vegetables
19	Golinga	100	40	16	Gravity	Rice and vegetables
20	Libga	22	16	16	Gravity	Rice/ vegetables
21	Tono	3860	2490	1300	Gravity	Rice and vegetables
22	Vea	1197	850	227	Gravity	Rice and vegetables
23	Tokpo	90	60	60	Pump/Gravity	Vegetables
24	Ada	120	103	103	Pump/Gravity	Vegetables
25	Dodoekope	200	110	110	Pump/Gravity	Vegetables
26	Volo	80	60	60	Pump/Gravity	Vegetables
27	Tordzinu	4	4	4	Pump	Vegetables
28	Koloe-Danyi	30	30	30	Pump	Vegetables
29	Agorveme	110	107	107	Pump/Gravity	Rice/ Vegetables
30	Kolor	138	138	138	Pump/Gravity	Rice/ Vegetables
31	Ekotsi	30	30	30	Pump	Vegetables
32	Baafikrom	6	4	4	Pump	Vegetables
33	Moseaso	81	48	48	Pump	Vegetables
34	Aponapon	83	50	50	Pump	Vegetables
35	Adiembra	65	45	45	Pump	Vegetables
36	Kokroko	66	66	66	Pump	Vegetables
37	Kaniago	66	60	66	Gravity	Vegetables
38	Akurobi	55	55	55	Pump	Vegetables
39	Nobeko	60	60	60	Pump	Vegetables
40	Asuoso	10	10	10	Pump	Vegetables
41	New Longoro	220	120	120	Gravity	Rice Vegetables
42	Asantekwa	143	88	88	Pump/Gravity	Rice/ Vegetables
43	Buipe	110	75	75	Pump	Rice/ Vegetables
44	Yapei	194	128	128	Pump	Rice/ Vegetables
45	Wambong	6	4	4	Pump/Gravity	Vegetables

No.	Schemes	Potential Area (ha)	Area Developed (ha)	Area Irrigated (ha)	Irrigation Type	Target Crop
46	Karimenga	6	6	6	Pump/Gravity	Vegetables
47	Dipale	148	114	114	Pump/Gravity	Rice/ Vegetables
48	Sogo	125	84	84	Pump/Gravity	Rice
49	Dinga	90	90	90	Pump/Gravity	Rice
50	Baare	12	12	12	Gravity	Vegetables
51	Goog	186	100	100	Gravity	Vegetables
52	Tiegu-Yarugu	150	126	126	Pump/Gravity	Vegetables
53	Sing Bakpong	56	35	35	Gravity	Rice
54	Belebor	120	80	80	Gravity	Rice
55	Tizza	76	50	50	Gravity	Rice/ Vegetables
56	Jawia	30	20	20	Gravity	Rice/ Vegetables
Total		**17081**	**11464**	**8809**		

Source: GIDA

14.3.3 Large Scale Commercial Irrigation

This category of irrigation falls under both formal and informal categories. Large scale commercial irrigation is formal when government provides the headworks, conveyance and primary distribution infrastructure, while the private investor provides secondary distribution and water application machinery and equipment. On the other hand, under the informal sub-sector, the headworks and the rest of the infrastructure, machinery, and equipment are provided by the private investor. Large scale commercial irrigation is usually export-oriented and comprises farm sizes of between 25 hectares and 1,000 hectares or more. High value fruits and vegetables are usually the main crops cultivated.

Table 14.3: Large Scale Commercial Irrigation Farms

No	Schemes	Area developed (ha)	Area irrigated (ha)	Irrigation system	Crops produced
1	Golden Exotic Ltd.	1,200	1,200	Drip System	Banana
2	IWAD	250	45	Pressurised system	Assorted crops
3	VEGPRO Limited	250	205	Centre pivot	Baby corn, vegetables
4	Brazil Agro Business Group	250	250	Pump and gravity	Rice
5	Solar Harvest	750	100	Centre pivot	Maize, other crops
6	Jokopan Farms	13	13	Pump & gravity	Vegetables
7	Thai Farms	80	80	Pump & gravity	Rice
8	Prairie Volta Ltd	250	250	River pumping	Rice
9	Mawuko Farms	15	15	Pump & gravity	Vegetables
10	GADCO/WIENCO	1,200	1,200	River pumping	Rice
11	Sanford Enterprise	300	300	River pumping	Maize, other crops
12	CAISSIE Farms	300	300	River pumping	Maize, vegetable
13	AgDEVCo	5,359	225	River pumping	Maize, other crops
14	Anyako Farms	500	100	River pumping	Maize, rice

Source: GIDA

14.4 Strategic Relevance of Irrigation

14.4.1 Economic Growth

Agricultural Water Management (AWM) and irrigation development spur economic growth by enabling all-year-round production of crops, increased crop intensification and diversification. All-year-round food availability reduces food inflation and food imports. Reduction of food imports increases the country's ability to save foreign exchange for use in the development of other sectors of the economy. Additionally, irrigation allows adoption of improved technologies such as high yielding varieties and fertilizers, leading to increased outputs, incomes, lowering of food prices and thus improvement in real net incomes.

Another major contribution of the sub-sector is the generation of direct and indirect employment of thousands of people along the irrigation value chain. It has the added advantage of improving food security, reducing climate change impacts and stemming rural-urban migration. Indeed, irrigation is known to reduce rural poverty. According to the World Bank, US$1.00 investment in irrigation is capable of generating US$5.00 in return[79].

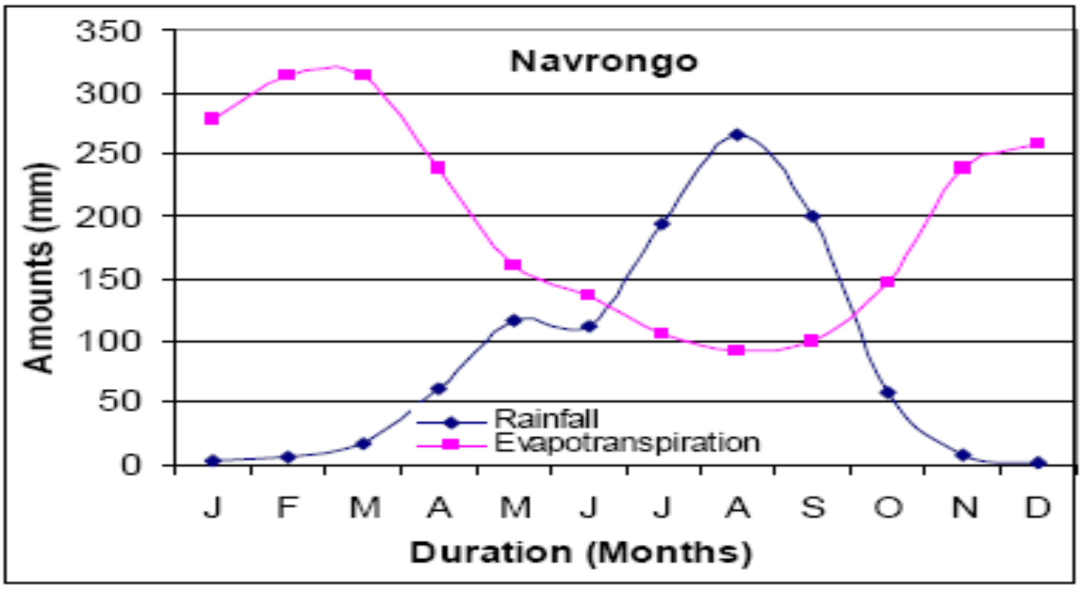
14.4.2 Food Security

Agriculture production in Ghana has been growing since independence but improvement in terms of factors of productivity such as land and labour has been very insignificant. Agricultural growth in general over this period has been largely achieved through bringing more land under cultivation with minimal increase in productivity of the land. However, arable land is shrinking and there is strong competition from non-agriculture uses. Agricultural growth could not keep pace with rapid population growth over the past 60 years.

Ghana's population has quadrupled since independence from 6.7 million to 27.043 million by 2014 according to MoFA and the population continues to grow. Yet the production of most staple foods, e.g., cereals, has lagged population growth significantly, making Ghana a net importer of these food crops. Moreover, population growth corresponds to shrinkage of the available agricultural lands as more cultivable lands are converted to estates. The danger is that food insecurity becomes even more pronounced as climate change impacts results in water shortages. The savannah and the transitional agro-ecological zones which experience unimodal rainfall and water deficits during major part of the year do not permit all-year-round agriculture (Figures 14.1-14.3). These conditions provide a setting for agricultural intensification which can best be realised presently under irrigation and AWM.

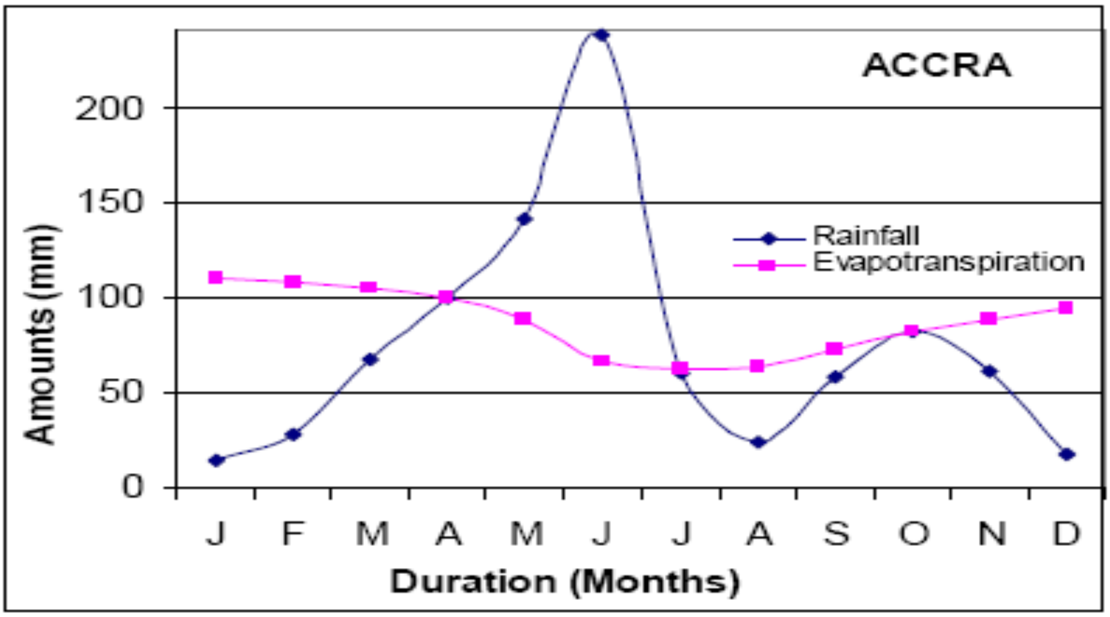
[79] United Nations World Water Assessment Programme, 2015

Figure 14.1: Rainfall and Evapotranspiration in the Northern Savannah Agro-Ecological Zone (Navrongo Synoptic Station)



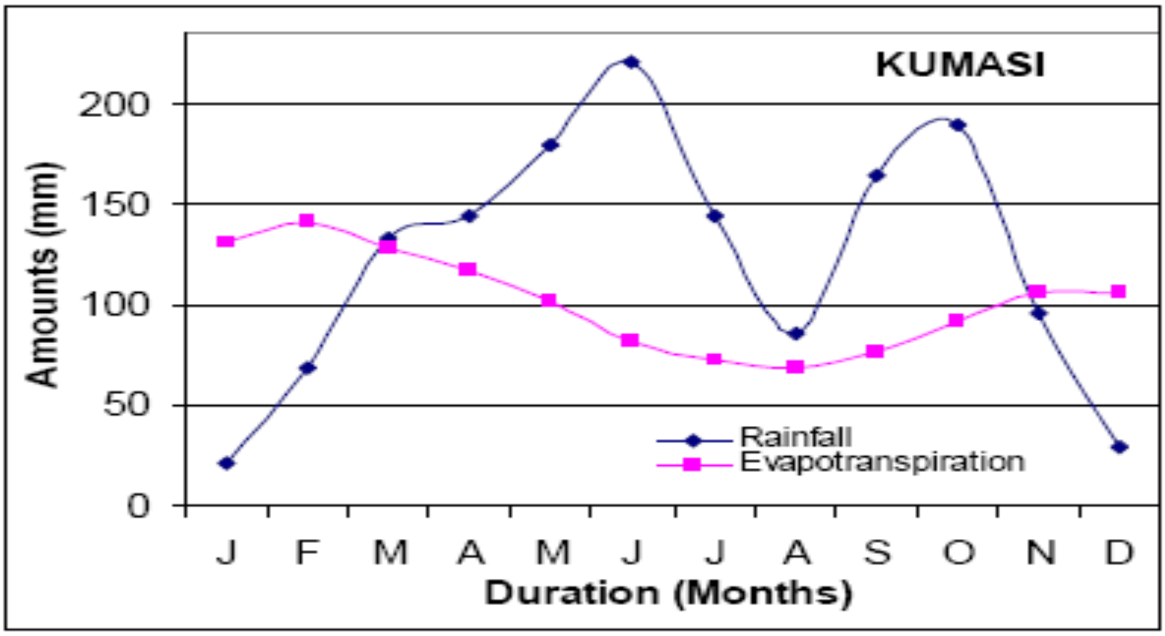
Source: GIDA

Figure 14.2: Rainfall and Evapotranspiration in the middle belt (Kumasi Synoptic Station)



Source: GIDA

Figure 14.3: Rainfall and Evapotranspiration in the Southern Savannah Agro-Ecological Zone (Accra Synoptic Station)



Source: GIDA

14.4.3 Climate Change

Climate change is any noticeable change in weather indicators including rainfall and temperature at a particular location over a period of time. It is one of the greatest environmental, social and economic threats that the world faces today. In Ghana, climate change is manifested as increasing temperatures, changing rainfall patterns, increased incidence of drought and floods, pests and disease build up, disasters and migration. These factors combine with increasing population to pose a threat to food security. Irrigation is a smart agricultural technology that is needed in arid and semi-arid zones of the country. It is an adaptation measure that is necessary to deal with climate change impacts on the agricultural sector through the use of efficient water management and distribution systems such as drip systems.

14.5 Irrigation Potential and Infrastructure Baseline

14.5.1 Overview of Land Availability

On a regional basis, numerous irrigation sites of various sizes were identified and catalogued. In all, a total irrigable area of about 1.9 million ha is available to grow various food and cash crops, e.g. yam, maize, rice, cassava, cocoyam, millet, sorghum, plantain, vegetables (tomato, pepper, okra, eggplant, onion), fruit crops (pineapple, citrus, banana, cashew, pawpaw and mangoes), and industrial crops (e.g. oil palm, cocoa, coconut, coffee, cotton, kola, and rubber). For the GIP, 32 feasible sites of various sizes are presented for development for the 30 year period.

Currently, lands already acquired for irrigation development are heavily encroached upon and in some instances military forces were used to eject the squatters. Legislation is required to deal with land acquisition for irrigation purposes to promote smooth development of irrigation in the country.

14.5.2 Overview of Existing Water Resources

Surface Water Sources (Rivers and Runoff)

Total annual runoff (TAR) is about 54.4 billion m^3. However, this varies from year to year and from season to season. This, if harnessed properly into retention structures, will greatly improve Ghana's irrigation potential. By construction of the listed projects, some of which will come with big dams and weirs, the storage of these runoffs will be assured and harnessed for irrigation.

Ghana also abounds in many perennial rivers and has 5 major basins, some of which are transboundary in nature. About 30% of TAR is from outside the country. Ghana shares the Volta, Tano and Bia rivers and groundwater aquifers with her neighbours. The outflow from the Kpong generation plant is about 1,200m^3/sec and this is targeted for the Accra Plains Irrigation Project on the right bank and for other relatively smaller projects at the other bank. The total water abstraction out of total surface freshwater resources is currently only about 13% of the total annual runoff. Ghana's water resources are largely underdeveloped. Climate change and climate variability is making the natural flow of water in the river channels highly variable. Fresh water regimes have been modified by climate change and time of occurrence. Annual precipitation is now highly unpredictable whilst annual volumes remain almost the same.

Ground Water Sources

Groundwater is available in various geological locations in the country. According to Water Resources Commission average yields are between 6 – 180 cubic meters/hr. Potential for groundwater use for irrigation abounds in the Upper East and Upper West Regions and the southern strip of the Volta Region while it is very difficult getting good yields for irrigation in the Northern Region. In the rest of the regions, surface water abounds and is cheaper than exploiting ground water for irrigation.

14.5.3 Markets and Ancillary Infrastructure

The irrigated crop production value chain is incomplete if the produce does not get to the final consumer. It is important that ancillary infrastructure is provided for all irrigation areas to sustain production. Such ancillary infrastructure includes cold transportation and storage facilities, drying patios, processing facilities such as rice mills, access roads, electricity, potable water etc. Currently, these infrastructure are lacking on most public schemes.

14.6 Ghana's Irrigation Development Framework

GIDA has a high level of irrigation technology with multi-disciplinary professional staff in the fields of project management, design and construction of dams/irrigation facilities, tube wells, fish ponds etc. There is also cheap labour as a result of free movement of people from one part of the country to another. Moreover, the establishment of agriculture mechanisation centres in each district nationwide plus government's fertilizer subsidy programme are expected to lower cost of production and boost crop yields and enhance the drive towards self-sufficiency. Besides the huge local market for cereals and vegetables which can easily be cultivated under irrigation, the West African sub-region, which has a population of 300 million people, presents another vast market for prospective investors. Additionally, the European market which is only about 6 hours from Ghana by air adds to the opportunities for expanding irrigated agriculture in the country.

14.6.1 Increase Rice Production under Irrigation

Rice is one of the most important food crops in Ghana and its consumption is increasing steadily due to population growth coupled with rapid urbanisation and changing food habits. According to a MoFA report in 2015, over a ten year period, from 2005 to 2014, Ghana imported a total of 4.53 million tonnes of rice valued at US$ 2.4 billion and this figure is projected to continue increasing. Consequently, it is projected that by 2046, Ghana's rice demand would be approximately 3 million metric tonnes which is estimated to cost US$ 1.6 billion per annum.

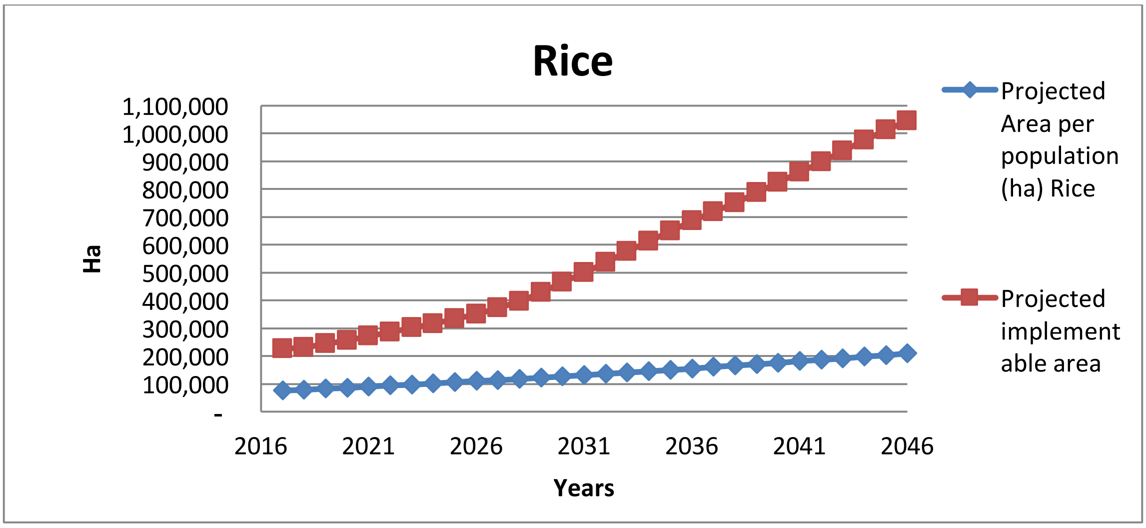
Much of the rice consumed currently is imported. This constitutes a substantial drain on the country's foreign exchange earnings which could have been used in development of other sectors of the economy. Yet increased and sustained local rice production of high quality will conveniently result in import substitution of rice and save foreign exchange. Currently just about 15 percent of the net rice consumption is produced under irrigated and agriculture water management ecologies. However, irrigation and agriculture water management ecologies have a major stake in progressively increasing rice production towards self-sufficiency level and possibly reversing the import trend. Ghana's huge irrigation potential together with suitable soils for rice production and availability of local markets make the prospects of irrigated rice production bright. Rice production under AWM and irrigated conditions is expected to gradually contribute to local consumption and progressively peak at about 70 percent of total local consumption by 2046 (Table 14.4 and Figure 14.4).

Table 14.4: Projected 70% Rice Demand and Cultivation under Irrigation

RICE (70% under Irrigation) 2X /year					70%
Year	**Projected Area (ha) Rice**	**Quantity of Rice to be produced under Irrigation (Mt)**	**Physical Targeted area (ha)**	**Projected implementable area (ha)**	**Difference in area (ha)**
2016			221,000.00	221,000.00	Existing irrigable area (ha)
2017	75,083.03	375,415.15	5,049.500	226,049.50	150,966.47
2018	78,597.65	392,988.24	5,282.500	231,332.00	152,734.35
2019	82,191.74	410,958.68	12,116.786	243,448.79	161,257.05
2020	85,865.29	429,326.47	12,406.786	255,855.57	169,990.28
2021	89,618.32	448,091.62	15,035.952	270,891.52	181,273.20
2022	93,450.82	467,254.12	14,635.952	285,527.48	192,076.65
2023	97,362.79	486,813.97	14,965.119	300,492.60	203,129.80
2024	101,354.24	506,771.18	14,965.119	315,457.71	214,103.48
2025	105,425.15	527,125.74	17,160.346	332,618.06	227,192.91
2026	109,575.53	547,877.65	17,160.346	349,778.41	240,202.88
2027	113,805.38	569,026.91	23,214.513	372,992.92	259,187.54
2028	118,114.71	590,573.53	23,854.513	396,847.43	278,732.73
2029	122,503.50	612,517.50	31,948.957	428,796.39	306,292.89
2030	126,971.76	634,858.82	35,073.957	463,870.35	336,898.58
2031	131,519.50	657,597.50	35,948.957	499,819.31	368,299.81
2032	136,146.71	680,733.53	37,001.100	536,820.41	400,673.70
2033	140,853.38	704,266.91	37,233.600	574,054.01	433,200.62
2034	145,639.53	728,197.65	37,788.600	611,842.61	466,203.08
2035	150,505.15	752,525.74	37,016.100	648,858.71	498,353.56
2036	155,450.24	777,251.18	37,016.100	685,874.81	530,424.57
2037	160,474.79	802,373.97	32,016.100	717,890.91	557,416.11
2038	165,578.82	827,894.12	32,016.100	749,907.01	584,328.18
2039	170,762.32	853,811.62	36,731.934	786,638.94	615,876.62
2040	176,025.29	880,126.47	36,731.934	823,370.87	647,345.58
2041	181,367.74	906,838.68	35,981.934	859,352.81	677,985.07
2042	186,789.65	933,948.24	37,636.934	896,989.74	710,200.09
2043	192,291.03	961,455.15	38,709.434	935,699.18	743,408.15
2044	197,871.88	989,359.41	38,709.434	974,408.61	776,536.73
2045	203,532.21	1,017,661.03	37,042.767	1,011,451.38	807,919.17
2046	209,272.00	1,046,360.00	32,310.624	1,043,762.00	834,490.00
Total			**822,762**		

Source: Author's construct

Figure 14.4: Projected Rice Cultivation and Total Acreage Development



Source: Author's construct

14.6.2 Exportable Vegetable and Fruit Production under Irrigation

Ghana currently exports pineapples and bananas to the European market but imports most vegetables including tomato, onions, ginger, carrots and cabbage. Yet there is enormous opportunity to increase local production of vegetables and fruits for export. Ghana consumes huge amounts of tomato, both fresh or canned, but local production does not meet demand hence 75,000 metric tonnes of fresh tomato was imported to supplement domestic production in 2013. Additionally, 78,000 metric tonnes of tomato paste valued at US$ 112.1 million was imported in the same year to meet demand according to research[80].

Notwithstanding deficit in supply, cultivation of tomato in the rainy season is associated with as high as 30 percent post-harvest losses, equivalent to over 510,000 metric tonnes of fresh tomato. It can be deduced that scarcity in tomato supply is a seasonal challenge which may not be a major issue if the crop were cultivated under irrigation. The favourable soil and climatic conditions coupled with high market demand (input and output) of vegetables provide excellent opportunity for growing these horticultural crops under irrigation. Tables 14.5 and 14.6 present the projected vegetable and fruit demand respectively that must be put under irrigation during the plan period. Also, Figures 14.5 and 14.6 present the projected vegetable and fruit cultivation in terms of total acreage development respectively for the plan period.

Table 14.5: Projected 70% Vegetable Demand Cultivation under Irrigation

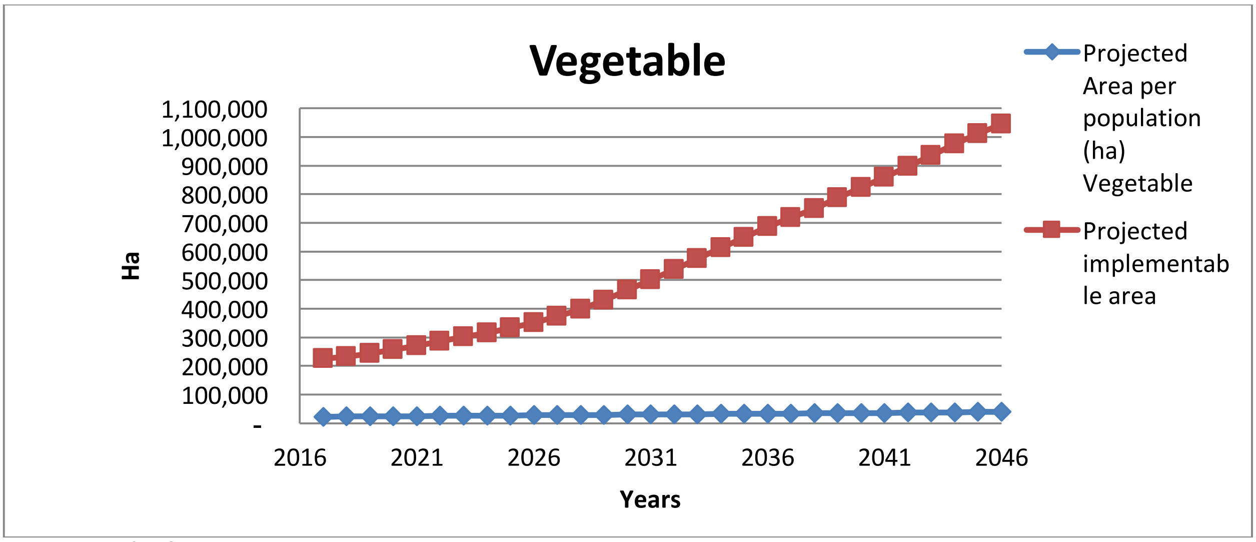
Vegetable (70% under Irrigation) 3X per year					70%
Year	**Projected Area for yearly demand (ha) Vegetable**	**Tonnage of Vegetable required (Mt)**	**Physical Targeted area (ha)**	**Projected implementable area (ha)**	**Difference in area (ha)**
2016			221,000.00	221,000.00	Existing irrigable area (ha)
2017	22,303.92	111,519.61	5,049.50	226,049.50	203,745.58
2018	22,875.82	114,379.08	5,282.50	231,332.00	208,456.18
2019	23,447.71	117,238.56	12,116.79	243,448.79	220,001.07
2020	24,019.61	120,098.04	12,406.79	255,855.57	231,835.96
2021	24,591.50	122,957.52	15,035.95	270,891.52	246,300.02
2022	25,163.40	125,816.99	14,635.95	285,527.48	260,364.08
2023	25,735.29	128,676.47	14,965.12	300,492.60	274,757.30
2024	26,307.19	131,535.95	14,965.12	315,457.71	289,150.52
2025	26,879.08	134,395.42	17,160.35	332,618.06	305,738.98
2026	27,450.98	137,254.90	17,160.35	349,778.41	322,327.43
2027	28,022.88	140,114.38	23,214.51	372,992.92	344,970.04
2028	28,594.77	142,973.86	23,854.51	396,847.43	368,252.66
2029	29,166.67	145,833.33	31,948.96	428,796.39	399,629.72
2030	29,738.56	148,692.81	35,073.96	463,870.35	434,131.79
2031	30,310.46	151,552.29	35,948.96	499,819.31	469,508.85
2032	30,882.35	154,411.76	37,001.10	536,820.41	505,938.05
2033	31,454.25	157,271.24	37,233.60	574,054.01	542,599.76
2034	32,026.14	160,130.72	37,788.60	611,842.61	579,816.46
2035	32,598.04	162,990.20	37,016.10	648,858.71	616,260.67
2036	33,169.93	165,849.67	37,016.10	685,874.81	652,704.87
2037	33,741.83	168,709.15	32,016.10	717,890.91	684,149.08
2038	34,313.73	171,568.63	32,016.10	749,907.01	715,593.28

[80] Boachie-Danquah B. and I. Sulaiman (2015). Ghana's Tomato Processing Industry: An Attractive Investment Option in 2016.

2039	34,885.62	174,428.10	36,731.93	786,638.94	751,753.32
2040	35,457.52	177,287.58	36,731.93	823,370.87	787,913.36
2041	36,029.41	180,147.06	35,981.93	859,352.81	823,323.40
2042	36,601.31	183,006.54	37,636.93	896,989.74	860,388.43
2043	37,173.20	185,866.01	38,709.43	935,699.18	898,525.97
2044	37,745.10	188,725.49	38,709.43	974,408.61	936,663.51
2045	38,316.99	191,584.97	37,042.77	1,011,451.38	973,134.38
2046	38,888.89	194,444.44	32,310.62	1,043,762.00	1,004,873.11
Total			**822,762**		

Source: Author's construct

Figure 14.5: Projected Vegetable Cultivation and Total Acreage Development



Source: Author's construct

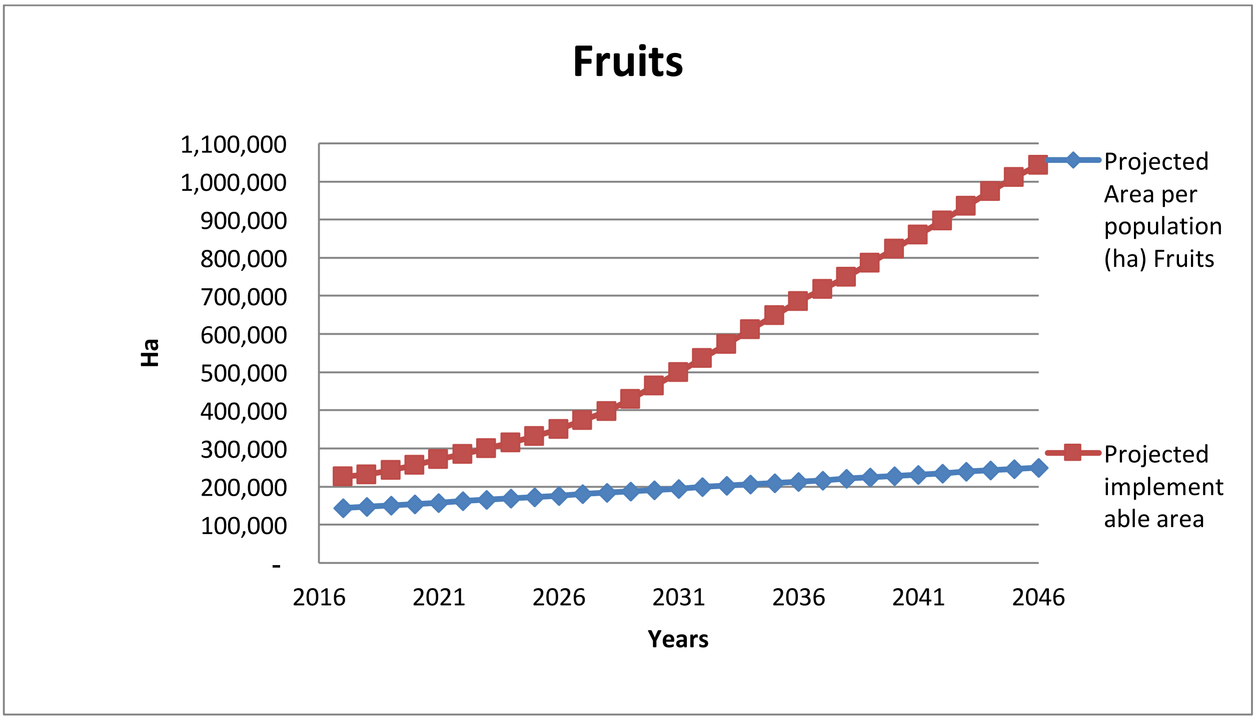
Table 14.6: Projected 50% Fruit Demand Cultivation under Irrigation

Fruits , 50% under Irrigation, 1X per year					50%
Year	**Projected Area for yearly demand (ha) Fruits**	**Tonnage of Fruits required (Mt)**	**Physical Targeted area (ha)**	**Projected implementable area (ha)**	**Difference in area (ha)**
2016			221,000.00	221,000.00	Existing irrigable area (ha)
2017	143,382.35	716,911.76	5,049.50	212,049.50	68,667.15
2018	147,058.82	735,294.12	5,282.50	217,332.00	70,273.18
2019	150,735.29	753,676.47	12,116.79	229,448.79	78,713.49
2020	154,411.76	772,058.82	12,406.79	241,855.57	87,443.81
2021	158,088.24	790,441.18	15,035.95	256,891.52	98,803.29
2022	161,764.71	808,823.53	14,635.95	271,527.48	109,762.77
2023	165,441.18	827,205.88	14,965.12	286,492.60	121,051.42
2024	169,117.65	845,588.24	14,965.12	301,457.71	132,340.07
2025	172,794.12	863,970.59	17,160.35	318,618.06	145,823.94
2026	176,470.59	882,352.94	17,160.35	335,778.41	159,307.82
2027	180,147.06	900,735.29	23,214.51	358,992.92	178,845.86
2028	183,823.53	919,117.65	23,854.51	382,847.43	199,023.90
2029	187,500.00	937,500.00	31,948.96	414,796.39	227,296.39
2030	191,176.47	955,882.35	35,073.96	449,870.35	258,693.88
2031	194,852.94	974,264.71	35,948.96	485,819.31	290,966.36
2032	198,529.41	992,647.06	37,001.10	522,820.41	324,290.99
2033	202,205.88	1,011,029.41	37,233.60	560,054.01	357,848.12
2034	205,882.35	1,029,411.76	37,788.60	597,842.61	391,960.25

2035	209,558.82	1,047,794.12	37,016.10	634,858.71	425,299.88
2036	213,235.29	1,066,176.47	37,016.10	671,874.81	458,639.51
2037	216,911.76	1,084,558.82	32,016.10	703,890.91	486,979.14
2038	220,588.24	1,102,941.18	32,016.10	735,907.01	515,318.77
2039	224,264.71	1,121,323.53	36,731.93	772,638.94	548,374.23
2040	227,941.18	1,139,705.88	36,731.93	809,370.87	581,429.70
2041	231,617.65	1,158,088.24	35,981.93	845,352.81	613,735.16
2042	235,294.12	1,176,470.59	37,636.93	882,989.74	647,695.62
2043	238,970.59	1,194,852.94	38,709.43	921,699.18	682,728.59
2044	242,647.06	1,213,235.29	38,709.43	960,408.61	717,761.55
2045	246,323.53	1,231,617.65	37,042.77	997,451.38	751,127.85
2046	250,000.00	1,250,000.00	32,310.62	1,029,762.00	779,762.00
Total			**822,762.00**		

Source: Author's construct

Figure 14.6: Projected Fruit Cultivation and Total Acreage Development



Source: Author's construct

14.6.3 Production of Grains under Irrigation

Maize is the most important food staple in Ghana and its consumption is increasing. Over the past decade, Ghana imported over 280,000 metric tonnes of maize valued at US$ 60.22 million. However, Ghana has the potential to produce maize and any of the other grains such as sorghum, millet, cowpea and groundnuts under irrigation. Being among the most important staples in Ghana, grains have huge markets and can easily be cultivated under irrigated conditions. Moreover, the establishment of agriculture mechanisation centres throughout the districts and the government fertilizer input subsidy programme will ensure increased cropping intensity and higher yields to over 5 metric tonnes per hectare for maize, 4.5 metric tonnes for soy beans, and 3 metric tonnes for groundnut and cowpea to take advantage of the huge local market for these grains.

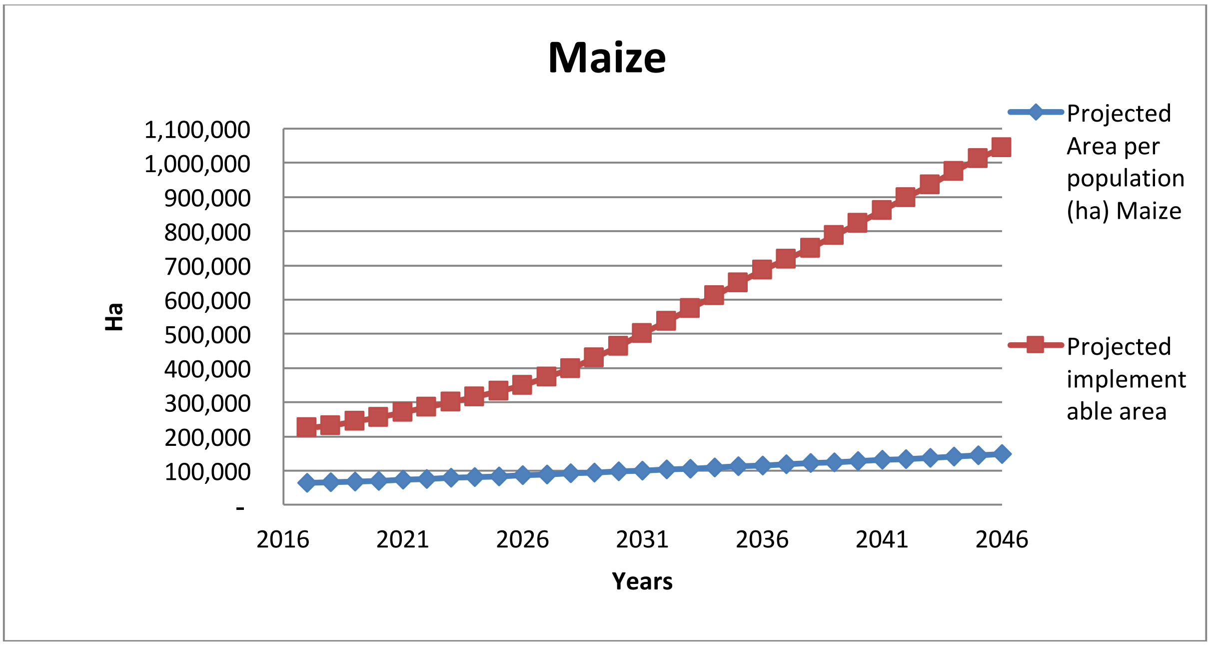
Conversely, cultivation of these grains under irrigation transforms low-energy extensive cultivation to high-energy levels and makes it possible to use improved varieties of the grains, and increased use of fertilizers and agro-chemicals that bring about increased cropping intensity and higher yields. Table 14.7 presents the projected maize demand that must be put under irrigation during the plan period. Also, Figure 14.7 presents the projected maize cultivation in terms of total acreage development for the plan period.

Table 14.7: Projected 50% Maize Demand Cultivation under Irrigation

MAIZE (50% under Irrigation) 2X per year					50%
Year	**Projected Area for yearly demand (ha) Maize**	**Tonnage of Maize to be produced under Irrigation (Mt)**	**Physical Targeted area (ha)**	**Projected implementable area (ha)**	**Difference in area (ha)**
2016			221,000.00	221,000.00	Existing irrigable area (ha)
2017	63,768.37	350,726.04	5,049.500	226,049.50	162,281.13
2018	66,152.46	363,838.54	5,282.500	231,332.00	165,179.54
2019	68,574.00	377,157.02	12,116.786	243,448.79	174,874.78
2020	71,032.99	390,681.47	12,406.786	255,855.57	184,822.58
2021	73,529.44	404,411.90	15,035.952	270,891.52	197,362.09
2022	76,063.33	418,348.30	14,635.952	285,527.48	209,464.15
2023	78,634.67	432,490.68	14,965.119	300,492.60	221,857.93
2024	81,243.46	446,839.04	14,965.119	315,457.71	234,214.25
2025	83,889.70	461,393.37	17,160.346	332,618.06	248,728.36
2026	86,573.40	476,153.68	17,160.346	349,778.41	263,205.01
2027	89,294.54	491,119.97	23,214.513	372,992.92	283,698.38
2028	92,053.13	506,292.23	23,854.513	396,847.43	304,794.30
2029	94,849.18	521,670.47	31,948.957	428,796.39	333,947.21
2030	97,682.67	537,254.68	35,073.957	463,870.35	366,187.68
2031	100,553.61	553,044.87	35,948.957	499,819.31	399,265.69
2032	103,462.01	569,041.04	37,001.100	536,820.41	433,358.40
2033	106,407.85	585,243.18	37,233.600	574,054.01	467,646.16
2034	109,391.15	601,651.30	37,788.600	611,842.61	502,451.46
2035	112,411.89	618,265.39	37,016.100	648,858.71	536,446.82
2036	115,470.08	635,085.46	37,016.100	685,874.81	570,404.72
2037	118,565.73	652,111.51	32,016.100	717,890.91	599,325.18
2038	121,698.82	669,343.53	32,016.100	749,907.01	628,208.18
2039	124,869.37	686,781.53	36,731.934	786,638.94	661,769.57
2040	128,077.37	704,425.51	36,731.934	823,370.87	695,293.51
2041	131,322.81	722,275.46	35,981.934	859,352.81	728,030.00
2042	134,605.71	740,331.39	37,636.934	896,989.74	762,384.03
2043	137,926.05	758,593.29	38,709.434	935,699.18	797,773.12
2044	141,283.85	777,061.17	38,709.434	974,408.61	833,124.76
2045	144,679.10	795,735.03	37,042.767	1,011,451.38	866,772.28
2046	148,111.79	814,614.86	32,310.624	1,043,762.00	895,650.21
Total			**822,762.00**		

Source: Author's construct

Figure 14.7: Projected Maize Cultivation and Total Acreage Development



Source: Author’s construct

14.6.4 Production of Sugarcane under Irrigation

Ghana imported 4,883 million tonnes of sugar over the past ten years with last year’s import of 412,000 tons valued at US$ 217 million according to Index Mundi. This means that an estimated US$ 2.6 billion was spent on sugar imports over the past 10 years and this is a major drain on the economy of the country. Being a tropical crop, the Ghanaian environment presents a conducive atmosphere for sugarcane production. Basic climatic conditions necessary for controlled cane growth, yield and quality are long warm growing temperatures with high incidence of solar radiation, adequate moisture, and a long sunny and cool season for ripening and harvesting. To add to these, high humidity of 80-85 percent favours rapid cane extension with moderate values of 45-65 percent together with limited water supply needed at the ripening phase. These conditions together with an irrigated environment present the northern half of the country as the most suitable location for sugarcane production.

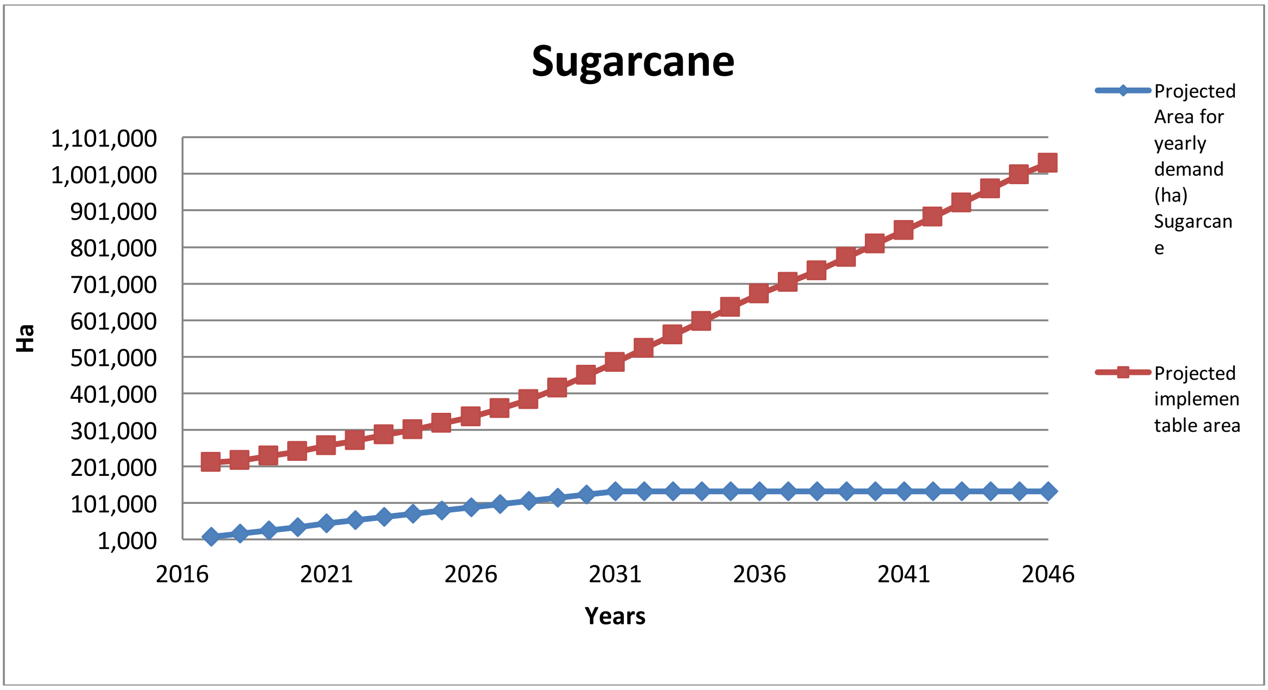
Table 14.8 presents the projected sugarcane demand that must be put under irrigation during the plan period. Also, Figure 14.8 presents the projected sugarcane cultivation in terms of total acreage development for the plan period. Also, the projected individuals crops curves and total acreage development is presented in Figure 14.9.

Table 14.8: Projected Sugarcane Demand Cultivation under Irrigation (100%)

Sugarcane (100% under Irrigation) 1X per year				100%
Year	**Projected Area for yearly demand (ha) Sugarcane**	**Physical Targeted area (ha)**	**Projected implementable area (ha)**	**Difference in area (ha)**
2016			207,000.00	Existing irrigable area (ha)
2017	8,933.33	5,049.50	212,049.50	203,116.17
2018	17,866.67	5,282.50	217,332.00	199,465.33
2019	26,800.00	12,116.79	229,448.79	202,648.79
2020	35,733.33	12,406.79	241,855.57	206,122.24
2021	44,666.67	15,035.95	256,891.52	212,224.86
2022	53,600.00	14,635.95	271,527.48	217,927.48
2023	62,533.33	14,965.12	286,492.60	223,959.26
2024	71,466.67	14,965.12	301,457.71	229,991.05
2025	80,400.00	17,160.35	318,618.06	238,218.06
2026	89,333.33	17,160.35	335,778.41	246,445.07
2027	98,266.67	23,214.51	358,992.92	260,726.25
2028	107,200.00	23,854.51	382,847.43	275,647.43
2029	116,133.33	31,948.96	414,796.39	298,663.06
2030	125,066.67	35,073.96	449,870.35	324,803.68
2031	133,333.33	35,948.96	485,819.31	352,485.97
2032	133,333.33	37,001.10	522,820.41	389,487.07
2033	133,333.33	37,233.60	560,054.01	426,720.67
2034	133,333.33	37,788.60	597,842.61	464,509.27
2035	133,333.33	37,016.10	634,858.71	501,525.37
2036	133,333.33	37,016.10	671,874.81	538,541.47
2037	133,333.33	32,016.10	703,890.91	570,557.57
2038	133,333.33	32,016.10	735,907.01	602,573.67
2039	133,333.33	36,731.93	772,638.94	639,305.61
2040	133,333.33	36,731.93	809,370.87	676,037.54
2041	133,333.33	35,981.93	845,352.81	712,019.47
2042	133,333.33	37,636.93	882,989.74	749,656.41
2043	133,333.33	38,709.43	921,699.18	788,365.84
2044	133,333.33	38,709.43	960,408.61	827,075.28
2045	133,333.33	37,042.77	997,451.38	864,118.04
2046	133,333.33	32,310.62	1,029,762.00	896,428.67
Total		**822,762.00**		

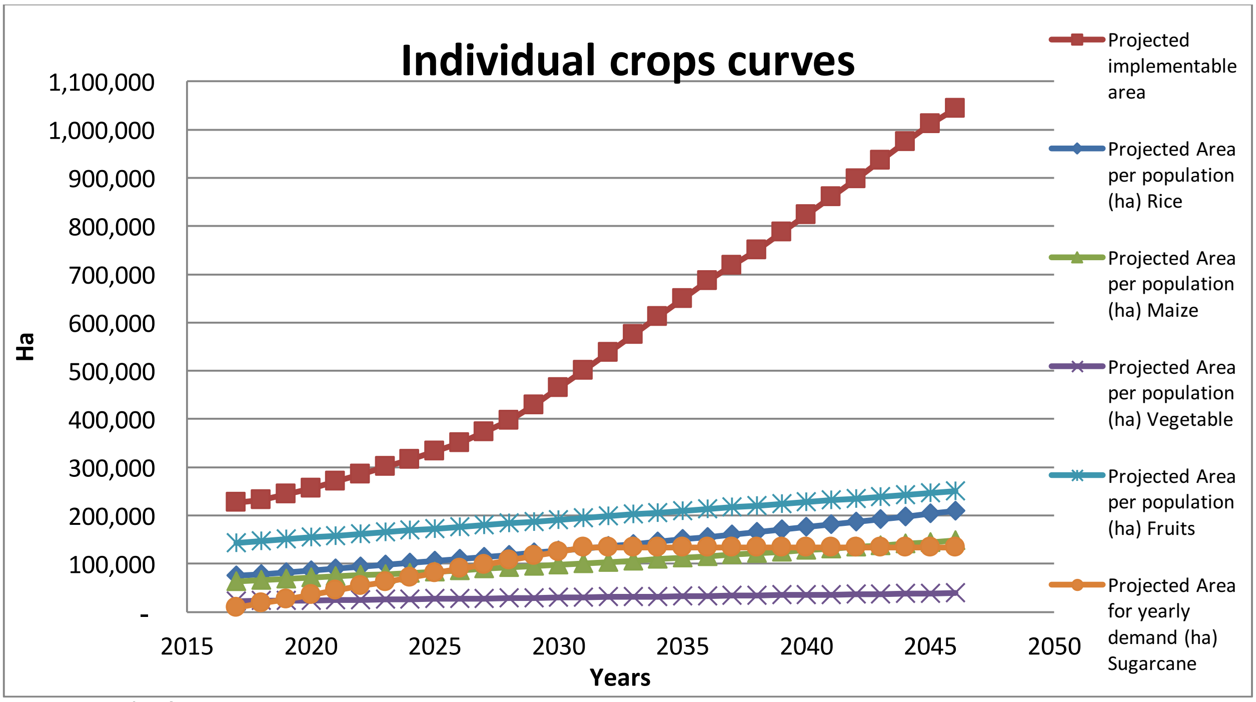
Source: Author’s construct

Figure 14.8: Projected Sugarcane Curve and Total Acreage Development



Source: Author's construct

Figure 14.9: Projected Individuals Crops Curves and Total Acreage Development



Source: Author's construct

14.6.5 Production of Combination of Crops under Irrigation

It is envisaged that the country will be self-sufficient in five (5) crops (rice, maize, vegetable, sugarcane and fruits) by 2036. Table 14.9 and Figure 14.10 present the projected total acreage development for the combination of crops.

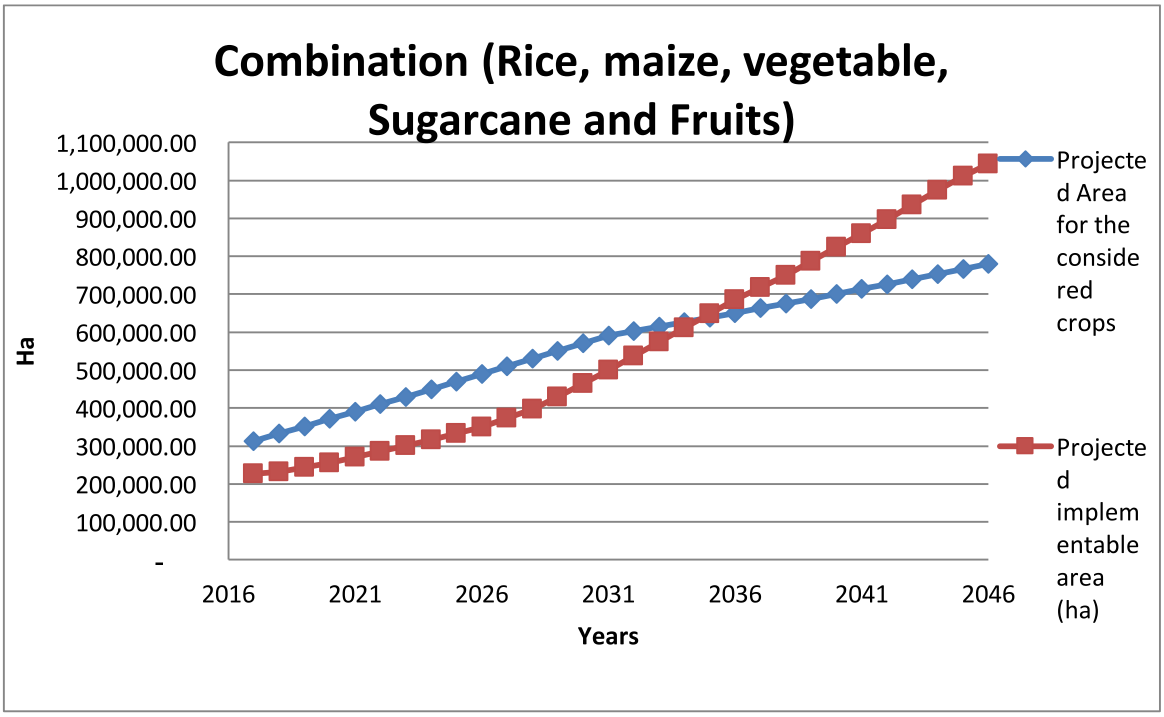
Table 14.9: Projected Cultivation of Combination of Crops under Irrigation

Combination of Crops				
Year	Projected Area for the considered crops	Physical Targeted area per year (ha)	Projected implementable area (ha)	Difference in area
1	2	3	4	5
			Compare 4 & 2	
2016		221,000.00	221,000.00	Existing irrigable area (ha)
2017	313,471.01	5,049.50	226,049.50	(87,421.51)
2018	332,551.42	5,282.50	231,332.00	(101,219.42)
2019	351,748.75	12,116.79	243,448.79	(108,299.96)
2020	371,062.99	12,406.79	255,855.57	(115,207.42)
2021	390,494.17	15,035.95	270,891.52	(119,602.64)
2022	410,042.26	14,635.95	285,527.48	(124,514.78)
2023	429,707.27	14,965.12	300,492.60	(129,214.67)
2024	449,489.20	14,965.12	315,457.71	(134,031.49)
2025	469,388.05	17,160.35	332,618.06	(136,769.99)
2026	489,403.83	17,160.35	349,778.41	(139,625.42)
2027	509,536.52	23,214.51	372,992.92	(136,543.60)
2028	529,786.14	23,854.51	396,847.43	(132,938.71)
2029	550,152.68	31,948.96	428,796.39	(121,356.29)
2030	570,636.13	35,073.96	463,870.35	(106,765.79)
2031	590,569.84	35,948.96	499,819.31	(90,750.54)
2032	602,353.81	37,001.10	536,820.41	(65,533.41)
2033	614,254.70	37,233.60	574,054.01	(40,200.69)
2034	626,272.50	37,788.60	611,842.61	(14,429.90)
2035	638,407.23	37,016.10	648,858.71	10,451.47
2036	650,658.88	37,016.10	685,874.81	35,215.93
2037	663,027.45	32,016.10	717,890.91	54,863.46
2038	675,512.94	32,016.10	749,907.01	74,394.07
2039	688,115.35	36,731.93	786,638.94	98,523.59
2040	700,834.69	36,731.93	823,370.87	122,536.19

2041	713,670.94	35,981.93	859,352.81	145,681.87
2042	726,624.11	37,636.93	896,989.74	170,365.63
2043	739,694.21	38,709.43	935,699.18	196,004.97
2044	752,881.22	38,709.43	974,408.61	221,527.39
2045	766,185.16	37,042.77	1,011,451.38	245,266.22
2046	779,606.02	32,310.62	1,043,762.00	264,155.98
	Total	**822,762.00**		

Source: Author's construct

Figure 14.10: Projected Total Acreage Development for the Combination of Crops



Source: Author's construct

14.7 Project Area and Indicative Cost of Implementation

The capital investment required for the thirty (30) year development plan for irrigation infrastructure development is estimated to be US$7.166 billion as indicated in Table 14.10 below.

Table 14.10: Project, Area and Indicative Cost of Implementation

	Project Title	Region	Order of Priority	Estimated Cost (US$)	Potential Area (ha)	Description
1	Bui irrigation project	Brong Ahafo	Medium term	360M	30,000	Studies completed and awaiting the development of irrigation infrastructure downstream Bui hydro-power dam for pilot area of 5,000 ha
2	Road culvert diversion weirs for irrigation and livestock watering	National	Medium term	48M	4000	Identify suitable locations along trunk roads to construct culvert diversion weirs for livestock watering and/or pipe networks for irrigation
3	Accra Plains irrigation project	Greater Accra/ Volta/ Eastern	Medium term	1800M	150,000	Completed feasibility study and designs and awaiting infrastructure development of first phase of 11,000 ha
4	Avu-Keta irrigation project	Volta	Medium term	92M	7,640	Pre-feasibility study completed, awaiting construction.
5	Small-scale/Micro-scale Irrigation and Drainage Project	National	Medium term	384M	32,000	Expansion of area under economically viable small-scale/micro-scale irrigation by about 32,000 ha in all 10 regions
6	Ho-Keta Plains irrigation project	Volta	Medium term	18M	1,500	Feasibility study completed and awaiting design-build contract for infrastructure development on area of 18,500 ha
7	Sabare irrigation project	North	Medium term	45.6M	3,800	Feasibility study completed and awaiting design-build contract for infrastructure development on area of 3,800 ha
8	Kamba irrigation scheme	Upper West	Long term	18M	1,500	Feasibility study completed and awaiting design-build contract for infrastructure development on area of 1,500 ha
9	Kpli irrigation scheme	Volta	Long term	18M	1,500	Feasibility study completed and awaiting design-build contract for infrastructure development on area of 1,500 ha
10	Rehabilitation of Amate irrigation scheme	Eastern	Short term	13.2M	110	Feasibility study completed and awaiting design-build contract for infrastructure development on area of 110

	Project Title	Region	Order of Priority	Estimated Cost (US$)	Potential Area (ha)	Description
						ha
11	Rehabilitation of Libga irrigation scheme	Northern	Short term	0.38M	32	Feasibility study completed and awaiting design-build contract for rehabilitation of infrastructure to increase area from 16 ha to 32 ha.
12	Rehabilitation of Nasia irrigation scheme	Northern	Short term	1.2M	100	Conduct feasibility study and develop infrastructure on pilot area of 100 ha
13	Construction of Tamne irrigation scheme	Upper East	Long term	24M	2,000	Feasibility study completed and awaiting design-build contract for infrastructure development on area of 1,500 ha
14	Mprumem irrigation scheme	Central	Long term	1.8M	150	Feasibility study completed with detailed designs and awaiting infrastructure development on area of 150 ha
15	Extension of Wheta irrigation project	Volta	Medium term	2.4M	200	Extension of existing scheme by 200 ha to bring total area under cultivation to 1,080 ha
16	Nasia-Nabogo irrigation project (Tamaligu – 5,800 ha; Zoggo – 2,800 ha; Bogdoo – 2,500 ha)	North	Long term	133.2M	11,100	Pre-feasibility study completed for infrastructure development on area of 11,100 ha
17	Nasia-Nabogo water management project	North	Medium term	240M	20,000	Pre-feasibility study for use of water management techniques completed. On-going infrastructure development for production
18	Angaw-Basin irrigation project	North	Long term	168M	14,000	Conduct feasibility study and implement irrigation scheme on 14,000 ha
19	Pwalugu Multipurpose Dam project (Irrigation Component)	North	Medium term	240M	20,000	Completed feasibility study, awaiting funding for construction of 20,000 ha to produce tomato for feeding Pwalugu Tomato Factory
20	Daboya irrigation project	North	Medium term	36M	3,000	Conduct feasibility study and implement irrigation scheme on 3,000 ha
21	Fumbisi Valley water management project	Upper East	Long term	300M	50,000	Conduct feasibility study for construction of irrigation scheme to cover area of about 100,000 ha
22	Sisilli Kulpawn irrigation project	Upper East	Medium term	600M	50,000	Feasibility study completed and on–going construction on pilot area of 400 ha
23	Passam irrigation project	North	Medium term	14M	1,200	Feasibility study and subsequent development of area of 1,200 ha
24	Mpaha irrigation project	North	Long term	66M	5,500	On-going feasibility study and subsequent construction on pilot area of 100 ha
25	Lamassa irrigation	North	Long	38.4M	3,200	Feasibility study and

	Project Title	Region	Order of Priority	Estimated Cost (US$)	Potential Area (ha)	Description
	project		term			subsequent construction on area of 3,200 ha
26	Extension of Mankessim irrigation scheme	Central	Medium term	3.96M	330	Feasibility study and subsequent construction on additional area of 330 ha
27	Katanga valley water management project	North	Long term	600M	50,000	Conduct feasibility study and implement irrigation scheme on 50,000 ha
28	Karaga irrigation scheme	North	Long term	270M	22,500	Conduct feasibility study and implement irrigation scheme on 22,500 ha
29	Daka Valley irrigation project	North	Medium term	210M	35,000	Feasibility study and subsequent construction on area of 3,000 ha
30	Fumbi Valley Water Conservation project	Upper East	Medium term	700M	242,400	Feasibility study and subsequent construction on area of 3,000 ha
31	Diversion weir on River Tano	B/A, Ashanti &CRs	Long term	240M	20,000	Feasibility yet to start
32	Komenda Sugarcane Irrigation Project	Central Region	Long Term	480M	40,000	
	TOTAL			**7,166.14**	**822,762**	

Source: GIDA

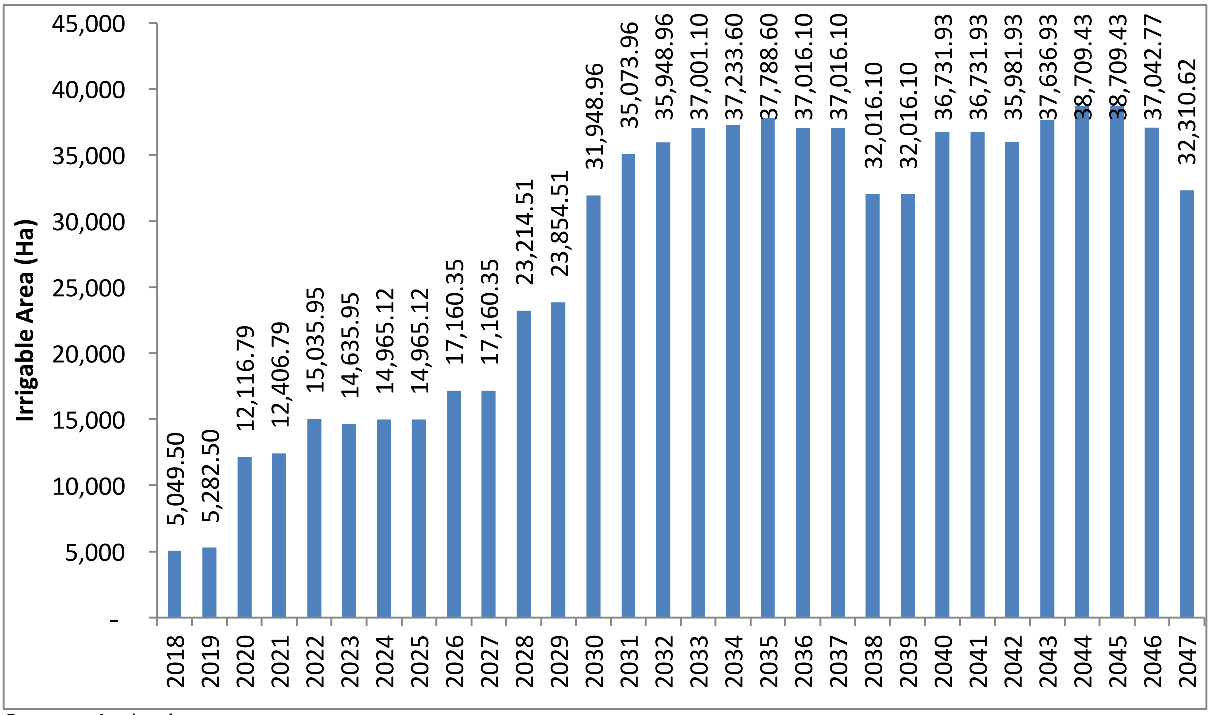
The project locations are as shown in Figure 14.11.

Figure 14.11: Project Location Map

Source: GIDA

It is estimated that about 822,762 hectares will be put under various irrigation systems in the country during the 30-year period. In addition to the total existing current irrigation coverage of 221,000 hectares, the total irrigated area envisaged to be under irrigation will be 1,043,762 hectares, forming about 54.9% of the estimated irrigable land of 1.9 million hectares available countrywide.

Figure 14.12: Annual projected irrigable area development



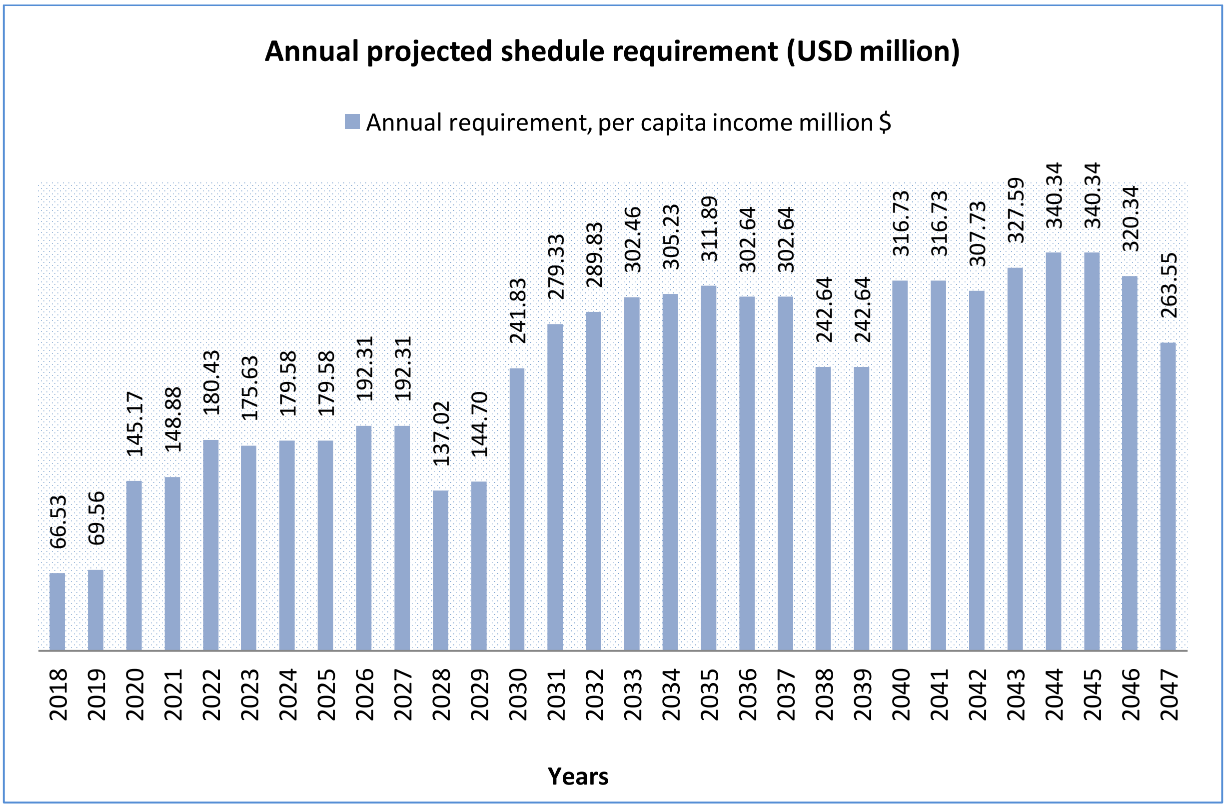
Source: Author’s construct

14.8 Implementation Schedule

Phasing of the projects is required to enable accessible funding for effective implementation of the programme over the targeted period. The phasing is done taking into consideration three factors:

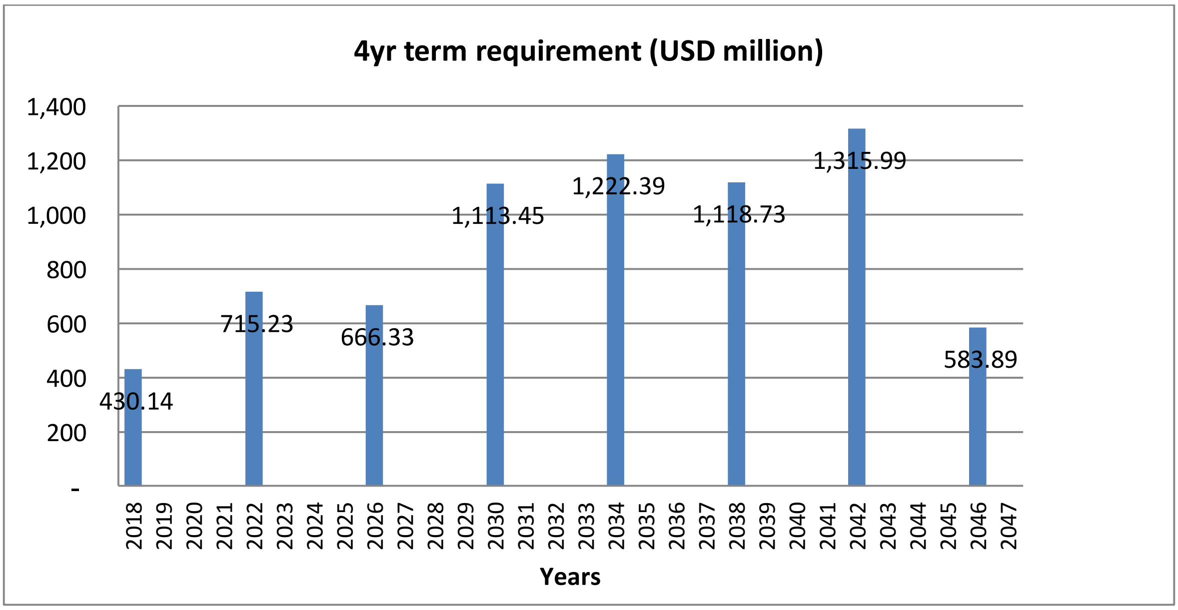
i. Establishing capital requirement for the 4-year term activities based on the current and the projected income per capita by 2047;
ii. Grouping based on priority levels of the projects; and
iii. Scheduling to keep to the capital cost requirement per year and per 4-yr term period.

Figure 14.13: Annual Budget Requirement (per project scheduling) for Irrigation Development - 30yr period (2018-2047)



Source: Author's construct

Figure 14.14: 4yr-Term Budget Requirement for GIP for Irrigation Development - 30yr period (2018-2047)

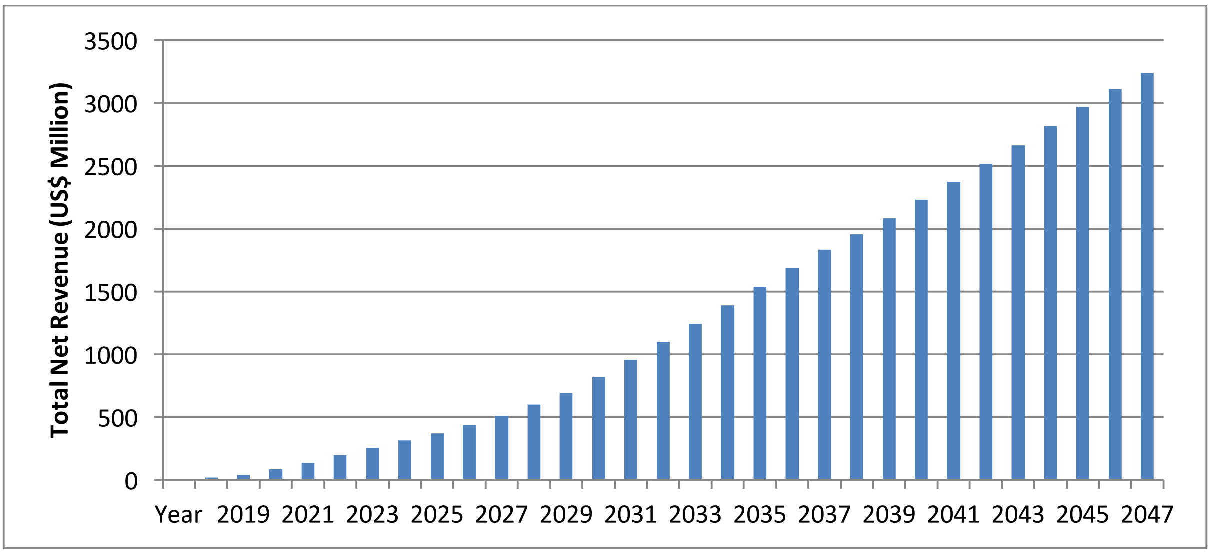


Source: Author's construct

14.8.1 Annual Revenue Projections for Selected Crops

The agricultural sector directly and indirectly employs about 45% of Ghana's working population. By making total net revenue projections from four selected irrigated crops, cumulative net revenues of USD 40,177.39 million will be obtained at the end of 30 years. The details of the annual total net revenue are shown in the Figure 14.15.

Figure 14.15: Total net revenue projections for selected irrigated crops per annum



Source: Author's construct

In 2013, Ghana's unemployment rate was 5.2% according to the CIA World Fact Book. This suggests that over 1.4million people in the country were unemployed and this number is increasing. But according to the United Nations, return on investment (ROI) in the irrigation sub-sector is 500%. This means that with prudent management, irrigation investment is immensely capable of reversing the high rate of unemployment in the country.

At the launch of the Africa Rice Advocacy Platform in October 2016, it was revealed that annual rice imports to Ghana exceed 500 million dollars. Currently just about 15% of the net rice consumption is produced under irrigated and agriculture water management ecologies. However, irrigation and agriculture water management ecologies have a major role in progressively increasing rice production towards self-sufficiency level and eventually curtailing the import trend. Import substitution could be replicated for sugar and canned tomato if steps are taken in the right direction of food processing and industrialisation.

Ghana consumes huge quantities of both fresh and canned tomatoes but had to import up to 75,000 metric tons of fresh tomatoes in 2013 to supplement inadequate local production. Additionally, 78,000 metric tonnes of tomato paste valued at US$112.1 million was imported in the same year to meet demand[81]. Moreover, sugar imports over the past 10 years amounted to US$ 2.6 billion, a major drain on the country's economy. Yet the northern half of the country presents an ideally suited location for sugarcane

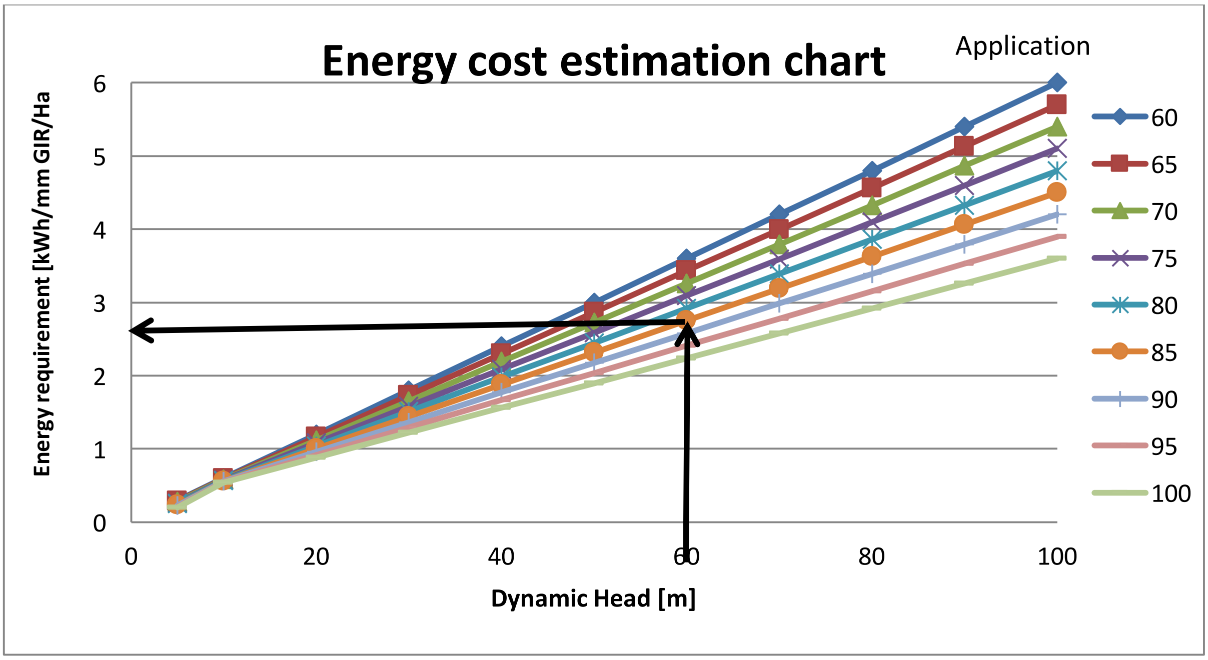
[81] Boachie-Danquah B. and I. Sulaiman (2015). Ghana's Tomato Processing Industry: An Attractive Investment Option in 2016

production given its favourable environment coupled with irrigation. GIDA therefore implores Government to deliver on its commitment of investing in the irrigation sub-sector within the 30-year GIP programme to assure adequate food production and even surpluses, which can be fed as raw materials inputs into agro-based industries, facilitating industrialisation and reversing the country's huge agricultural import bills and youth unemployment.

14.9 Energy Requirement

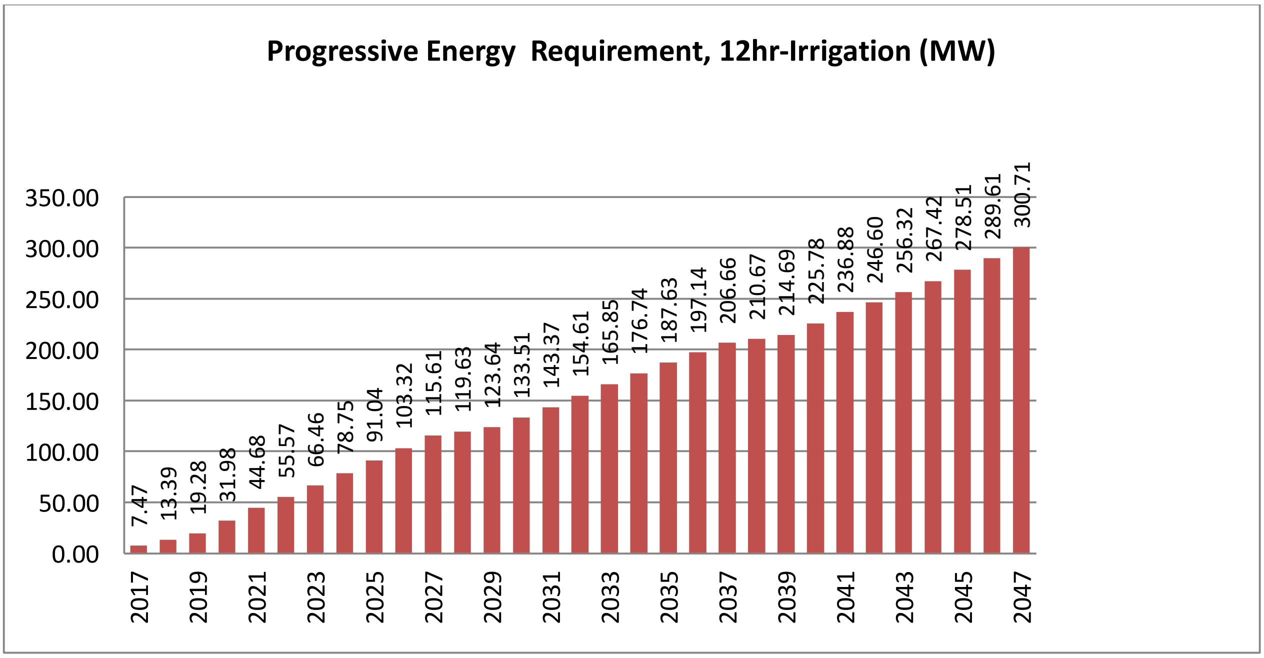
The projected energy requirement was assessed based on the consumption of existing pressurised systems and the annual new pressurised development envisaged for the 30 year period. About 300 megawatts of power would be required by the end of 2047 to operate the systems on 12 hour irrigation cycles per day. The power requirement will be halved if irrigation water delivery is increased to 24 hours per day. Average system efficiency of 85% and 60m head combination and 6mm Gross Irrigation Requirement (GIR) have been used for the computation of progressive energy required as shown in Figure 14.16. The progressive annual power requirements for 12-hour and 24-hour irrigation are shown in Figures 14.17 and 14.18 respectively.

Figure 14.16: Energy cost Estimation Chart



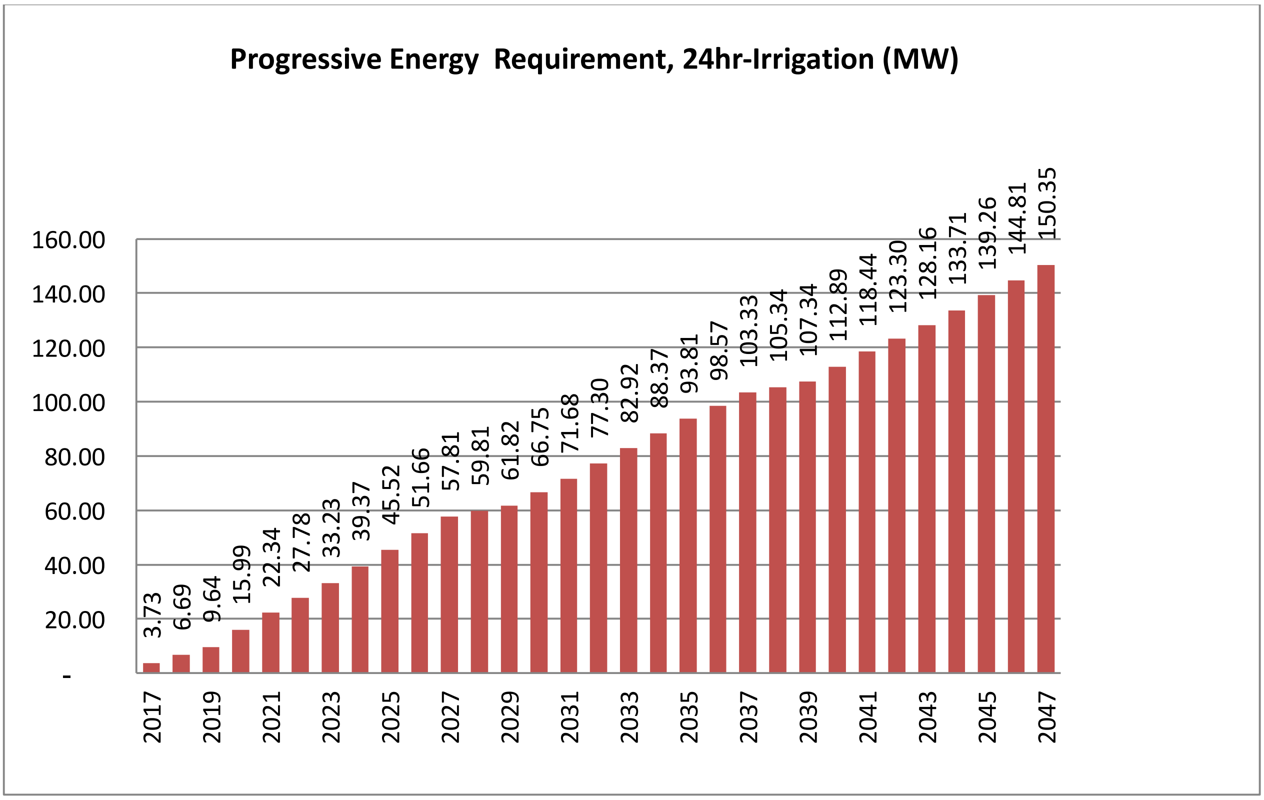
Source: Author's construct

Figure 14.17: Progressive energy requirement for Irrigation (12hr)



Source: Author's construct

Figure 14.18: Progressive energy requirement for Irrigation (24hr)



Source: Author's construct

14.10 Proposals for Progressive Investment

To achieve progressive investment increase in the irrigation sub-sector, the following funding strategies are proposed:

i. Ring-fencing or dedication of funds released from the Ministry of Finance for irrigation development. Policy direction should be devised to spell out sources and restocking of funding as well as guidelines for disbursement of the funds. This is to ensure sustainable funding and by extension development of irrigation in the country;
ii. Public-Private Partnership (PPP) is the new concept of involving public and private partnership in irrigation infrastructure development in Ghana and this will be exploited fully for development, management, operation and maintenance of irrigation schemes;
iii. Accessing funds from the Ghana Infrastructure Investment Fund (GIIF) for irrigation development;
iv. Adoption of a policy that mandates District Assemblies to allocate part of their funds for the development of irrigation projects in their areas of jurisdiction;
v. Use of land as equity in project development. This excludes social tension and allows the descendants of the land owner to benefit from the project so long as the project exits.

14.11 Risk Management Measures

Implementation of the Irrigation Infrastructure Plan will encounter a number of risks. The identified risks, assessment and the mechanisms to manage the risks are provided in Table 14.11.

Table 14.11: Risks and Challenges Management

Plan Implementation Risks	Level of Risk	Mitigation Measures
Inadequate remuneration resulting in high attrition rate	High	GIDA is in a process of restructuring and modernising. This will lead to expanded scope of work which is supposed to bring more internally generated funds to the Authority as GIDA becomes a regulatory body for irrigation in the country. Staff remuneration and human resource development in the Authority will be improved to attract staff to stay in service
Lack of legal title to lands belonging to GIDA poses a problem for development of these lands and is an operational risk for the sector	High	Agricultural land title policies in Ghana should be revisited, so as to empower the Authority to easily access and own land for irrigation development in the country
High cost of energy (fuel and electricity)	High	The government must come out with a social tariff for agricultural production and processing as a matter of policy intervention. This will make agricultural production and processing attractive and sustainable.

Plan Implementation Risks	Level of Risk	Mitigation Measures
High cost of farm inputs	High	Subsidies in the agricultural sector must be critically considered, if the food security agenda of the nation is to be achieved.
Inadequate budgetary allocation for operation and maintenance of existing schemes	High	Realistic irrigation service charge (ISC) is to be paid in order to generate enough funds for operation and maintenance. In this sense, farmers must be profitable (farm income must increase) in their farming operations so that all farmers using the irrigation infrastructure will be able to pay for the service charges. Farmers must be sensitised to grow high value crops that can generate enough farm income to pay for all services provided.
Inadequate provision of funds for new projects	High	As part of restructuring the irrigation subsector, GIDA will seek to develop new schemes with the private sector on a PPP basis.
Environmental degradation	High	Irrigation and drainage operation improvement plans must be put in place to address the problem of environmental degradation especially the effect on soils (soil amendment & environmental management plan must be put in place)
Negative impact of climate change	Moderate	Awareness creation on the impact of climate change on irrigated agriculture must be enhanced among all stakeholders. Also in-depth knowledge on climate change indicators must be acquired by irrigation planners so as to put in place an emergency preparedness plan should the negative impact of climate change cause any major problem in the country
Encroachment on irrigation scheme lands	High	Strong law enforcement measures on encroachment on agricultural lands must be put in place
Weak GIDA impact on private irrigation /AWM subsectors	Moderate	Modernisation of GIDA has factored in AWM methods and GIDA will be mandated to support private irrigators
Insufficient plant and equipment for O&M	Moderate	A comprehensive plan to involve the private sector in the area of agricultural machinery service provision can be done under the PPP arrangement for all irrigation schemes in the country
Weak staff training and development	High	A comprehensive fully-funded staff training and development plan is to be put in place by the Authority to build the human resource base of the Authority and also improve on staff succession plan
Other entities implement irrigation	Moderate	The restructuring requires GIDA to operate as

Plan Implementation Risks	Level of Risk	Mitigation Measures
projects without the full consultation with GIDA		sub-sector facilitator, regulator, planner, supervisor, public service provider and advisor for all irrigators. GIDA plans to certify all irrigation infrastructure designs prior to their implementation
Poor retrieval of ISC	High	A collection mechanism that will involve a task force formation and operationalisation to assist in the retrieval of ISC is recommended
Water quality. Unwholesome water being used in the cities irrigation for vegetable production.	High	Water quality standards for irrigation must be set by GIDA and must be followed by all irrigators in the country
PPPs that involve private investments in irrigation sector may not be attractive to the private sector because of the low returns associated with the agricultural sector	High	Improve legislation and enforcement of relevant laws on PPP arrangements in agricultural sector in the country
Introduction of new approaches and technologies that have not been tested widely in Ghana	Moderate	Implementing pilots based on the new approaches prior to large scale investments. However technologies such as usage of irrigation machines such as centre pivot etc. are gradually increasing and therefore risk is moderate. Canal lining with new materials apart from the usual concrete lining is yet to be explored on large scale on our canals.
Degradation of irrigated lands, Salinisation, Waterlogging Alkalisation, Soil Acidification etc.	High	Improve irrigation and drainage infrastructure and operation to match demand Provide drainage including disposal of water to evaporation ponds or the sea if quality of river flow is adversely affected by drainage water Maintain channels to prevent seepage, and reduce inefficiencies resulting from siltation and weeds. Allow for access to channels for maintenance in design

Source: Author's construct

Chapter 15 Spatial Planning and Human Settlements Development

15.1 Introduction

Human Settlements planning and development remains a very critical component of the overall infrastructure portfolio required to deliver the envisaged growth desired to fulfil the goals of the long term plan.

This chapter presents the management challenges of spatial planning and human settlements development in Ghana. It highlights the existing gaps in supply and quality, as well as forecasts the needs for the future within the context of the economic growth envisaged, and defines a pathway to meeting the current and anticipated needs.

15.1.1 Vision, Goals and Objectives for Human Settlements Development in Ghana

The long term vision for Ghana, as far as this sector is concerned, is to "safeguard the quality of the living environment". The goal, therefore, is to "create accessible, safe and sustainable settlements". This vision is based on the backdrop of spatial planning analytics presented in the National Spatial Development Framework (NSDF) and the vision for human settlements developed by the NDPC.

The objectives of this sector are:

- To achieve balanced polycentric spatial development and improved infrastructure provision in medium to small size settlements.
- To improve connectivity at local, regional, national and international levels to make Ghana competitive in the West African Sub-Region.
- To safeguard and improve the quality of the living environment.
- To identify and develop Secondary Cities.

15.2 Human Settlements in Ghana: Background

With a few exceptions, most human settlements in Ghana have emerged from being indigenous townships that have evolved, growing from the expansion of their own populations and the inflow of migrants. The exceptions have been the few new towns that were built from the ground-up, where virtually no human settlements existed before. The latter type, comprising Tema, Akosombo and Bui, have been designed and built on the back of an industrialisation and national infrastructure drive (hydroelectric power dams and commercial harbour). Other settlements have emerged from extensions of existing ones (taking different names from the primary settlement and growing to become towns on their own right).

The settlements growth in Ghana, after independence, has been mainly led by Accra (as the national capital) and Kumasi (deriving its significance from the strength of the intensive commercial activities and the deeply embedded cultural norms) followed by Sekondi-Takoradi (driven mainly by the economic functionality of the Takoradi port), which combines to form the so-called *"Golden Triangle"*. Patterning the existing human settlements in an orderly framework did not yield the expected evenly spread hierarchical network of cities, towns and villages. That notwithstanding, rural settlements tend to be organised around small, medium and major settlements, as is depicted in Figure 15.1.

Generally, the southern parts of the country portray a more nucleated spatial development pattern, and the settlements have higher built-up and population densities. It is therefore not surprising that the level of infrastructure provision is relatively higher than found in the northern parts of the country where settlements have sparse population densities (Figure 15.1) as well as smaller and invariably inadequate population densities to support the provision of basic infrastructure and services. This, therefore, requires spatial planning and engineering efforts to attract and concentrate populations to form more compact and denser settlements. The nature of the sparse populations within the settlements offers greater opportunities to plan and develop settlements with the needed infrastructure even before large numbers of people move to settle in.

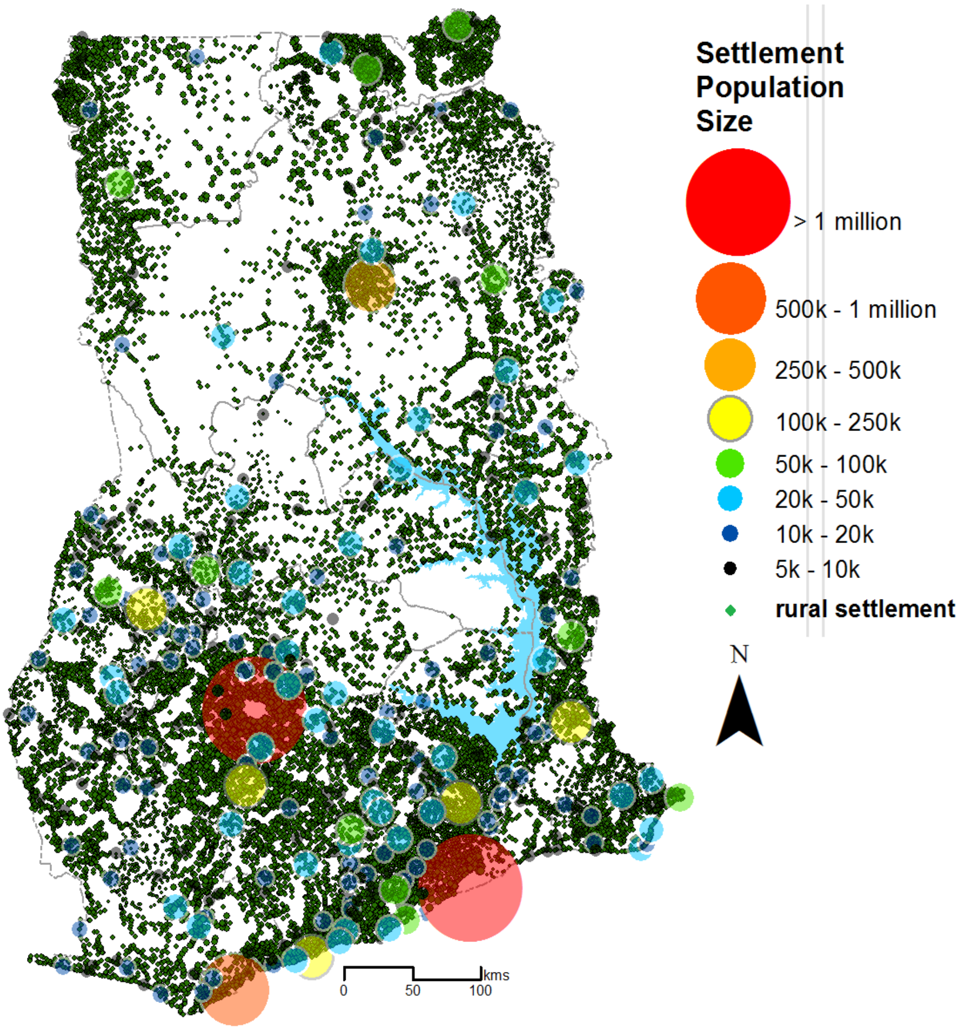


Figure 15.1: Settlement Distribution in Ghana

Source: TCPD, National Spatial Development Framework, (2015)

To provide adequate levels of infrastructure and services in settlements, it is economically prudent to develop spatial patterns that are more compact with higher population densities to merit the levels infrastructure required. To this end, the National Spatial Development Framework (NSDF) proposes the development of settlement networks that that take advantage of the existing spatial distribution of settlements, to create stronger synergies between rural settlements, small and medium sized towns as well as high order settlements at the zenith of the settlement hierarchy.

15.3 Human Settlements Baseline Status/Conditions and Gap Analysis

15.3.1 Overview of Human Settlements Sector

To provide a general view of the spatial distribution of the settlement types in Ghana and their evolution from 2000 to 2010, this section focuses on the changing trends of settlement types and its implication for settlement management and infrastructure provision.

Changing Trend of Settlements and Implications for Infrastructure Provision

The number of small sized settlements is increasing rapidly. Small urban centres (settlement size classes – with population ranging between 5,000 and 10,000) experienced the largest expansion between the year 2000 and 2010 (Table 15.1). As at 2000, this category of settlement size class numbered 157, which increased to 220 by 2010 representing the largest growth in numbers among all the settlement size classes. This indicates that rural settlements with populations just below 5000 initially, have now crossed the figure. Aside the absolute increase in numbers, their percentage share rose marginally from 11% to 12%. Infrastructure provision in the long term strategic planning will focus on these small sized urban settlements as well as possible rural settlements that have high potential of attaining urban status.

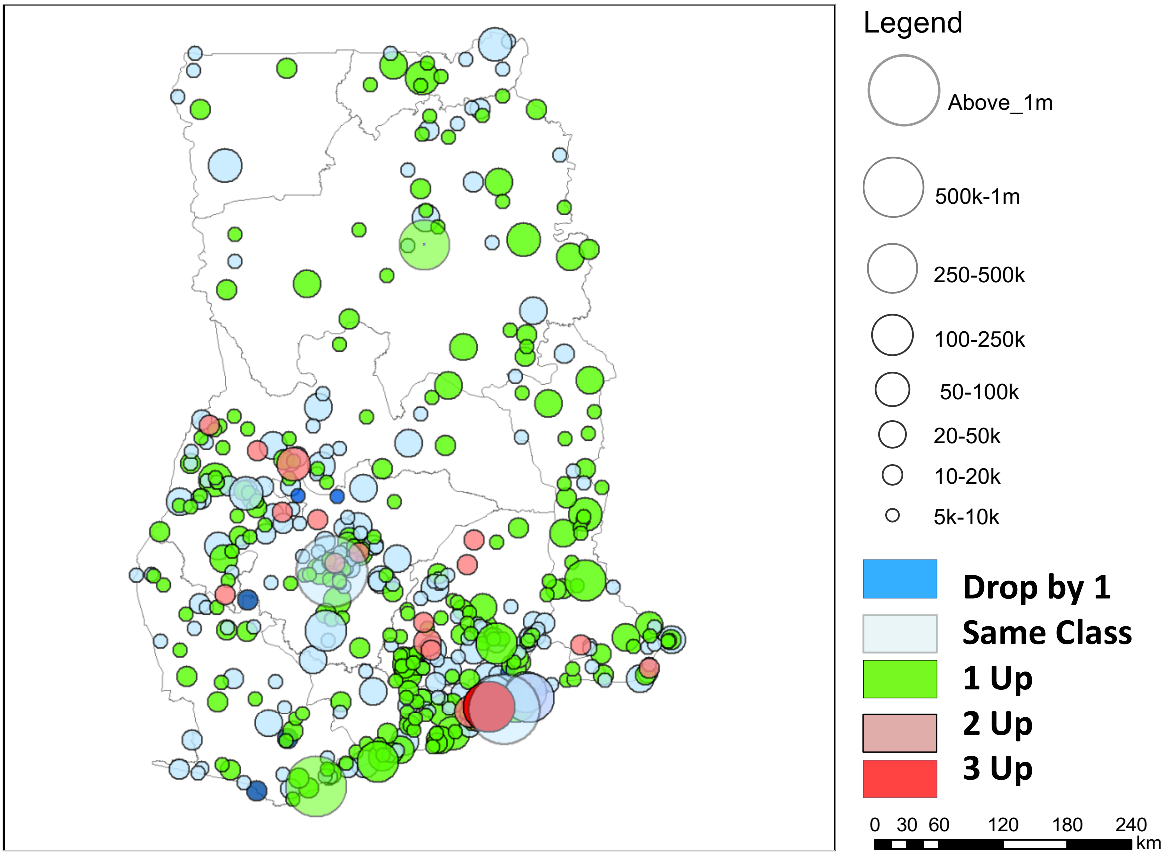
Table 15.1: Changes in Settlement Size Classes, 2000-2010

	Settlement Size Class	Count	2000 Pop. Sum.	% share	2010 Pop. Sum.	Count	% share	Change
1	> 1,000,000	2	4,106,641	49	6,058,071	2	49	3.96
2	500,001 - 1,000,000	1	373,916	4	588,987	1	5	4.65
3	250,001- 500,000	1	202,317	2	274,022	1	2	3.08
4	100,001 - 250,000	5	450,915	5	634,643	5	5	3.48
5	50,001- 100,000	11	495,818	6	751,471	11	6	4.25
6	20,001 - 50,000	45	957,837	11	1,308,962	45	11	3.17
7	10,001 - 20,000	96	975,112	12	1,365,014	103	11	3.42
8	5,000 - 10,000	157	894,811	11	1,484,913	220	12	5.20
		318	8,457,367	100	12,466,083	388	100	3.96

Source: Town and Country Planning Department (2015)

Though the settlements from medium-sized to the largest settlements types, with population thresholds of 50,000 upwards, did not change in terms of their absolute numbers within the inter-censal period, the population gains were quite significant, necessitating considerations of massive infrastructure upgrade and provision of new ones. Kumasi and Accra together grew by 50% (amounting to nearly two million people) for the same period (Table 15.1). These two settlements alone constituted a quarter of the nation's entire population and almost half of the urban population as at 2010. In this respect, infrastructure interventions in these centres would require enhanced efficiency through expansion and retrofitting of critical services such as water, energy supply, and transportation. On the other hand, the number of small settlements with populations of between 5,000 and 10,000 grew significantly in number (40%) and actual population (66%) during the 2000–2010 inter-censal period. The future population increases in these settlements will be considered in planning for infrastructure provision and management. In view of the changing dynamics of settlement patterns ranging from small, medium and large settlements, there is the need to develop strong economic gateways or sub-centres within the functional urban regions (city-regions) in Ghana.

Figure 15.2: Changes in Settlement Size Classes in Ghana



Source: TCPD (2015), based on 2000 and 2010 Population and Housing Census by GSS

Nature of Settlements and Infrastructure Provision in Ghana

Hierarchy of Human Settlements (Spatial Distribution of Settlements)

The largest settlements are located in the southern half of the country. Accra, Kumasi and Sekondi-Takoradi, which form the so called "golden triangle", also host quite a huge number of medium size settlements with surrounding clusters of rural settlements. The settlements in the Northern part of the country are predominantly rural with a few medium sized settlements that provide higher order of services to the immediate surrounding settlements.

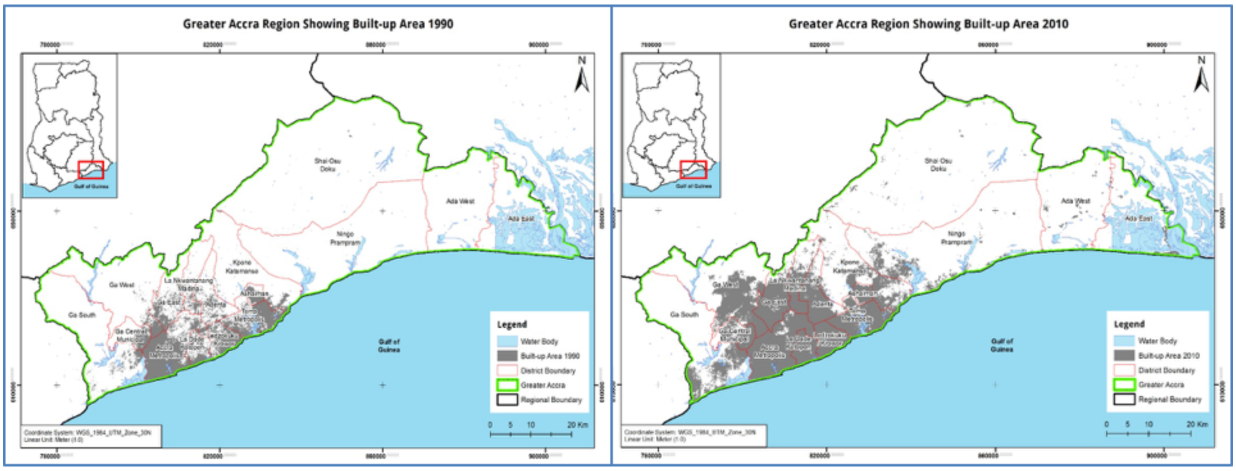
Metropolitan and Regional Development (Settlement Expansion and the Formation of Metropolitan Regions)

The fast rate of settlement expansion, particularly in the leading core economic areas, has resulted in the formation of greater metropolitan areas (i.e, functional areas), which are contiguous built-up spatial footprints. These greater metropolitan areas extend beyond their administrative boundaries and have strong economic linkages with surrounding towns and villages that are quite distant apart. A typical example is the Greater Accra Metropolitan Area (GAMA), which as at 2010, comprised the Accra Metropolitan Area (AMA) and seven (7) other surrounding districts, namely Tema Metropolitan Area (TMA), Ga East, Ga West, Ga South, Ashaiman, Adentan and Ledzokuku-Krowor Municipal Areas. By 2013, GAMA had grown to include La Nkwantanang Madina, La Dade Kotopon and parts of Ningo Prampram and Upper West Akim Districts.

Another greater metropolitan area that has been created is the Greater Kumasi conurbation, also referred to as the Greater Kumasi Metropolitan Area[82], delineated by the boundaries of KMA, Afigya Kwabre, Kwabre East, Ejisu Juaben, Asokore Mampong, Atwima Nwabiagya, Atwima Kwanwoma and Bosomtwe.

In the case of GAMA, however, the urban sprawl has spilled over into the Central and Eastern regional boundaries. Places like Kasoa and Aburi are typical settlements that have merged with the built-up footprint of settlements in Greater Accra as at 2015. These serve as dormitory towns and constitute a part of the daily commuting zone of the area. Figure 15.3 shows the settlement footprint of GAMA (between 1990 – 2010), growing to merge with the earlier mentioned settlements in the Eastern and Central regions.

Figure 15.3: Built up footprint in Greater Accra between 1990 and 2010



Source: Town and Country Planning Department, 2016

GAMA has, over the twenty-year period, expanded mainly towards the northern and western corridors of the region. The challenges of the fast pace of urban sprawl or expansion of these mega-regions present serious implications for infrastructure provision. Many settlements within these regions are long established before the infrastructures needed are provided. This is because physical development far outpaces planning efforts and infrastructure provision.

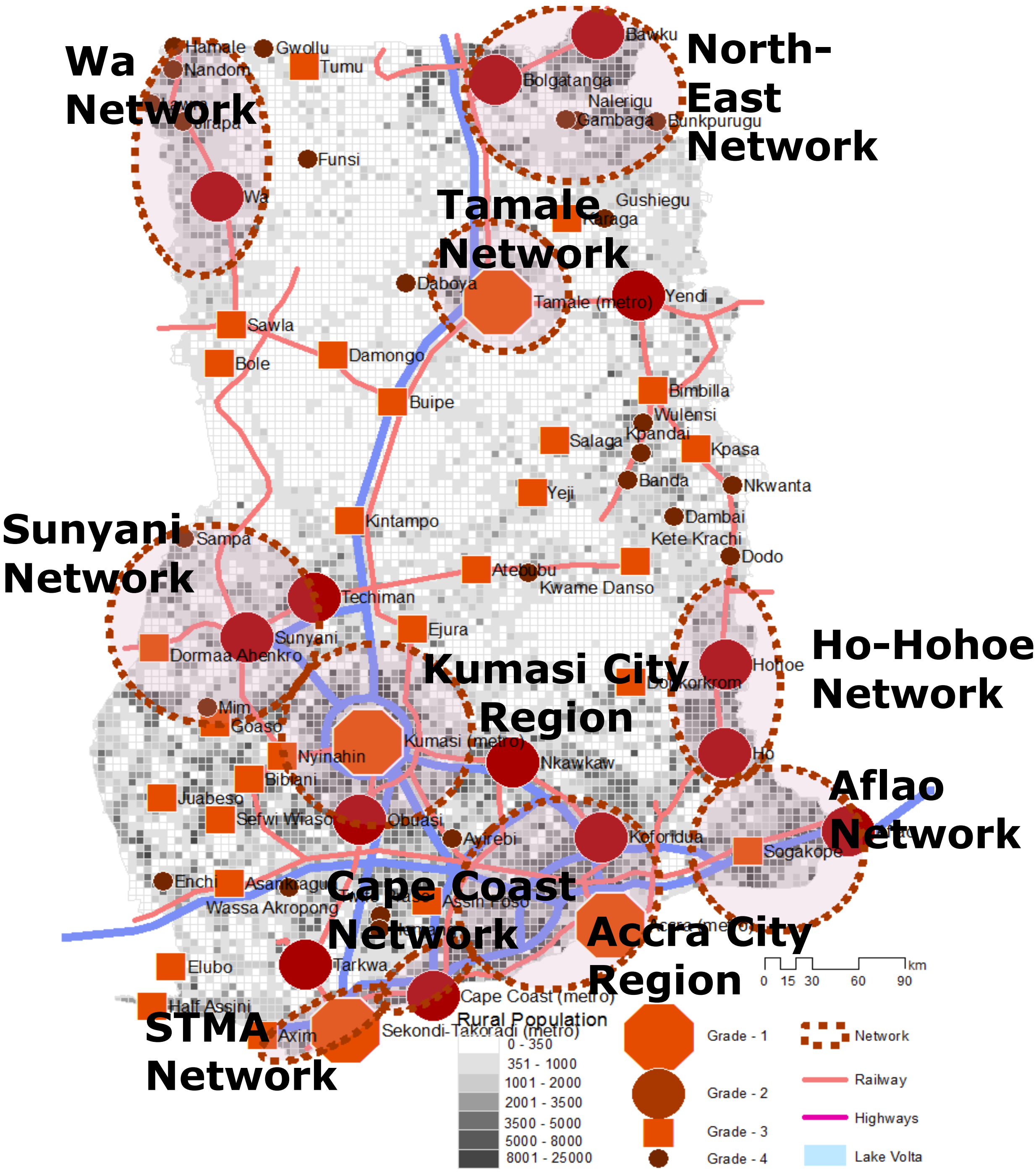
[82] In 2012, the Japanese International Cooperation Agency supported Greater Kumasi sub-region, which consist of KMA and its surrounding 6 districts to prepare a master plan under the auspices of the Ministry of Science, Environment, Technology and Innovation. This plan is composite of a Sub-Regional Spatial Development Framework (SDF) for the Greater Kumasi Sub-Region, Sub-Regional Structure Plan (SP) to guide the development and/or redevelopment of the urbanising portion of the Greater Kumasi Sub-Region, an implementation plan for the Greater Kumasi Sub-Regional SDF and SP.

It is imperative to emphasise that the formation of these metropolitan regions requires effective spatial and infrastructure planning efforts, focusing more on these spatial entities as a whole rather than the separate jurisdictional (administrative) conceptualisations, which more often than not results in waste of economic resources and possible losses in the achievement of economies of scale.

Based on this discussion, it is important to note that spatial and infrastructure plans must be developed to manage the rapid growth of these areas as they hold a lot of economic potential and their neglect would lead to immense urban development managerial challenges with adverse environmental and economic losses. Spatial Development Frameworks of these metropolitan regions should be developed with identified functionalities of the major towns/districts after which the structural plans of the districts/major settlements be clearly detailed out. This will contribute to the effective management of settlements and their growth in Ghana.

The NSDF (Figure 15.4) recognises and places human settlements in networks to create stronger symbiotic synergies between the highest levels of settlements through the medium to the lowest levels in the country. The identified networks are Accra-City Region, Kumasi City Region, Cape Coast Network, STMA Network, Aflao Network, North-East Network, Tamale Network, Wa Network, Sunyani Network and Ho-Hohoe Network. Apart from the strong transportation networks proposed between and within networks, infrastructure ranging from health, education, energy, and waste management would have to be provided to ensure efficient delivery of services. It is believed that when infrastructure provision is focused in these identified networks, maximum economic returns can be generated and there will be adequate and efficient infrastructure in almost all settlements in the country.

Figure 15.4: National Spatial Development Framework

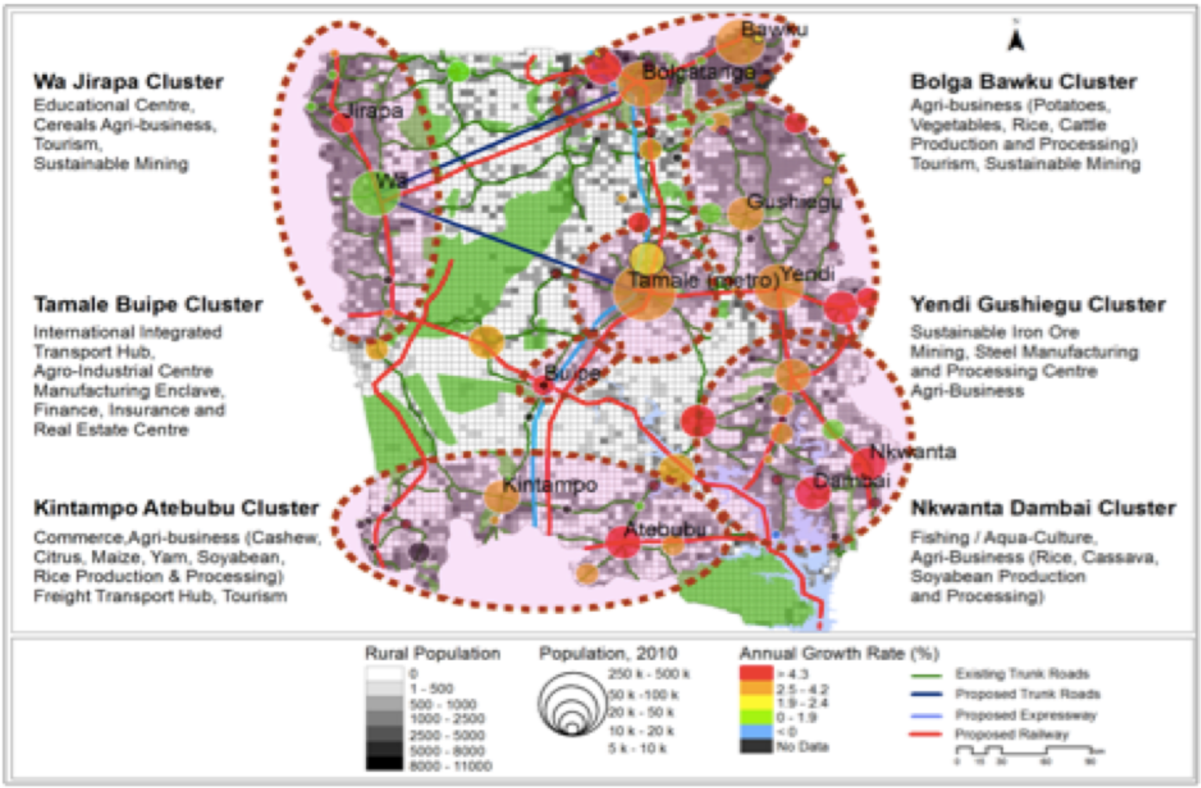


Source: TCDP (2015)

The Town and Country Planning Department in collaboration with SADA prepared a Sub-National Spatial Development Framework for the Northern Savannah Ecological Zone. This framework presents further detailed proposals for the development and management of settlements in the Northern Savannah Ecological Zone of Ghana. The framework makes modifications to the settlement networks identified in the NSDF and

adds new settlement networks. The Tamale City Region is extended to cover Buipei to form the new Tamale-Buipe Cluster because of the strong transportation and economic linkages proposed and envisaged for the area.
The other newly identified networks or settlement clusters include the Nkwanta-Dambai Cluster, Yendi-Gushiegu Cluster and the Atebubu-Kintampo Cluster. The Wa Network (now the Wa-Jirapa Cluster) and the North-Eastern Network (same as the Bolga-Bawku cluster) were maintained. Below the Spatial Development Frameworks (SDFs) at the regional or sub-regional level, SDFs and structural plans are to be prepared for Metropolitan, Municipal and District levels for the management of settlements in Ghana. At the last tier/scale, local community plans should be prepared for all towns or communities.

Figure 15.5: Northern Savannah Ecological Zone's SDF (2016-2036)



Source: TCPD (2016) – NSEZ's Spatial Development Framework

15.4 Overview of Proposed Development Strategy

The ten urban networks the NSDF proposes (as shown in Table 15.3) are in tandem with the character of existing settlements and population growth trends. The focus is on traditional growth nodes with Kumasi, Accra and Sekondi-Takoradi continuing to play significant roles in the spatial growth of the country. These nodes will still attract large sections of the population with the coastal belt eventually developing into a mega urban conurbation.

Table 15.2: City Regions and the urban metrics

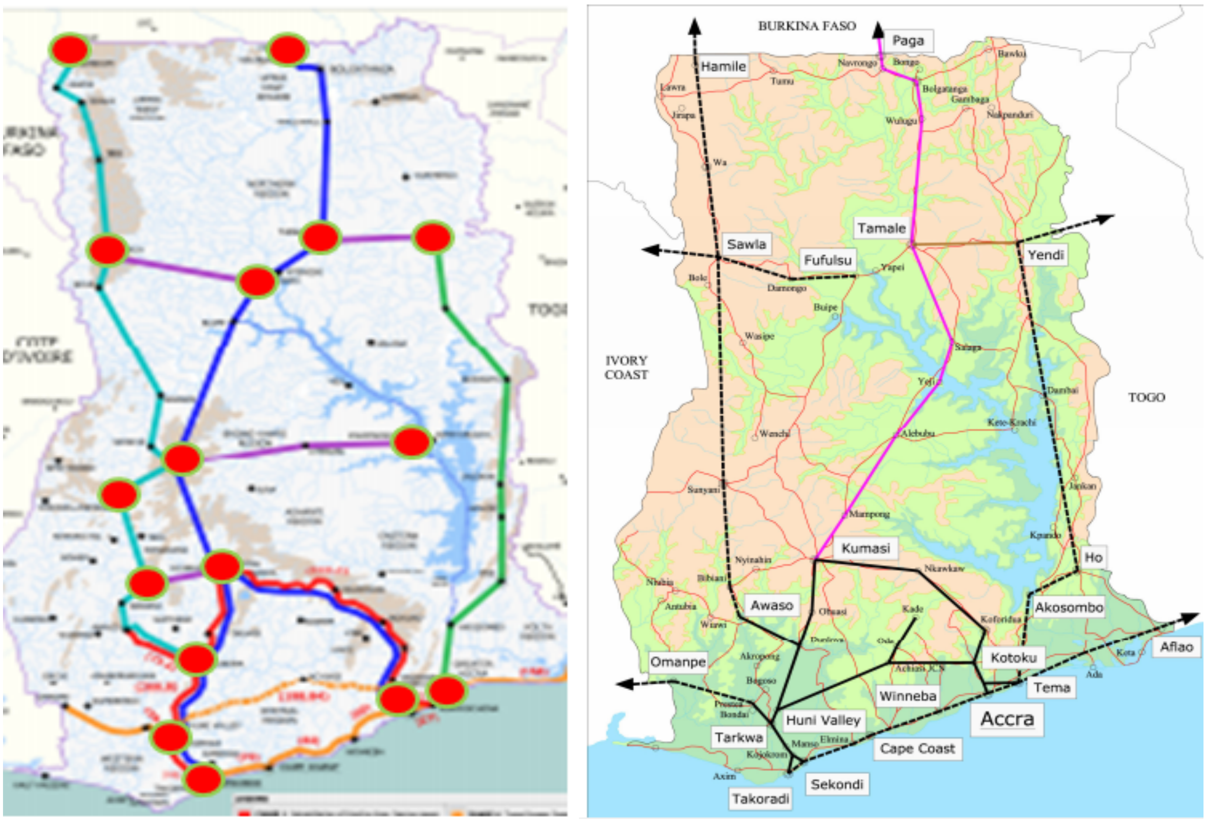
		2010					2035					Pop. Growth Rate		
	Network area (km^2)	Total population ('000)	Rural population ('000)	Urban ('000)	Urbanisation level	Network density p/km^2	Total population ('000)	Rural population ('000)	Urban ('000)	Urbanisation level	Network density p/km^2	Total population ('000)	Rural population ('000)	Urban ('000)
Accra City Region	9,840	5,847	1,196	4,651	80	594	11,127	676	10,450	94	1,131	2.61	-2.25	3.29
Kumasi City Region	11,108	4,023	1,266	2,756	69	362	7,797	1,029	6,768	87	702	2.68	-0.83	3.66
Sunyani Network	15,496	1,652	828	796	49	105	2,374	611	1,763	74	153	1.53	-1.21	3.23
North-East Network	10,876	1,263	955	308	24	116	1,907	1.002	905	47	175	1.66	0.19	4.44
Aflao Network	5,449	890	597	293	33	163	1,136	503	633	56	208	0.98	-0.68	3.13
Ho-Hohoe Network	4,884	835	499	336	40	171	1,622	261	1,360	84	332	2.69	-2.56	5.76
STMA Network	905	752	120	632	84	831	1,896	500	1,397	74	2,096	3.77	5.86	3.22
Tamale Network	4,169	626	301	325	52	150	859	283	577	67	206	1.28	-0.25	2.32
Wa Network	9,027	598	494	104	17	66	881	749	133	15	98	1.56	1.68	0.97
Cape Coast Network	1.005	558	238	321	57	555	766	206	560	73	762	1.27	-0.56	3.35
Total in Networks	72,259	17,016	6,495	10,521	62	234	30,366	5,820	24,526	81	417	2.34	-0.44	3.45
Pop outside networks	154,774	7,643	5,613	2.030	27	49	11,325	5,680	5,645	50	73	73	0.05	4.18
TOTAL	227,533	24,659	12,107	12,551	51	108	41,690	11,500	30,191	28	183	183	-0.21	3.57
% population in Networks		69	54	84			73	51	81					

Source: NSDF Study based on data from GSS and the Forestry Department Satellite Imagery

In this case, additional future housing provision will thus be linked to meet the new demand based on the anticipated growth in these areas, to address the deficits in the rural areas as well as the slow growth areas in response to the population dynamics. The intent of this plan is to draw population away from the large traditional centres into small towns. A new spatial development pathway is proposed anchored on natural resources-based industrialisation and development of knowledge hubs.

This scenario seeks to promote industrialisation based on the resource endowments of the various regions and their competitive advantages, which may be economic – directly linked to their resource base or strategic purpose – created through man-made systems or linked to location. This will require that each region will be uniquely known for the production of a particular product and/or service based on its competitive advantage – natural or man-made. The regional functions will thus be further assigned to the districts in the regional SDFs and subsequently to the respective towns in the various districts through the district SDFs. Housing needs assessment will be focused on these centres and the extra population to be attracted there because of the new economic activities. Important for success is the need to directly link the work of the energy sector, transport sector, water, ICT among others to this scenario. Also, crucial for success is the human resources needed to drive this agenda, i.e., the technical and vocational skills needed to drive industrialisation, right from the production of raw materials, value addition, packaging and marketing etc. There will be the need for some information or knowledge of the potential production value chains this scenario is likely to generate since it can affect labour mobility significantly, hence housing and other basic social services. In this way, people are effectively attracted away from the traditional large centres to minimise their dominance and ease urban management efforts.

Figure 15.6: Growing Nodes Linked to Resource Endowment and Locational Advantages



Source: NSDF

To complement the industrial activities will be the creation of knowledge hubs to promote research and innovation through research and development. Such research should generate global outcomes as well as further enhance industrialisation activities.

15.5 Key Development Goals and Objectives

Implementation of the Human Settlement Development plan will begin with addressing the current settlement gaps, and evolve towards the development, management and maintenance of sustainable cities in the long term. Within the first ten (10) years, existing cities will be re-engineered along sustainability principles. This process will involve land use reclassification, active urban regeneration and slum upgrading/phasing out on the one hand, and the increase in the quality of housing, infrastructure and urban spaces on the other hand. The main thrust of the plan implementation within this intermediate phase is to transform planning practices in the country to reflect the demands of contemporary cities and societies. This will be pursued in tandem with efforts to re-engineer existing settlements into sustainable ones. This will be accompanied by the necessary infrastructure complements over the period.

Programmes to re-engineer existing human settlements to meet sustainable city principles and in accordance with the NSDF will be extended into the long-term phase of the plan implementation. New cities and city extensions will be established according to eco-city models. Complementary efforts to provide functional municipal services and infrastructure in existing cities and towns are a priority. These include social and civic services; health, education, markets, public parks etc. It is envisaged that by the end of this period, a significant proportion of infrastructure deficiencies in settlements will be addressed and existing settlements will begin to emerge as modern sustainable cities. This is to be seen as the stage where spatial management, infrastructure, social systems and housing have evolved to meet the vision of a high-income country.

Table 15.3: Key Development Goals and Objectives

GOALS	OBJECTIVES
1. Sustainable city planning and urban development	1.1 Improve planning and urban management capacities of local governments for developing sustainable cities
	1.2 Refine and formulate enabling policy and institutional mechanisms for district development planning
	1.3 Foster and promote knowledge exchanges and research on sustainability and urban resilience
2. Cities without slums and/or informal settlements	2.1 Enhance economic status of low–income households to improve their quality of living
	2.2 Ensure equity in access to housing and housing finance
	2.3 Regularise security of tenure of slum residents
	2.3 Build social capital, institutional capacity and framework to sustain slum upgrading activities
	2.4 Initiate and sustain home improvement schemes for slums across the country
	2.5 Improve access to quality basic services
	2.6 Formulate and implement slum upgrading and infrastructure improvement strategies
3. Promote efficient use of urban land	3.1 Reduce urban sprawl relative to population increases
	3.2 Facilitate the rehabilitation, adaptive reuse, redevelopment of public housing estates
	3.3 Actively enforce zoning and building regulations to improve quality of urban space.
	3.4 Strengthen institutional capacities, structures and frameworks for effective urban governance
	3.5 Initiate and further implement comprehensive slum upgrading programmes and urban regeneration programmes
	3.6 Promote urban (re)development schemes to maximise use of land
4. Improve functionality, efficiency and resilience of existing settlements	4.1 Actively promote compact development, adherence to building codes, and sustainable growth of human settlements
	4.2 Explore innovative financing and foster new partnerships for urban development
	4.3 Identify and develop balanced polycentric settlement hierarchies with high economic vibrancy
	4.4 Stimulate growth poles to curb ineffective migration to the major urban conurbations
	4.5 Develop and promote public green spaces in both urban and rural areas.
5. Improve quality of life and environment of rural communities and small towns	5.1 Ensure housing market that effectively supplies and allocates housing to various household income groups
	5.2 Increase access to green open spaces and parks
	5.3 Promote non-motorised mobility and improve supporting facilities
	5.4 Encourage mixed-used developments at specified locations
	5.5 Encourage preservation of historical, cultural and distinctive character of rural areas
	5.6 Pragmatic and robust planning regimes to manage the built environment
	5.7 Improve housing quality in rural areas and small towns
	5.8 Promote rural enterprises and innovation
6. Improve institutional capacities to effectively manage urban	6.1 Ensure effective planning and management of urban growth and sprawl.
	6.2 Develop and implement settlement disaster and risk management strategies

GOALS	OBJECTIVES
development and space	
7. Improve functionality, efficiencies and resilience of human settlements	7.1 Incentivise the construction of compact, new mixed-use projects, maximise use of land resulting in the creation of liveable neighbourhoods
	7.2 Ensure effective management of urbanisation and human settlements.
	7.3 Accelerate slum upgrading and programmes to prevent the formation of new slums.
	7.4 Develop resilience strategies and strengthen settlements' disaster coping mechanisms
	7.5 Enable and synergise functional hierarchies of settlements
	7.6 Promote urban development research
	7.7 Increase investments in promoting cities as engines of economic growth
8. Promote healthy, prosperous and equitable cities	8.1 Develop new towns and growth centres that attract migration away from the Kumasi and GAMA conurbations
	8.2 Enhance capacity of local governments to effectively manage spatial planning and development
	8.3 Develop safe and compact sustainable cities complemented with smart growth principles and energy efficient, transit oriented development to maximise use of public transport systems
	8.4 Create an environment for increased public awareness of environmental issues and participation in decision making
	8.5 Safe and equitable access to city services

Source: Author's Construct

Implications of Development Strategy – Shelter and Human Settlements Sector

Land and Settlement Management

Population and wealth increases have a positive bearing on demand and per capita consumption of municipal services. The expected population increases by 2047 puts tremendous pressure on capacities of service delivery and settlement management.

Similarly, solving the housing needs implies significant land consumption even with the proposed vertical developments. Availability of unoccupied lands as well as optimisation of usage of currently occupied parcels of land through tools available to planning authorities like urban regeneration and densification will be central to the materialisation of increased housing production without exerting unnecessary pressure on environmental and land resources as well as curtailing urban sprawl. The slum upgrading/phasing out and urban regeneration programmes will seek to leverage about 90,000 acres of land across the country to provide housing within the existing urban fabric. This will take care of about 30 percent of the land needs for housing the additional households expected between 2010 and 2047.

15.6 Programme Implementation Framework[83]

Over the plan period, the following flagship programmes are proposed to hasten the re-engineering and functionality of human settlements, with the understanding that the successful implementation of the entire GIP rests on the backbone of a well-structured human settlement design.

National urban regeneration and economic renewal programme

The national urban regeneration and economic renewal programme will seek to regenerate prime areas within cities using land redevelopment schemes etc. This will

[83] Further details are provided in respective sector policies and frameworks

ensure the efficient use of land in order to harness the full potential of urban assets for further growth and development.

The programme will ensure the development of comprehensive schemes to improve the public environment, with increased access to social services and better access to quality and safe housing as well as improved housing and mutually beneficial economic relationships between city districts and the broader metropolitan/municipal areas will be enhanced and strengthened.

The programme implementation will involve brownfield developments within towns and cities, and the maximisation of land use through relative densification. General goals at improving traffic flow, waste and environmental management, drainage and sanitation systems and urban security, which will improve the general well being of the inhabitants will be pursued. Attention will be given to reviving ecosystems by incorporating green parks and rejuvenating water bodies that go through cities.

The NSDF proposes that a grid-based system be adopted for urban expansion to promote compact development, increase connectivity, promote mixed land use, avoid waste and improve land values. The greater metropolitan areas and regional capitals will implement their master plans within this framework, while current settlements that are adaptable will be redesigned and laid out in grid form. Future developments and expansions will adopt this pattern of development.

Implementing the programme successfully will require the strict enforcement of and the adherence to zoning regulations as well as strong linkages with the water resources, drainage and waste management sub-sectors, together with the transportation, energy, ICT, construction, housing and civic infrastructure and climate resilience sectors.

Cities without slums – “Make Slums History”

This will involve phasing out all slums by converting them into viable and functional suburbs in cities, with improved quality of life and secure tenures for inhabitants. The implementation, which will be done in connection with the national urban regeneration programme, will adopt a participatory approach in order to ensure that the development is holistic and sustainable.

The principles of upgrading and progressively phasing out slums, will be applied to all the existing slums in Ghana, which will be determined through detailed profiling of slums in the country.

The approach to make slums history in Ghana will be one of progressive transformation, starting from upgrading of infrastructure and allied services, enhancement of the building fabric, replacement of dilapidated buildings, and incremental densification towards complete modernisation. The process will also seek to improve the general environmental quality of the slum areas, making them fit adequately into the fabric of the regenerated urban areas.

Strong institutional commitment, proper coordination between the different levels of government and adequate stakeholder participation will be required to make these efforts successful.

Sustainable/Smart Growth of Small Towns and Rural Communities

Rural areas/small towns, which are mostly found in close proximity to urban areas, have such resources that include agricultural land, forests and water resources that need to be preserved. It is important that development is sensitive to the conservation of these resources and heritage while strengthening the economies of these rural areas.

The NSDF proposes certain key strategies to promote sustainable growth of rural areas and small towns, so as to safeguard agriculture, diversify rural employment options, maintain the character of rural communities and to strengthen rural communities in order to retain the rural population.

Community action plans and local structure plans will be prepared and enforced as a basis for the transition of rural communities into sustainable ones. Decent housing, settlement structure, economic viability, improved access to basic services among others will all be promoted within a highly informed and educated rural populace. The implementation of any related schemes will be preceded by detailed community profiling supported by the respective local governments.

Revitalisation of distressed mining towns

This will involve the detailed profiling of mining communities; establishment of a technical committee to advice on revitalisation initiatives; creation of partnerships among necessary government, mining companies and other private organisations; establishment of a set fund for revitalisation of mining towns, based on profile of mining towns; enhancement of the capacity of local government authorities to better plan and manage mining towns; and the commencement of corresponding initiatives including infrastructure development (including roads, water, electricity, drainage, sewerage & telecommunications), relocation, integrated housing programmes, awareness creation, working conditions of miners etc. based on profile of towns.

The first phase of the plan will place attention on large-scale mining towns across the country, with special focus on Obuasi, Konongo and Tarkwa. These settlements will be redesigned to host a population equivalent to a metropolis with corresponding supporting infrastructure. Efforts to revitalise mining towns will be integrated with economic, social, environmental and infrastructure systems. The overall objective is to transform mining towns into sustainable human settlements of which decent housing will be key. The support of mining companies operating in these areas will be necessary to ensure the success of the programmes.

Re-planning of Informal Industrial Enclaves

Several informally developed and progressively conscripted spaces are littered around the country's urban landscape. Known by the generic reference of "kokompe", these spaces are usually auto-repair industrial precincts that tend to be quite intense in activities, and yet are largely premised on poorly equipped garages using archaic technologies. These sites tend to be poorly serviced, and unstructured in their layouts. The largest ones are found in Accra (Abossey Okai, Kokompe) Kumasi (Suame Magazine) and Takoradi (Kokompe). Businesses in these areas are typically dependent on extraordinarily innovative and highly skilled native acumen where knowledge is accumulated by tacit learning. Notwithstanding these constraints, Suame in Kumasi and Kokompe in Accra have grown in their reputation for industrial ingenuity in auto-repairs, drawing clientele from all over West Africa.

The potential for stimulating economic growth in these enclaves is not in doubt and gives reason for an infrastructure retrofitting and technology enhancement investment programme in these precincts. Under the GIP, this programme dedicated to upgrading the auto-repair and light industrial sites enclaves must insert all the basic services – access roads, solid waste management, water and sanitation, and telecommunication. To enhance the identity of these precincts, it is proposed that facilities for learning and sharing such as buildings for demonstrations, and internet services must be incorporated into the upgrading. It is important that the environment within the enclaves have enough greenery incorporated and deliberately maintained as well.

Establishing Green Infrastructure Networks

The Green Infrastructure Network (GIN) comprises a network of green places and water systems that deliver multiple environmental, social and economic values and services to urban and rural communities. Simultaneously, a GIN serves as an ecological network, wildlife corridor or a river buffering system. It can also be an enhanced forest reserve network, a recreational asset and a visual amenity, as described in the NSDF. While the GIN protects natural systems and preserves open spaces, they also serve as a life support system for the urban environment, and mark where one settlement begins and ends.

The proposed GIN in Ghana comprises all protected areas, the entire coastline as well as the main water bodies. It will also include new connectors between these elements using green corridors along existing and new roads as well as railways.

The implementation of the GIN country-wide, will be led by the public sector (government agencies, local authorities, etc.), although strong partnership with the private sector and civil society will be strongly encouraged. SDFs and development plans, whether at the regional or district level will have GIN strongly incorporated. Sector agencies like the Forestry Commission, MOFA, MWRWH etc., will play major roles in the planning and maintaining of the GIN.

Development of Agricultural Growth Corridors

This involves the conversion of land in regions with subsistence agricultural practices and huge unrealised agricultural potential into areas of commercial agriculture at an industrial scale. While this does not necessarily mean bringing excessive physical development to the defined areas, strategic infrastructure like transportation networks, irrigation schemes, storage and processing facilities, etc, which will attract the necessary investments and help promote commercial agriculture will be developed.

The Ministry of Food and Agriculture (MoFA) will spearhead and define policies that will guide the implementation process. Opportunities for Public-Private Partnerships (PPP) will be considered strongly for the successful implementation of this process. The NSDF defines the following actions as critical for effectively implementing the AGC:

1. The development of the required infrastructure.
2. Promotion of small scale farmers as out growers and contract farmers.
3. Strong opportunities for PPP.

It is important to acknowledge that as cities grow and expand, there is the tendency for agricultural lands to be converted into residential areas and so this concept strongly relies on the promotion of dense, compact and vertical cities in order for agricultural lands to be preserved.

Creation of a Model Modern City

The development of a model modern city in a pre-determined location in the country is proposed. The new model city which will be designed as a smart city, equipped with advanced technology, world class underground drainage and transportation systems, with strong environmental sanitation and waste management schemes, built to be climate resilient and branded to serve a specific set of functions as a model sustainable city, could be built to possibly fit an area ranging from about 1km square to a large area, say 100km square. This model city will be a pivot around which other mixed use settlements will be built.

Lessons from the setting up and running of this city could be replicated in other cities in the country, based on the principles of aesthetics, technological advancement and environmental sustainability.

Capacity building and institutional restructuring

Enhance planning and development control capacities of local governments through skills training, capacity building exercises, restructure institutional relations and policy environment for planning

15.7 Indicators for Human Settlements

Based on the challenges identified with settlement planning and management in Ghana, a number of indicators have been developed to track settlement planning and management to fast–track the creation of liveable settlements envisaged for Ghana in the next 30 years. The indicators developed are based on the weaknesses of settlement planning and the poor state of most settlements in Ghana, which needs to be changed. The other source of the indicators is from the sustainable city indicators[84]. It is believed that tracking these indicators can provide valuable information for planning, settlement management and evaluation to further improve settlement planning and management in Ghana.

Table 15.4: Indicators for human settlements in Ghana

THEMATIC AREA	INDICATOR (S)
Land use planning and management	Number of SDFs by the districts (%)
	Number of structural plans
	Number of local plans in a district (% of district with local plans)
	Number of slums/blighted areas upgraded (% as a percentage of existing slums and % settlements)
	Number of district residents aware of structure plans/SDF/local plans
	Number of billboards with local plans displayed
	Percentage of land use conforming to local plans/structural plans
Transport	Transportation mode split (percentages)
	Availability of motor and bicycle lanes (% of existing roads)
	Availability of pedestrian lanes (ratio to existing roads)
	Availability of disability friendly traffic signals at road intersections
	Percentage of road ways in good condition (of built up areas of MMDAs)
	Percentage of trips made by bicycles/walking
Quality Open Spaces (Environment)	Percentage of preserved areas, parks, water bodies etc. in relation to land area
	Percentage of green space in relation to total land area
	Percentage of play grounds/ active open space in relation to total land area/ population
Access to water and sanitation	Percentage of population with properly engineered sewage systems (effective alternatives)
	Percentage of population with access to adequate and safe water
	Percentage of population with access to toilets

[84] Issues of housing and informal settlements which are all urban planning issues are discussed under the housing section.

Air Quality	Level of particulate matter in major cities
Solid Waste Management	Percentage of solid waste recycled
	Availability of engineered land fill sites
	Availability of waste segregation systems in MMDAs/communities
Compact settlement / city	Access to local services like schools, health facilities and local shopping centres etc.

Source: Author and European Commission Sustainable Cities Indicators (2015)

15.8 Existing Policy and Institutional Arrangements

The following policy frameworks and institutional arrangements already exist to guide human settlements development in the country.

The National Spatial Development Framework establishes a national direction for land use and spatial planning and management. It is meant to guide the preparation of lower hierarchy plans and ensure balanced urban and rural development.

The Land Use and Spatial Planning Act (Act 925, 2016) guides land use planning at all levels within the decentralised contexts. It defines the planning procedures and the kinds of plans to be prepared at each decentralised level.

The Zoning Guidelines and Planning Standards (2011) is a two-part document, with the first part detailing out permissible land uses within classified zones, and the second part defining spatial planning standards and criteria for determining the site and sphere of influence of relevant facilities.

The National Urban Policy and Action Plan identifies urban challenges and their effects on the country's urban systems, and defines initiatives to promote sustainable, spatially integrated and orderly urban development.

The National Housing Policy (2015) provides the broad framework for addressing the variety of challenges in the housing sector and offers guidance to programmes and initiatives in the sector. The issues identified in the policy are segmented into those affecting the supply of housing on the one hand, and issues affecting the affordability of the delivered housing, on the other hand. The focus is to provide adequate housing that is accessible and affordable to satisfy the needs of all people.

The Ghana Infrastructure Investment Fund (GIIF) (Act 887, 2014) is a fund set up with the principal aim of obtaining financial resources from the public sector and other non-state sources towards the infrastructure needs of the country that are captured within a strategic plan. It is expected to act independently of the government in its outlook with an appropriate assessment of the risks, making room for partnerships in the execution of its mandate.

The 1992 Constitution and Local Government Act (1993) encapsulate all decentralised planning issues in the country. Chapter 20 of the constitution defines the contexts for local governance and administration, while article 242 makes district assemblies the highest planning authority at the local level.

National Climate Change Policy (2013) addresses climate change issues that relate either directly or indirectly to human settlements. The policy seeks to address the conflict between the sprawl of human settlements and preserving agricultural land uses in peri-urban areas. It also addresses ways to improve urban planning, building infrastructure that are resilient and adapting communities to climate change

Chapter 16 Shelter and Housing Systems

16.1 Introduction

The demand for housing has generally outpaced supply over the years due to rapid population growth and increasing urbanisation, thus making shelter a critically scarce commodity and prompting a yawning deficit between demand and supply. Overcrowding, declining quality of housing and access to housing services characterise much of the housing stock in the country.

The housing challenge in Ghana, therefore, is presented in both quantitative and qualitative measures. There is therefore the need to develop a strategy in the short term that will bridge the housing supply gap in the country, in the medium to long term, in order to ensure that every individual, particularly those in the low income cohort, has access to decent housing, either by ownership or rental. The government has a major role to play in this, particularly in the creation of an enabling environment for housing delivery.

Over the plan period and beyond, the citizens' right to live in dignity and under habitable circumstances must be recognised, as much as their right to choose what their own housing needs are. It must also be recognised that the housing sector plays an important role in the socio-economic development of the country, thus:

1. Housing sector investments represent a large share of total capital formation at the national level.
2. Expenditure on the consumption of housing services accounts for a substantial part of the disposable income of private households.
3. Housing ownership, for most people, is the most important incentive to save, the principal asset they might own, a source of rental income, and, perhaps most importantly, the basis of economic activities (the shop or workshop for small scale enterprises).

While previous attempts at resolving the issue have not been well defined, the gravity of the challenge requires that the country adopts a clear strategy or policy that will bring a boost to the housing sector and efficiently clear the housing deficit. This will also ensure that the country accrues the economic benefits (employment, fixed capital, and financial deepening) from the housing sector.

Inherent in fulfilling the agenda for human settlements in Ghana for the period, lies the strong intent to develop an efficient housing market and housing system that equitably delivers different housing types to meet the diverse needs of the varying social classes of the population, while driving national and local economic growth through its multi-sectoral interconnections, and fostering strong public, private and community partnerships.

16.1.1 Vision of Housing provision in Ghana

The vision for the housing sector for the next 40 years therefore, is dubbed "housing for all, by all". Government envisions, therefore, to "create viable and sustainable communities through the provision of adequate, decent and affordable housing that is accessible and sustainable to satisfy the needs of Ghanaians". It is thus projected that the housing market will generate competitive developers and other service providers capable of expanding their operations across the country. It also envisages central and local governments that are versed strategically and transparently, in leveraging public resources to draw-in private and community resources towards meeting housing needs, both quantitatively and qualitatively.

To meet this vision over the period requires that housing be:

i. Built Efficiently;
ii. Serviced Adequately;
iii. Located Appropriately; and
iv. Affordable to all households, irrespective of their income and social standing (including student housing, housing for the aged and the marginalised).

To fulfil this aspiration, the involvement of all stakeholders in all spheres of the housing value chain – planning, design, development and management – is required and must be actively engaged.

16.2 Overview of the Housing Sector

16.2.1 Housing Supply

The national census results indicate an increase in housing stock over the different census years. Between 1984 and 2000, housing stock increased by 81percent and a further 55percent by 2010 to reach 3.4 million[85] units (Table 16.1), with about four in seven houses of the inventory being in rural areas. The increasing congestion suggests that the rate of construction of new dwelling units was slower than the formation of new households. The increase in housing stock however, is irrespective of housing quality.

In spite of the gradual increase in housing delivery, the housing sector is characterised by high rental prices and costs[86], which caters to the needs of high-income households and expatriates. With the influx of large populations into the cities in addition to immigrants from the diaspora, housing supply (both formal and informal) is under substantial strain. A significant proportion of households are thus living in severe congestion and/or in poor housing conditions.

Table 16.1: Stock of housing and occupancy

	1960	1970	1984	2000	2010
Population (Total)	6,726,815	8,559,313	12,296,081	18,912,079	24,658,823
Housing stock	636,189	945,639	1,204,395	2,181,975	3,392,745
% Increase in stock		49%	27%	81%	55%
Mean number of persons per houses	10.6	9.0	10.2	8.7	7.3

Source: GSS (2013)

The increase in demand for housing that is affordable, particularly in the country's prime cities, is thus overwhelming even for the informal delivery systems to meet. The prices of properties even in the informal market are skyrocketing, further worsening the living standards of the urban poor. These households, therefore, require housing both in quantitative and qualitative terms.

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[85] The inventory captures absolute numbers. There is currently no data on the quality of the houses.
[86] The Bank of Ghana (2011) sees these as being overpriced.

One of the causes of such high levels of poor housing is the low prioritisation of shelter needs by the government, in the face of other pressing needs such as energy and sanitation. While focus on improving and sustaining incomes of households is rational and augers well for the long-term development goals of government, engineering housing solutions that meet what can be described as a housing crisis, is urgent.

Approaches for Housing Supply in Ghana

Housing is supplied by the public sector and the private sector in Ghana. The public sector housing development activities are handled by agencies like the State Housing Corporation (SHC), the Tema Development Corporation (TDC) and the Social Security and National Investment Trust (SSNIT). Real estate developers usually lead the private sector, although the overall output of the formal private sector accounts for less than 10 percent of the total housing stock in the country.

There is also a third sector, which is referred to as the traditional or vocation based approach. This latter approach comprises of two delivery systems: the self-help and self-managed housing delivery systems, in which individual households engage in self-build or self managed construction, and the cooperative land aggregation and private housing developments systems in which a group of people, mostly vocation-based collectives, jointly acquire land, which they later subdivide and allocate to individual members who then undertake the construction by themselves.

16.2.2 Housing Need

Housing need refers to the quality and quantity of shelter that is required by all households in spite of their income status. The term further describes the needs of people without any housing at all, and that of persons whose household size calls for expansion or improvement of their current dwelling unit.[87]

Estimating Housing Needs and Market Segments

In order to establish the housing need, the National Population Council presents three (3) population growth scenarios for the country, based on contraceptive prevalence (CPR) rates of 0.5, 1.0 and 1.5 percentage points per annum for high, medium and low variants respectively (Table 16.2). These scenarios provide the population bases for the housing needs assessment in this sub section.

The Urbanisation split of the population is based on the urbanisation scenarios provided by the NDPC.

Table 16.2: National population growth scenarios

Year	Urbanisation	Low birth rate scenario	Average birth rate scenario	High birth rate scenario
2018	54.0%	29,242,422	29,491,279	29,740,135
2020	57.2%	30,425,791	30,819,286	31,212,780
2025	60.0%	33,396,229	34,329,697	35,263,164
2030	62.6%	36,267,646	38,040,887	39,814,128
2035	64.8%	38,925,683	41,925,917	44,926,151
2040	66.8%	41,242,203	45,997,564	50,752,925
2045	68.7%	43,270,415	50,168,787	57,067,159
2047	70.5%	44,081,699	52,252,835	59,603,971

Source: National Population Council and NDPC projections, 2017

[87] Housing Need differs from housing demand, which describes the ability and willingness of households to pay for the housing required.

Housing needs based on households per dwelling units

The number of households in Ghana recorded in the 2010 PHC was 5.5 million with an average household size of 4.44. It is expected that the number of households will increase to 12.2 million by 2047, although the household size will reduce to 3.8.

The 2010 PHC, as well as GLSS 5 and 6 reports indicate that ideally, a household should occupy a dwelling unit or a house. In practice, that is not the case. The number of households recorded in the 2010 PHC was 5.5 million, while the number of dwelling units was 3.4 million. The report also indicates that an average of 1.6 households occupy a house in Ghana. It is expected that the average number of households per house will gradually reduce from 1.6 2010 to 1.2 by 2047.

According to the UN MDG 2015 Report 2015, the number of houses with access to portable water and safe toilet is less than 20percent while the percentage of houses with access to all-weather access road is about 20percent. To achieve High-income country status, it is expected that a house must have all the facilities needed in the home, namely piped water, flush toilet, access road, security of tenure on the land and house, durable structure of a permanent nature and secured from the risk of collapse, etc. Currently, it is only for about 10percent of the existing housing, that water can be connected and flush toilets incorporated without the need to rebuild the house. Therefore, the number of houses in satisfactory condition is about 30percent.

This implies that only about 1 million houses in Ghana satisfy this condition, with the remaining 2.34 million being in unsatisfactory and dilapidated conditions.

Table 16.3: Estimated housing needs per household (HH), 2010 to 2047 based on the medium/average population growth variant

Year	Projected Population	Household Size (projected)	Additional Population after 2010	No. of new Households	No. of houses needed
2010*	24,658,823	4.44			2,100,000
2015	27,491,279	4.38	2,832,456	646,679	646,679
2020	30,819,286	4.32	3,328,007	770,372	770,372
2025	34,329,697	4.24	3,510,411	827,927	827,927
2030	38,040,887	4.15	3,711,190	894,263	894,263
2035	41,925,917	4.05	3,885,030	959,267	959,267
2040	45,997,564	3.97	4,071,647	1,025,604	1,025,604
2045	50,168,787	3.88	4,171,223	1,075,057	1,075,057
2047	52,252,835	3.8	2,084,048	548,434	548,434
TOTAL					**8,847,603**

Source: NDPC (2016) and Authors' estimates (2016)
*Backlog from 2010 PHC

Given the average population growth scenario (Table 16.2), where the total population of the country reaches about 52.2 million by 2047, an extra 8.84 million houses (including the backlog from the 2010 PHC) must be added to the housing stock of the country in order to accommodate the additional households by the year 2047 (Table 16.3), in order to meet the vision of "housing for all, by all".

Housing needs according to room[88] occupancy

The 2010 PHC together with the GLSS 5 and 6 studies indicate that households often occupy a dwelling unit within a house, as is the case of compound houses, being the

[88] 'Rooms' as used in this section refers to sleeping rooms

commonest housing typology in both rural and urban areas. Between 2000-2010, households occupying rooms in compound houses increased from 44.5percent to 51.5percent.[89]

Considering the housing need based on the number of rooms will provide a more realistic assessment, given that it follows the current tenure practice.

Estimating the number of rooms in Ghana

The 2010 PHC reports that 44.5 percent of households in Ghana occupy single rooms. With only 4.4percent of households occupying nine or more rooms, the number of rooms available in Ghana in 2010 can be estimated based on this information[90].

Table 16.4: Estimated number of rooms available in Ghana in 2010

	Number of Rooms						
	1	**2**	**3**	**4**	**5+**	**Mean rooms**	**Total Rooms**
Percentage distribution of rooms	44.5	24.8	11.6	7.1	12.0		
Number of households occupying these rooms in 2010 ('000s)	2,432	2,712	1,903	1,553	4,286	2.4	13,116

Source: Authors' construct based on GSS (2013). *In calculating the rooms occupied for households occupying 9 or more rooms, a class value of 11 was used.

Per Table 16.4, of the estimated 13 million rooms that existed in the year 2010, households occupied an average of 2.4 rooms, with an average household size of 4.4 persons. There were fewer rooms per urban household, as compared to rural households. In urban areas, about 51.4 percent of households occupied single rooms as compared to 35.9 percent in rural areas. This suggests significant levels of crowding, especially in urban households.

Decongesting Existing Rooms

As earlier indicated, per the 2010 PHC report, about one in every two urban households (with a household size of 3.6) occupies a single room. However, about 26 percent of this category of households, that were occupying single rooms (792,854 households), actually required more rooms, per the new zoning and planning standards, which proposes a maximum of 2 people per room (ppr)[91], for high-density areas. Therefore, in order to decongest and maintain a recommended 2 ppr as at 2010[92], urban households required an additional 1.7 million rooms[93].

Table 16.5: Number of rooms per household required at 2 PPR in Urban Ghana in 2010

	Number of Rooms						
	1	**2**	**3**	**4**	**5+**	**Mean* rooms**	**Total Rooms (,000s)**
2 persons per room (%)	35.4	29.1	20.3	8.8	6.4	2.4	7,151
Percentage of households actually occupying these rooms	61.4	22.2	7.8	4.2	4.5		
Number of rooms actually occupied by these households ('000s)	1,872	1,354	714	512	961	1.8	5,413

Source: Authors' estimates based on GSS (2013) Household size data from 2010 PHC (p.g. 76)

[89] GSS (2013)
[90] GSS (2013) pg. 381
[91] MEST (2011), used as threshold for the prognosis
[92] The analysis used 'sleeping rooms' as captured in the PHC. In an expected housing setting additional space for living, kitchen etc. should be anticipated
[93] This estimation does not take into consideration the quality of existing rooms

*For 5 or more rooms, a class value of 7 was used.

Approximately 23 percent of households occupying one and two rooms (20 percent and 2.5 percent of households respectively) required additional rooms (Table 16.6). In total, therefore, 1.9 million additional rooms were needed to decongest households in rural areas to attain the desired number of 2 ppr in 2010.

Table 16.6: Number of rooms per household required at 2 PPR in rural Ghana in 2010

	Number of Rooms						
	1	**2**	**3**	**4**	**5+**	**Mean rooms**	**Total Rooms (,000s)**
2 persons per room (%)	25.5	24.4	22.9	13.6	12.6	2.9	7,987
Percentage of households actually occupying these rooms	45.5	26.9	13.1	6.8	7.6		
Number of rooms actually occupied by these households ('000s)	1,272	1,505	1,099	761	1,487	2.2	6,124

Source: Authors' estimations based on GSS (2013) Household size data from the 2010 PHC
*For 5 or more rooms, a class value of 7 was used.

Room needs for extra urban households by 2047 according to average growth scenario[94]

By the year 2047, about 9.6 million households (70.5percent of the population) are expected to live in urban areas in Ghana. Urban areas will add on approximately 6.9 million households in relation to the baseline from the year 2010. Assuming the additional households retain similar household sizes as in the year 2010, the households can be distributed according to the number of rooms they will require at 2ppr. Within the period, an additional 16.1 million rooms must be built to cater for the extra households that will be living in urban areas.

Table 16.7: Room needs by extra urban households over 2010 population at 2 PPR

Year	Proportion of urban population[95]	Extra urban households over 2010	Total rooms needed (,000s)
2018	54.0%	728,107	1,707
2020	57.2%	1,183,561	2,775
2025	60.0%	1,843,380	4,323
2030	62.6%	2,804,132	6,576
2035	64.8%	3,584,225	8,405
2040	66.8%	4,947,680	11,602
2045	68.7%	5,882,576	13,795
2047	70.5%	6,884,297	16,144

Source: Authors' estimations (2017)

Room needs for additional rural households by 2047

Household sizes tend to be relatively larger in rural areas (averagely 5.1 persons), than in the urban areas (averagely 3.6). However, given that the proportion of rural dwellers will progressively reduce within the plan period, reaching 29.5 percent by 2047, the extra households to live in rural areas by this period will require an additional 4 million rooms.

[94] Other scenarios are presented in the main report
[95] The 2010 PHC indicates that 51% of the Ghana's population live in urban areas and 55.8% of households live in urban areas. The proportion of population in urban areas is used in estimating room needs

Table 16.8: Room needs by additional rural households over Y2010 at 2 PPR

Year	Proportion of rural population	Extra rural households over 2010 (,000s)	Total rooms needed (,000s)
2018	46%	322	925
2020	42.8%	304	854
2030	37.4%	682	1,957
2040	33.2%	1,191	3,418
2047	29.5 %	1,397	4,012

Source: Authors' estimations (2017)

Assuming the 2010 deficit of 3.6 million rooms (in both urban and rural areas) remains unresolved, a total of 23.7 million rooms must be supplied by 2047 – an average 66,000 rooms per month over the next 30 years.

16.3 Housing Demand and Affordability

The demand for housing in Ghana is greatly influenced by the ability of the individual/household to afford it and the willingness to pay for it.

It can be inferred that 35percent of all urban households can only afford a house priced at Gh¢12,000 as the capital cost of their housing and 85percent of all urban households can afford less than Gh¢72,000. The figure also reveals that only the top 20-25percent of urban households can afford the cost of just any house either for purchase or rental, at one-third of their income. Rental levels at the current rent to household income of 10percent or less are also very low, showing 50percent capable of paying GH¢ 300 or less per month and 35 percent requiring accommodation with rents of GH¢10 or less[96].

Figure 16.1: Housing affordability pyramid[97]

Income Range	Income GHC/Month	Percentage of all Households	Maximum affordability HC:Y=3	Housing cost aimed at the thresholds*	Monthly maximum rent levels affordable at R:Y of 10%
Very High	>4,000	5%	180,000	476,000 & 204,000	500+
High	3,001-4,000	10%	144,000	163,200	400
Mid-high	2,001-3,000	50% of households can afford housing costing less than GH72,000	108,000	95,200	300
Middle	1,001-2,000		72,000	Up to 54,000	200
Moderate	501-1,000		36,000		100
Low Income	101-500		18,000		50
	51-100	35% of households can afford housing costing less than GHC12,000	12,000		10
No wage Income	0-50				

The government of Ghana must adopt and follow sustainable housing processes, which will enable Ghanaians to acquire housing with secure tenure, within an integrated society, within a safe and healthy environment, in liveable and productive communities within the shortest possible time, all in a bid to clear the housing deficit.

[96]Sourced from the national Housing profile, (2011)
[97] Sourced from: http://www.housingfinanceafrica.org/country/ghana/

16.4 Land Requirements for Future Housing Needed

The average population growth rate scenario as projected in Table 16.2, shows that 52.2 million people, made up of over 12.2 million households, will be inhabiting Ghana; implying an additional approximately 6.7 million households will be added over the plan period (in relation to the 5.5 million households in 2010).

To house the anticipated 8.8 million households alone in single dwellings by 2047, would require a gross land area of 953,000 ha[98]; nearly 2.9 times the land size of the Greater Accra Region. The amount of land required is reduced by more than five-fold if the new housing is provided in line with the new density standards — a minimum gross density of 176 p.p/ha and a maximum of 330 p.p/ha[99]— translating to 177,000 ha and 94,000 ha of land respectively.

16.5 Building Materials Requirements

16.5.1 Building Materials and Construction Technology for the Supply of Housing

Building materials used in the country are either imported or locally manufactured. Those that are imported include paint, locks, tiles, ceramics, fittings and fixtures for water supply, sanitation and electrification. Over 90percent of building materials are imported, which thus exposes the market to shocks from external sources and leads to instabilities in the currency[100]. Enhancing local alternatives will promote competition in the local market (as is happening currently in the cement industry in Ghana), leading to price reduction, which will in turn contribute to driving down the cost of housing delivery, as well as creating a positive trickle down effect along the construction value chain.

Sandcrete is widely used in building construction in urban areas and is fast catching up in the rural areas (Table 16.9). In the GAMA region for instance, nearly all buildings are constructed using sandcrete blocks. In the rural areas however, the use of sandcrete blocks is often associated with prestige, as against the use of earth based and organic materials. Sandcrete materials are evolving into different forms, in attempts to efficiently use cement and sand. Hollow blocks[101] of different forms are increasingly becoming popular among new homebuilders to increase speed of housing delivery and profit from cost reductions.

Table 16.9: Summary of Main Materials Used for Outer Wall

	Accra (GAMA)		Other Urban		All Urban				All Rural			
Main materials used for outer wall	GLSS V (2008)	GLSS VI (2013)	GLSS V (2008)	GLSS VI (2013)	PHC (2000)	GLSS V (2008)	PHC (2010)	GLSS VI (2013)	PHC (2000)	GLSS V (2008)	PHC (2010)	GLSS VI (2013)
Mud/Mud	2.3	0.6	26.5	15.0	21.5	18.5	12.4	10.4	74.5	72.9	60.5	56.9

98 Using a typical government built bungalow, which usually occupies a plot size of 750m². This gives a gross of 8.6 plots per ha (1 plot = 75*100ft). Additional details are found in the main report. For details on methodology see UN-Habitat (2011). (You are quoting plot size in m² but providing a breakdown in ft²)
99 TCPD (2011)
100 UN habitat (2011)
101 GAMA blocks from Parakuo for example promises up to 30% reduction in cost and up to 50% savings in time.

bricks/Earth												
Wood	7.5	6.5	0.5	0.6	5.4	2.8	4.8	2.5	2.7	1.0	1.8	0.7
Metal/sheet/slate /asbestos	0.5	1.0	0.1	1.0	0.9	0.2	1.0	1.0	0.3	0.1	0.5	0.5
Stone	0.2	0.2	0.5	-	0.3	0.4	0.2	0.1	0.2	0.3	0.2	0.1
Burnt bricks	0.3	0.1	0.8	0.4	2.0	0.6	0.7	0.3	1.1	0.6	0.6	1.3
Cement blocks/ concrete	88.4	91. 5	69.4	82.5	65.3	75.7	78.5	85.3	16.6	21.8	32.1	39.7
Landcrete		-		0.4	2.9		1.2	0.3	2.6	3.1	2.5	0.3
Bamboo/Palm leaves/Thatch grass /Raffia/Others		0.1		0.1	1.6		1.3	0.1	2.0	0.1	1.7	0.5

Source: GLSS 2008 and 2013; PHC 2000

A new trend is however emerging in the urban landscape where new buildings are clad with glass and aluminium. Glass is also used for partitioning, especially in commercial properties. In other instances, where sandcrete is used for partitioning or filling in the structural frame, glass windows are equally becoming popular in new buildings in the cities.

16.5.2 Material Requirements to Meet Housing Need

Based on the premise of the average population growth rate scenario, and assuming that cement will be the major construction material during the period, approximately 299 million Mt/year of cement will be required to meet housing needs by the year 2018[102]. Currently, Ghana's installed cement grinding capacity is about 7.65 million Mt/year, i.e. GHACEM (4.4 million Mt/year), West African Cement (1.75 million Mt/year) and Dangote (1.5 million Mt/year).

The current collective capacity for cement production cannot meet the anticipated demand as it clearly falls short of the lowest estimated demand of 60 million Mt/year.

This presents both opportunities and challenges, where the opportunities lie in the fact that businesses can take advantage of the huge demand for materials, and the challenges, in the huge environmental effects of the demand for such materials as sand, chippings, wood, etc.

There is therefore the urgent need for research and development of new construction technologies, wood plantation development, development of an iron ore industry, cost effectiveness analyses and standardisation of design of building components, etc.

Table 16.10: Volume of materials required using medium variant (2018-2047)

Year	Total Dwelling Units/ Houses Required	Cement	Iron Rod	Wood	Roofing Sheets	Paint	Tiles	Glazing	Sand	Chippings
Quantities needed per 3-bedroom		61.85 tonnes	7.59 tonnes	$2.5m^3$	$461m^2$	$7\ m^2$	$404\ m^2$	$69\ m^2$	$150\ m^3$	$50\ m^3$

102 It is assumed that housing construction technology, which is currently cement based will remain the same throughout the plan period without substantial technology changes.

Year	Total Dwelling Units/ Houses Required	Cement	Iron Rod	Wood	Roofing Sheets	Paint	Tiles	Glazing	Sand	Chippings
dwelling unit										
2018	4,838,413	299 mil	36 mil	120 mil	2,230 mil	33 mil	1,954 mil	333 mil	725 mil	241 mil
2027	5,872,440	363 mil	44 mil	146 mil	2,707 mil	41 mil	2,372 mil	405 mil	880 mil	293 mil
2037	7,141,841	441 mil	54 mil	178 mil	3,292 mil	49 mil	2,885 mil	492 mil	1,071 mil	357 mil
2047	8,505,465	526 mil	64 mil	212 mil	3,921 mil	59 mil	3,436 mil	586 mil	1,275 mil	425 mil

Source: Authors' estimations (2017)

16.6 Basic Services for Housing

Ghanaian cities appear to have two distinct layers of municipal infrastructure in neighbourhoods. One layer comprises of well-serviced neighbourhoods inhabited by bourgeoisies and top income classes. Pockets of such neighbourhoods abound in prime cities; Accra, Kumasi, Sekondi-Takoradi. These areas have functional water, sewerage, solid waste and electricity supply systems. Often in close proximity to these settlements are the second layer of ill-serviced neighbourhoods occupied by low and middle income households. The rate of servicing settlements fast out paces the growth and expansion of cities in Ghana.

Potable Water

Access to safe drinking water is an important indicator for assessing slum settlements. Adequacy of water is determined by the proportion of households having access to potable water — not less than 60 litres/person/day[103], quality of the water, affordability and ease with which water is accessed[104]. The water and sanitation progress report, 2010, puts water supply coverage at 64 and 62 percent for urban and rural areas respectively and an overall coverage of 63 percent[105]. This implies that nearly 37 percent of Ghanaians do not have access to potable water, an indication of poor housing. By the end of the plan period, it is anticipated that up to 99 percent of Ghana's population will have access to potable water, with at least 90 percent having piped water in their homes.

Improved Sanitation

Sanitation is broadly defined to encompass both solid and liquid waste disposal. Sanitation coverage in Ghana for liquid waste was estimated at 18 percent and 7 percent respectively for urban and rural areas with an overall coverage of 13 percent as at 2010[106]. As at 2010, a total of 54 percent of the population shared toilet facilities, with 30 percent of households depending on public toilets, while more than 5 million people practiced open defecation. Only an estimated 5 percent of urban settlements were connected to a sewer system. Over the plan period, when toilets in particular are defined in relation to housing, the following are anticipated:

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[103] MEST (2011) recommend 60l/person/day for low income households
[104] Medal and Boyer (2010)
[105] Ministry of Water Resources, Works and Housing (2010)
[106] MWRWH (2010)

1. At least 70 percent of households report access to flush toilets
2. The facility must guarantee privacy
3. The sharing arrangement must be between a maximum of two households

The 70 percent coverage requirement measures availability whereas the privacy and sharing criteria exclude public toilets, open pits and bucket latrines as good sanitation facilities.

Also critical to the analysis is the pricing of sanitation services, accessibility, and supply constraints. Although households' expenditures on sanitation are generally low due to the high numbers of patrons who do not pay for sanitation services, it is still useful that affordability of same is ascertained. In order to address the sanitation and water infrastructure gap, an estimated USD 1.3billion is needed for rehabilitation and expansion of urban water infrastructure[107].

Electricity

Electricity is mostly used at the household level for the dual purposes of lighting and cooking. For some households, particularly in rural areas, cooking with electricity is totally out of the question since they are either not connected to the national grid or cannot even afford it for lighting. Electricity coverage at the end of 2010 was 72 percent overall but was lower in rural areas. Charcoal and LPG are fast becoming the dominant energy sources for cooking. It is worthy to note that there exist a significant number of households that are still using unclean cooking energy sources such as biomass or plant residue, which produce a lot of smoke. The target over the plan period is to have at least 99 percent of the total population with secure access to electricity, and to reduce drastically the use of unclean cooking energy in the process.

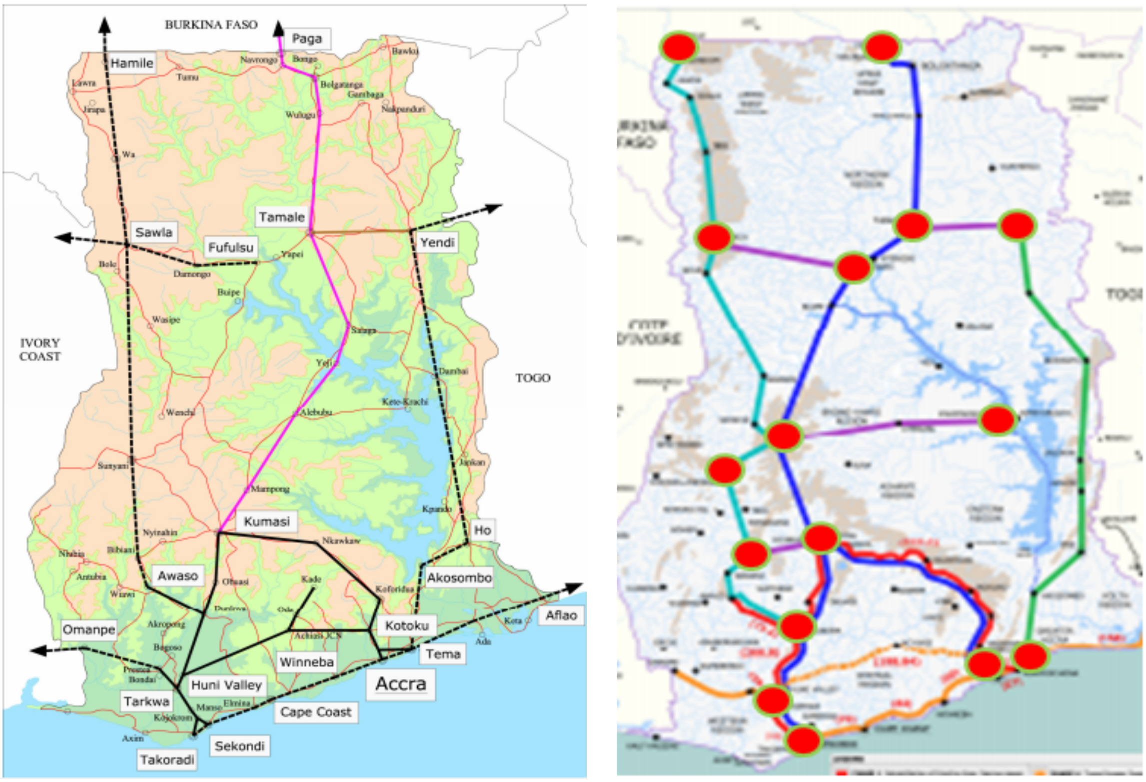
16.7 Overview of the Proposed Development Strategy

A new spatial development pathway anchored on the proposed urban regions of the NSDF and natural resources based industrialisation is recommended. This scenario seeks to promote industrialisation based on the resource endowments of the regions and their competitive advantages.

Housing needs assessment must be aligned to these centres and the extra population to be attracted there because of the new economic opportunities. Important for success will be the need to directly link the energy, transport, water, and ICT sectors among others to this scenario. Also, crucial for success will be the human resources, i.e., the technical and vocational skills needed to drive the whole industrialisation process right from the production of raw materials, through value addition, packaging, marketing, etc. There will be the need for some information on or knowledge of the potential production value chains this scenario is likely to generate since it can affect labour mobility significantly, hence housing and other basic social services. In this way, population is attracted away from the traditional large centres to minimise their dominance and ease urban management efforts.

[107] http://www.oecd.org/countries/ghana/38562673.pdf (the estimate is over an unspecified period)

Figure 16.2: Growth nodes linked to resource endowments, locational advantages



Source: Town and Country Planning Department (2015)

16.7.1 Key Development Goals and Objectives

In the short to intermediate phase, the focus must be to address the acute housing deficit, targeting both the quality and quantity of housing. The focus for the intermediate to long-term phase is to ensure effectiveness in the supply and demand systems of housing to provide the diversity of housing financing needed. Although this will be started in the short term, it will be strengthened in the intermediate to long term.

Table 16.11: Key Development Goals and Objectives

GOALS	OBJECTIVES
1. Provision of adequate new housing through stimulation of market efficiency and competition with public assistance for no and low-income households who cannot afford adequate housing.	Explore new sources of finance and partnerships for housing delivery including from the voluntary sector.
	Promote commercialisation and use of local building materials
	Promote decent affordable housing particularly for targeted populations; including low-income households, the disabled, young professionals and retirees.
	Provide opportunities for construction of dense mixed-used and mixed-income dwellings.
	Promote sustainable housing design and production.
	Facilitate access to land and security of tenure for all socio-economic groups.
	Initiate and promote training programmes to improve labour skills for housing construction and maintenance.
2.Sustainable management of existing housing stock through enhancement of market	Facilitate the rehabilitation, adaptive reuse, and redevelopment of public housing estates.
	Actively enforce zoning and building regulations to eliminate blight

GOALS	**OBJECTIVES**
mechanisms and land redevelopment to ensure optimum housing choice.	and improve building quality and initiate refurbishment programmes for substandard housing.
	Upgrade existing slums in major cities
3. Develop and enhance systems for sustainable housing supply and inventory management.	Promote greater private sector delivery of housing that meets the needs of the various market segments.
	Initiate and promote growth of the housing finance market and products.
	Attain full industrialisation building materials production backed by research and development.
	Encourage research into building materials and construction technologies.
4. Ensure sustainable human settlement growth and development that encourages liveable neighbourhoods with compact mixed-use development.	Incentivise the construction of compact, new mixed-use projects and maximise use of land.
	Ensure participation of all stakeholders including infrastructure service providers in housing development decisions.
	Periodic revision and update of the building code and the national zoning regulations
5. Improve institutional capacities to effectively manage urban development and space.	5.1 Effective management of urbanisation and human settlements.
	5.2 Accelerate slum upgrading and programmes to prevent the formation of new slums.
6. Improve functionality, efficiencies and resilience of human settlements.	6.1 Ensure effective planning and management of urban growth and sprawl.
	Provide and improve supporting infrastructure in cities
	Develop and implement settlement disaster and climate risk management strategies.
7. Ensure a mature, robust and functioning housing market to efficiently supply and allocate through the market system.	Ensure equity in access to housing and housing finance.
	Enhance economic status and viability of low-income earners to improve quality of household livelihoods.
	Eliminate customary and legal barriers to land tenure.
	Continuous innovation in housing supply and financing.
GOALS	OBJECTIVES
1. Provision of adequate new housing through stimulation of market efficiency and competition with public assistance for no and low-income households who cannot afford adequate housing.	Explore new sources of finance and partnerships for housing delivery including from the voluntary sector.
	Promote commercialisation and use of local building materials
	Promote decent affordable housing particularly for targeted populations; including low-income households, the disabled, young professionals and retirees.
	Provide opportunities for construction of dense mixed-used and mixed-income dwellings.
	Promote sustainable housing design and production.
	Facilitate access to land and security of tenure for all socio-economic groups.
	Initiate and promote training programmes to improve labour skills for housing construction and maintenance.
2.Sustainable management of existing housing stock through enhancement of market mechanisms and land redevelopment to ensure optimum housing choice.	Facilitate the rehabilitation, adaptive reuse, and redevelopment of public housing estates.
	Actively enforce zoning and building regulations to eliminate blight and improve building quality and initiate refurbishment programmes for substandard housing.
	Upgrade existing slums in major cities
3. Develop and enhance systems for sustainable housing supply and inventory management.	Promote greater private sector delivery of housing that meets the needs of the various market segments.
	Initiate and promote growth of the housing finance market and products.
	Attain full industrialisation building materials production backed by research and development.
	Encourage research into building materials and construction technologies.

GOALS	OBJECTIVES
4. Ensure sustainable human settlements growth and development that encourages liveable neighbourhoods with compact mixed-use development.	Incentivise the construction of compact, new mixed-use projects and maximise use of land.
	Ensure participation of all stakeholders including infrastructure service providers in housing development decisions.
	Periodic revision and update of the building code and the national zoning regulations
5. Improve institutional capacities to effectively manage urban development and space.	5.1 Effective management of urbanisation and human settlements.
	5.2 Accelerate slum upgrading and programmes to prevent the formation of new slums.
6. Improve functionality, efficiencies and resilience of human settlements.	6.1 Ensure effective planning and management of urban growth and sprawl.
	Provide and improve supporting infrastructure in cities
	Develop and implement settlement disaster and climate risk management strategies.
7. Ensure a mature, robust and functioning housing market to efficiently supply and allocate through the market system.	Ensure equity in access to housing and housing finance.
	Enhance economic status and viability of low-income earners to improve quality of household livelihoods.
	Eliminate customary and legal barriers to land tenure.
	Continuous innovation in housing supply and financing.

Source: Authors' Construct

16.8 Proposed Development Initiatives for the Housing Sector

National Urban Regeneration and Economic Renewal Programme

This will employ comprehensive schemes that will improve the public environment, increase access to social services, and improve access to housing and the housing environment. It will also improve skills of local artisans, improve economic vibrancy and strengthen mutually beneficial economic relationships between city districts and the broader municipal/metropolitan areas. The first hotspots for such initiatives are the GAMA region and Greater Kumasi Metropolitan Areas.

Commercialisation of Local Building Materials, Construction Technology and Skills Improvement

There is the need for continuous investments in research and effective partnerships with industry and private sector to translate research findings into commercially viable products. Public education and awareness creation will ensure social acceptability of local building materials and promote mass usage. This is necessary to trigger further research and production. Production facilities to be established will be based on the local resource base.

Capacity Building and Institutional Restructuring

Capacity building has a wide scope and includes knowledge and skills on the one hand, and tools, technologies and logistics on the other. These must complement each other to ensure that agencies, departments and institutions responsible for urban management and local governance are adequately equipped to translate this plan into the anticipated results.

Land Banking and Site & Services

Acquire 100,000 acres of land to be held in reserve for directed private sector investments in housing as well as service a further 10,000 acres (of already existing publicly held lands) with infrastructure (including roads, water, electricity, drainage, sewerage & telecommunications).

Public Institutional Housing Scheme (Redevelopment & Rehabilitation)

This will seek to rehabilitate existing as well as develop new accommodation for 50,000 public and civil servants, and to rehabilitate, refurbish and maintain 2,500 existing public residential facilities.

National Adaptive Re-use of Properties Programme

This will seek to identify government owned properties dotted around the country, that have been constructed to serve specific purposes but are currently lying in ruins and being inhabited by squatters. These buildings will be re-engineered, fixed and adapted to meet the basic requirements of housing infrastructure that is safe for human habitation, towards contributing to the reduction in the housing deficit. Avenues for private sector involvement will be explored

16.9 Programme Scoping

In the intermediate period, the following flagship programmes are proposed to hasten housing supply.

Formation of an Institutional or Regulatory Body (National Housing Authority) to Manage the Housing Sector

A strong institutional framework needs to be established to facilitate and enable mass production of housing, efficient allocation and sectoral integration, given the anticipated growth in the housing sector over the next 40 years. The National Housing Policy (2015) proposes the establishment of a National Consultative and Coordinating Committee on Housing and a National Housing Authority.

Additionally, a consortium for housing research and a National Housing Fund will be established, while existing housing agencies (SHC and TDC) will be subjected to reforms to make them more efficient and competitive at the local level.

Cities without slums – "Make Slums History"

In connection with the proposed National Urban Regeneration Programme, towards building sustainable cities that are attractive, liveable and secure, it is important to comprehensively upgrade and progressively phase out all slums and dilapidated settlements and houses, thereby creating viable and functional suburbs with improved quality of life, services, and livelihoods as well as secure tenancies for the inhabitants.

This strategy will seek to identify and profile existing slums and informal settlements in Accra, Kumasi and Takoradi, which would be redeveloped to provide quality and well serviced housing units in high rise structures, employing densification measures to create mixed use, functional and viable settlements.

National Home Extension, Improvement and Repair Programme

This will pursue the improvement of the quality of existing buildings in both urban and rural areas in partnership with the private and non-profit sector. It will also ensure that such facilities as energy, water, sanitation etc., are available within the homes. Improvements in housing quality will include the integration of renewable energy into the existing building fabric as well as repair schemes to improve efficiency. It should extend to include improvements in buildings facades and support business development for commercial buildings or properties and businesses located within down town areas and home completion.

Developing 8.84 million houses by 2047

Several initiatives are proposed develop safe and affordable housing units in self-sustaining neighbourhoods, especially providing institutional housing in mixed-use facilities for the employees of major public sector agencies. These include the medical and security services, teachers, civil servants etc.

By the end of the plan period, a house in Ghana, should be described as a dwelling unit with a permanent nature, that protects against extreme climate conditions. It must have sufficient living space, and access to safe water in sufficient amounts, and adequate sanitation and a security of tenure.

Establishing Green Belts and City Boundaries

It is expected that Ghanaian cities will establish green belts as boundaries in order to preserve the uniqueness of cities as well as prevent urban sprawl. These boundaries, will also be established for towns and villages, and must be described in a legislative instrument. A property within a city's boundary can then be effectively subjected to taxation and other regulations, as well as provided with the needed services

16.10 Outline of Stakeholder Roles and Responsibilities

There are several institutions involved in the housing and services sector, whose operations are however, incoherent with duplications across institutional mandates[108].

The Physical Planning Department undertakes spatial planning functions at the district level, with Local Governments having no direct role in housing delivery. At the national level, however, institutional arrangements are too fragmented to coordinate and monitor national multi-sectoral resource allocations.

Table 16.12: Major Stakeholders and Roles in Housing Development

No.	INSTITUTION/AGENCY/DEPARTMENT/ORGANISATION	ROLES AND RESPONSIBILITIES
1.	National Development Planning Commission	Policy formulation and advisory services, coordination, monitoring and evaluation
2.	Ministries – Ministry of Water Resources, Works and Housing; Ministry of Finance and Economic Planning, Ministry of Local Governance and Rural Development; Ministry of Environment, Science and Technology	Policy, Monitoring and Evaluation
3.	District Planning Authorities, Lands Commission, Rent Control Department, Ghana Standards Board, Environmental Protection Agency, the Architects Registration Council, Bank of Ghana	Regulation and supervision, monitoring and evaluation
4.	Banks, mortgage companies, susu associations, GHAMFIN, and Insurance brokers	Home financing, mortgages, insurance and foreclosures
5.	Civil and Non-Governmental Organisations – People's Dialogue, Habitat for Humanity, Homeless International etc.	Policy advocacy
6.	Traditional Authorities and customary land secretariats	Facilitation of land delivery for spatial projects
7.	Research, education and training	BRRI, KNUST, ILGS, ISSER, NVTIs, CSRI

[108] MWRWH (2015)

8.	Local Governments and relevant decentralised departments including TCPD, DPCU, Architectural and Engineering Services Ltd, Department of Parks and Gardens, Public Works Department etc.	Planning, design and supervision of project implementation, monitoring and evaluation
9.	Professional and Trade Associations – GIP, GIS, GhIE, ARC etc.	Regulation and quality control of practitioners
10.	GREDA, SHC, TDC and other private developers	Property development, site and servicing, monitoring
11.	Slum Dwellers International UN-Habitat, JICA, African Development Bank, UNICEF, UNDP, DFID etc.	International development partners in co-financing schemes, technical support, research and surveys etc.
12.	Public Service Providers – Department of Feeder Roads, Department of Urban Roads, Ghana Highways Authority, Ghana Water Company Ltd, Community Water and Sanitation Ltd, Electricity Company of Ghana etc.	Public Infrastructure, advisory and servicing
13.	Fire Service, NADMO, Red Cross, Ghana Police Service and the Armed Forces	Disaster management and security
14.	GHACEM, Dangote Cement, Tropical Cables, Aluminium roofing sheets companies etc.	Materials and logistics
15.	MeQasa, Lamudi, Jumia and other online portals	Marketing, advertisement and property information management

Source: Authors' Construct (2017)

Chapter 17 Social, Civic and Commercial Infrastructure

17.1 Introduction

Determining the social, civic and commercial infrastructure needs of the country is necessary towards establishing Ghana's infrastructure portfolio, required to deliver the envisaged goals of the long-term development plan. In this report, the qualitative and quantitative gaps in the supply of infrastructure in the country are established, and then extrapolated to determine the future needs in the context of the envisaged growth rate of the economy.

17.1.1 Vision and Goal

The vision for the social, civic and commercial infrastructure sector is "to have efficient and equitably distributed infrastructure to support Ghana's socio-economic transformation". The goal, however, is "to build dynamic, robust social infrastructure facilities that will create the enabling environment for Ghana's accelerated and planned transition from a middle-income status to high-income status".

In order to attain these therefore, the proposed infrastructure must have the following features:

i. Be flexible and amenable to change.
ii. Cater for the physically challenged, the vulnerable, the aged, and socially disadvantaged persons.
iii. Keep pace with technological developments such as ICT and/Telemedicine.
iv. Be culturally sensitive.
v. Have built-in sustainable maintenance features.
vi. Integrate green building concepts for all facilities with climate resilient features.
vii. Align with various sector visions for the next 40 years such as the National Spatial Development Framework (2015 to 2035

17.2 Overview of Social, Civic and Commercial Infrastructure in Ghana

Social, civic and commercial infrastructure encompass all physical facilities, structures and buildings that are constructed to serve the community at large. The visible facilities include hospitals, schools, markets, offices, libraries, correctional institutions, museums, public parks and open spaces, etc.

It is easily discernible that Ghana is confronted with a significant deficit in the provision of social infrastructure. This is manifested by the clear differences in the standards as set in the New Zoning Guidelines and Planning Standards[109] and the prevailing access to social infrastructure facilities.

[109] This document was produced by the Ministry of Environment Science and Technology in collaboration with the Town and Country Planning Department in November 2011, to serve as a guide and to describe the criteria acceptable for the use or development of a piece of land or an area, as well as to determine the scale, location and site requirements of various land uses and facilities.

While rural areas have green spaces[110] and parks, which are used for communal activities, for example, the urban areas have very few planned open spaces.

As the population grows, the pressure on existing infrastructure increases and with time the infrastructure ages, bringing in its wake inefficiencies in operations and higher operating costs. With most cities, there is significant under–investment in social infrastructure as there are competing demands for limited government budgets. This results in an irreversible breakdown of the existing infrastructure, thus entrenching the situation by increasing demands for new infrastructure.

The major challenge to most communities is the retrofitting of aging infrastructure, establishing the scope of the gap (both qualitatively and quantitatively) and then ensuring that the planned new infrastructure will respond to more efficient city building. As steps are taken to attain the standards of developed countries there is the need to have a balance between a city's social, economic and environmental needs[111]. To be sustainable, the infrastructure must meet the needs of the present generation without compromising the ability of future generations to meet their own needs[112].

17.3 Current Gaps and Needs Assessment

17.3.1 Health Infrastructure Needs Assessment

Health Care Delivery Facilities in Ghana

Starting from the lowest unit, health facilities in Ghana include the Community Based Health Planning and Services (CHPS) Compounds, Clinics, Health Posts, Urban Health Centres, District Hospitals, Regional Hospitals and Teaching Hospitals.

Currently, the vision of the Ministry of Health (MOH) is to "ensure a healthy and productive population that reproduces itself safely"[113]. The objectives under this above-mentioned goal include the following:

i. To ensure that people live long, healthy and productive lives and reproduce without an increased risk of injury or death.
ii. To reduce excessive risk and burden of morbidity, mortality and disability especially in the poor and the marginalised groups.
iii. To reduce inequalities in access to health, populations, nutrition services and health outcomes.

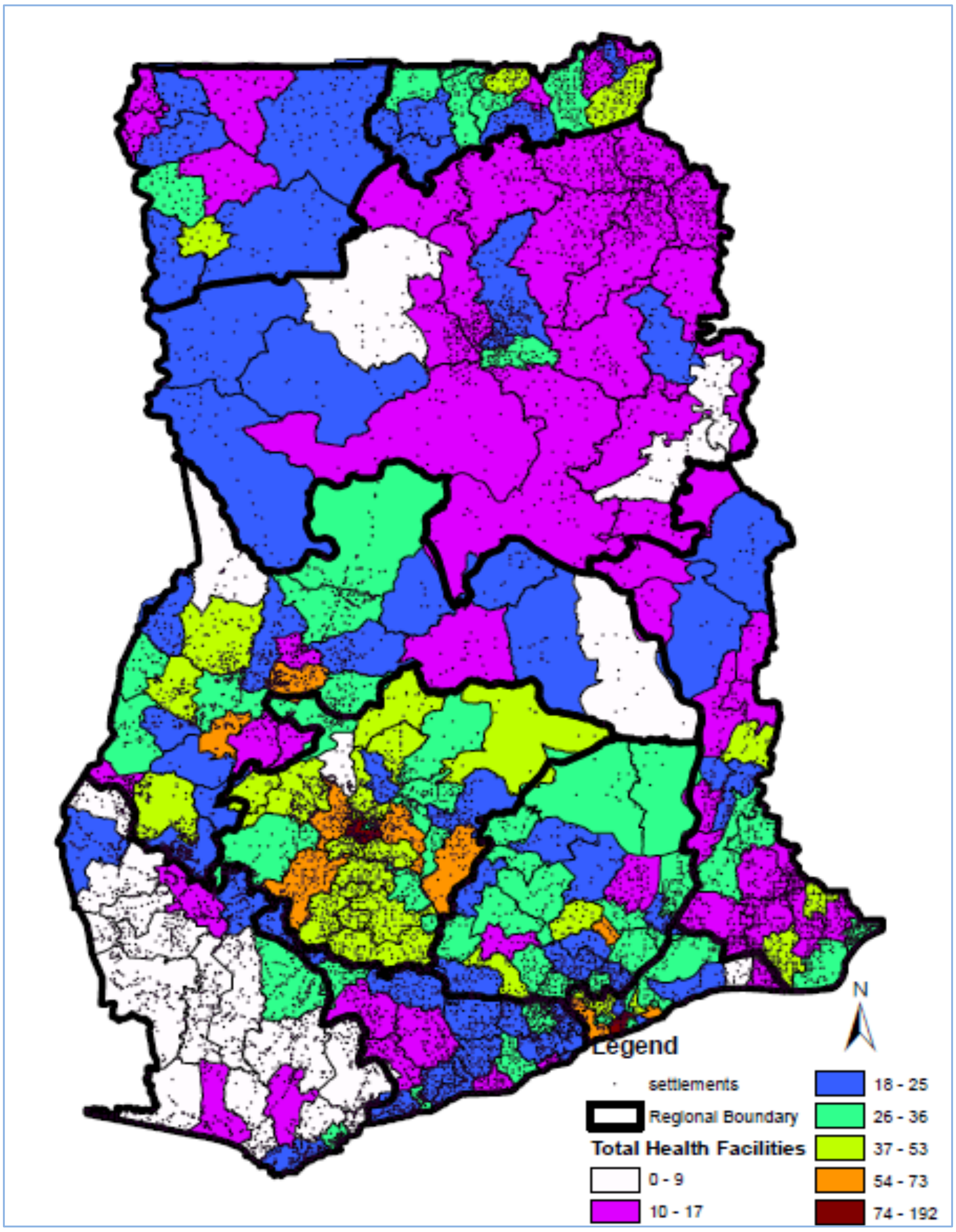
Towards 2057, the new vision that is proposed is to have "total access to good quality health care for all." This vision is attainable through a combination of innovative use of emerging technology based on smart phones and education of the populace on preventive medicine. This should be supported by an equitable spatial distribution of district hospitals in line with the standard of 1 district hospital serving a maximum of 200,000 persons[114] and remote monitoring of patients.

[110] Based on the loose definition of green spaces as land that is partly covered with trees, shrubs, grass or other vegetation, green spaces in this report will include cemeteries, community gardens and parks.
[111] Toppeta 2012, Sohely at Al (2005)
[112] Brutland Report UN (1987)
[113] Health Sector Medium Term Development Plan 2014-2017
[114] Zoning Guidelines and Planning Standards MEST/TCPD Nov. 2011

Existing Stock of Health Facilities in Ghana

There were 5,549-health facilities nation-wide as at April 2016 distributed across the ten regions. These facilities are owned and operated by Government, faith based institutions (CHAG etc.), private and commercial organisations.

Figure 17.1: Distribution of Health Facilities at MMDA Level, 2016



Source: TCPD (2016)

With about 30% of all CHP compounds (which comprises 60% of all health facilities in the country), Ashanti Region records the highest share of health facilities in the country. The Western region on the other hand, depicts (per Figure 17.1) the existence of the least number of health facilities in the country.

Teaching Hospitals

Teaching Hospitals are the most specialised hospitals with almost all the required medical departments, and are mostly involved in handling emergency and specialised cases. Teaching hospitals in Ghana provide services to quite a large number of people within the country, as well as the West African sub-region. They also serve as grounds for medical teaching and research.

Currently, there are three Teaching Hospitals in Ghana, namely the Korle Bu, Komfo Anokye and Tamale Teaching Hospitals, which are located in the Greater Accra, Ashanti and Northern Regions respectively. The construction of Legon Teaching Hospital (which is already underway) will increase the number to four. There are plans to develop a teaching hospital for Kwame Nkrumah University of Science and Technology as well. It is proposed that all the public medical training institutions like the University of Health and Allied Sciences and University of Cape Coast's Medical School should all have Teaching Hospitals by the end of the plan period.

Regional Hospitals

The sphere of influence of a Regional Hospital spans the entire Region within which it is located, and they are supposed to serve a minimum population of 600,000 – a maximum population of 1,000,000. Each region in Ghana, therefore, has a Regional Hospital. This hierarchy of health facilities offer specialist as well as general medical services, although the extent of the current state of logistics remain unknown. The Greater Accra Regional Hospital (Ridge) has been redeveloped to meet the increasing number of patients it is receiving over the years.

District Hospitals

These serve as the main source of health care delivery. The district hospital, with between 100 to 150 beds, is expected to serve a population of 80,000 to 200,000. If well-equipped and resourced, it can handle the majority of health cases and will only make referrals to the Regional and Teaching hospital for cases that are completely beyond its competence and capacity. The adherence to the ratio of one district hospital to 200,000 persons will result in a near 100% access to health care. As per current definition by the Ministry of Health[115], the district hospital provides the full range of Primary Health Care (PHC) needs of the populace within its catchment area.

The present minimum staffing requirement of at least two general practitioners should be raised to include specialists[116] such that the District Hospital becomes the main centre for the delivery of health to all. The provision of accommodation for key staff within the precincts of the hospital is essential for the efficient functioning of the facility and retention of staff.

CHPS Compound

The CHPS Compound is the smallest health care unit of the primary health care system. It is meant to bring health services within reach of every one such that basic primary health care objectives are achieved. They are community based and manned by a residential Community Health Officer (CHO), and are generally sited in rural areas to serve a population of 5,000 persons. The CHPS Compounds cover clinical care for minor ailments as well as preventive services through house-to-house visits and emergency service delivery at CHP residence[117]. Towards attaining the vision of becoming a high

[115] GHS Standard Hospitals Estate Management Department Ghana Health Service, 2016
[116] Specialists: ENT, Eye, Dental, Pediatrician, Gynecologist, Dietician
[117] National Community-Based Health Planning and Services (CHPS) Policy Ministry of Health March 2016

income country, CHPs compound facilities will be gradually phased out of the system, where facilities in good condition will be upgraded to the status of Polyclinics, and equipped with the requisite infrastructure to provide an upgraded set of services to a wider population scope.

The Number of Health Facilities needed by 2047

The planning standards and guidelines have been used to estimate and define the population threshold to be served by which hierarchy of health facility, based on the assumption that the people being served by the facilities have adequate financial, geographical and physical access to the facilities. Supposing the existing health facilities remain the same, there will be a huge deficit in health infrastructure, as depicted in Table 17.1. The Western Region would require four extra Regional Hospitals while Central, Ashanti and Northern Regions would each require three Regional Hospitals to be constructed. The remaining regions would each require an additional Regional Hospital.

Table 17.1: Projected Health Infrastructure Needs by 2047

Region	2015 Population (million)	2047 Population (million)	Deficit/ Surplus Pop. To be served (million)	Total Population Served (Assumed 100% Financial Access and Physical Access) (million)	Number of Extra Facilities needed by 2047
Upper West	0.8	1.7	0.1	1.8	1 Regional Hospital
Volta	2.4	4	1.2	2.8	1 Regional Hospital 1 District Hospital
Eastern	2.9	4.5	0.9	3.6	1 Regional Hospital
Brong Ahafo	2.6	4.7	0.9	3.8	1 Regional Hospital
Upper East	1.1	2.8	0.9	1.9	1 Regional Hospital
Greater Accra	4.7	6	0.9	5.1	1 Regional Hospital
Central	2.6	5.6	2.7	2.9	3 Regional Hospitals
Ashanti	5.5	10.3	2.6	7.7	3 Regional Hospitals
Northern	2.9	7	2.8	4.2	3 Regional Hospitals
Western	2.6	4.8	3.9	0.9	4 Regional Hospitals

Source: TCPD, 2016 based on Data from GHS, (2016)

This number of regional health facilities (and the district hospitals for that matter), should be distributed spatially, in a manner to ensure ease of access to such health facilities.

Additionally, existing district hospitals, with enough available land, should be identified and developed into regional hospitals. Alternatively, new lands can be secured for new developmental projects as far as the provision of healthcare facilities are concerned.

The Western and Northern regions need special attention within the plan period, to improve access with the ultimate gaol of the district hospital being recognised as the main provider of primary health care services in each district.

17.4.2 Education

Ghana has more than 12,000 primary schools, 5,500 junior secondary schools, 700 senior secondary schools, 17 technical institutions, 9 public universities, 10 quasipublic/professional institutions, 8 technical universities, 2 polytechnics[118], 3 colleges of agriculture, 65 private universities and private university colleges, 42 colleges of education and 30 nurses training colleges.

Educational Infrastructure Needs Assessment

First Cycle Education

The first cycle needs the most attention as it lays the foundation for the ensuing cycles. Given the vision of attaining high-income status within the next forty years, and to be competitive on the global market it cannot be over emphasised that any drive to improve education in Ghana must include an early introduction of pre-school children to ICT.

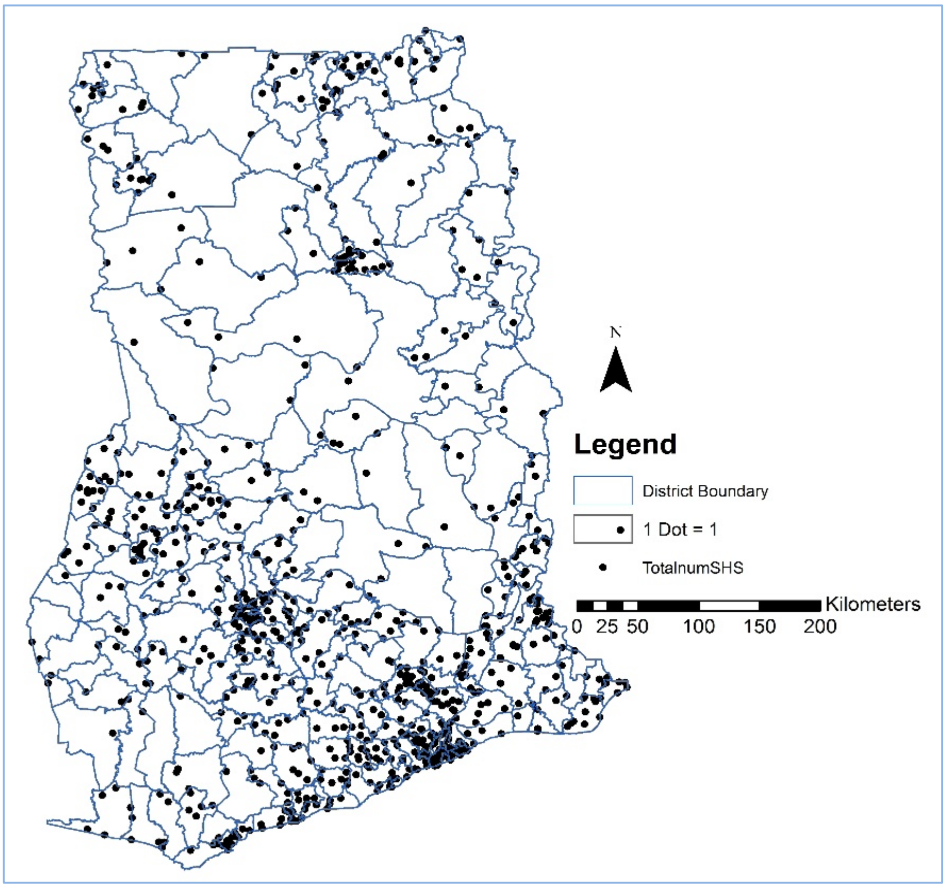
Second Cycle Education

For Senior High Schools the planning standards require that an SHS be sited between 2 to 4 neighbourhoods with a total population of 20,000 and a maximum commuting distance of 4 km. A look at the spatial distribution of the second cycle institutions shows that some districts do not have an SHS, whilst the three largest cities have the highest concentrations. It is noted further that there is a disparity between the southern and the northern parts of the country in the spatial distribution of these institutions. Another issue worth noting is the Gender Parity Index (GPI), which indicates that the percentage female enrolment has still not attained 50% though it has improved from 0.87 in 2010/11 to 0.94 in 2015/16.

It should be noted that private sector SHSs constitute 34% of the SHSs in the country and this poses a major challenge in meeting the physical facilities requirements for extra-curricular activities such as playing fields, assembly halls, etc.

[118] The polytechnics are in the process of being converted into Technical Universities

Figure 17.2: Spatial distribution of SHS in Ghana



Source: TCPD, (2016)

From Figure 17.2, the spatial distribution of Senior High Schools shows a stronger concentration in the southern half of the country where the population is relatively denser. The concentration is very pronounced between the so called "Golden Triangle"- encompassing Kumasi, Accra and Sekondi-Takoradi . In the northern half of the country, the regional capitals where population concentration is relatively high, have larger concentrations of Second Cycle Institutions.

The increasing involvement of the private sector in providing Senior High School facilities helps to meet demand levels, thereby relieving the pressure on government. Currently, 34% (284), out of the 834 Second Cycle Institutions available belong to the private sector. The main challenge with the private Senior High Schools, however, is that hardly do they meet the planning standards regarding the space requirements and other ancillary facilities like sports infrastructure among others, that are essential to provide a well rounded educational service for their students.

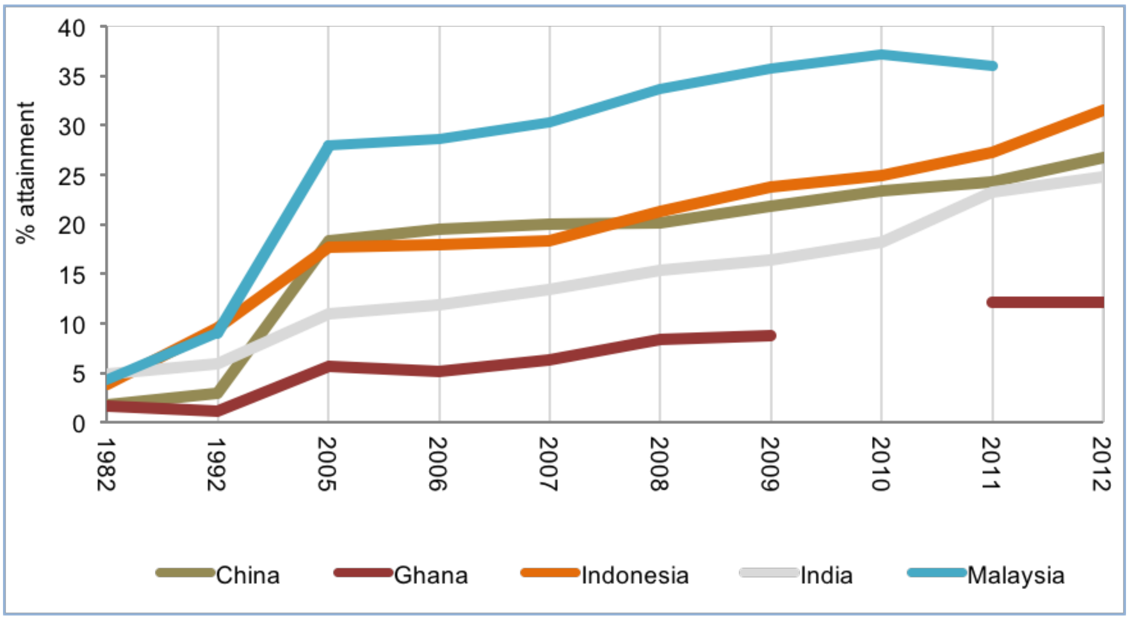
Technical and Vocational Training (TVET)

An important component of second cycle education is technical and vocational training, which prepares students for Technical Universities and industry. TVET appears to be stigmatised as it has hitherto been patronised mainly by students with low grades at the Basic Education Certificate Examination (BECE). Further to this, trades like carpentry, masonry, auto mechanics, hairdressing, dressmaking etc., are considered to be the preserve of students who do not have the intellectual ability to pursue tertiary education in the university. The passing of the law for converting polytechnics into technical universities may reverse this trend.

Tertiary Education

Ghana has 166 recognised public and private tertiary institutions. Both private and public tertiary institutions are not adhering to the policy focus on science and technology, which results in the producing of larger numbers of Humanities and Social Sciences graduates for whom there are no immediate employment opportunities. A comparison of Ghana to Indonesia, India, and Malaysia shows that the relatively high tertiary education attainment levels in those countries have largely contributed to their economic transformation, and they have stronger and competitive manufacturing sectors and are approaching the high-knowledge service economies that Ghana aspires to achieve in the next 40 years.

Figure 17.3: Tertiary Education Enrolment Level in Selected Middle Income Countries



Source: NSDF study, based on World Bank data (2014)

Aside the 9 public universities currently in existence, there is a proposal to develop the University of Environment and Sustainable Development in the Eastern Region. With 8 of the 10 polytechnics having been converted into Technical Universities (and the other 2 awaiting to be converted), there will be a total of 20 public universities in the country, which will be adequate in terms of numbers. However, the inadequacy of infrastructure for teaching, learning, as well as other ancillary facilities (e.g. for sports) presently poses a challenge. Existing facilities therefore need upgrading and expansion to cater for the current as well as future needs.

There are 3 chartered private universities and 62 private university colleges in Ghana. More than 70 percent of these private university colloeges are located in the Greater Accra Region followed by the Ashanti Region and Eastern Regions. The private university colleges however focus mainly on business programmes and the humanities (68 percent), with science and technology programmes constituting only 32 percent[119] of the programmes offered. It is therefore necessary for government to focus on developing

[119] TEI Annual Statistical report for 2014-2015- NAB 2016

the science and technology programmes in the public universities and also provide incentives and other measures to ensure that private universities shift their focus to the science-oriented programmes.

Creation of Education Clusters

For Ghana to develop a strong industrial and high-end knowledge service economy it is proposed that education clusters strongly linked with industry to generate innovative solutions via research works be developed. Given that the premier university has a number of tertiary institutions within a 5 kilometre radius, it proposed that a pilot project be run there. Other hubs could then be replicated using results and feed back from this.

17.4.3 Judiciary, Security Service and Law Enforcement Needs Assessment

The court system in Ghana comprises 5 levels of courts: district courts, circuit courts, High Courts, Court of Appeal, and the Supreme Court. The District Courts and the Circuit Courts are classified as the Lower Courts whilst the other 3 fall in the category of Superior Courts.

There were 214 judges in 2015 and 175 magistrates[120] in 2016 giving us a total of 389 persons dispensing justice. The District Court statistically handles the largest number of cases and by law it is required that each district should have at least one court.[121] This metric should be revised to ratio of population to district court. A target of 50 judges to 100,000 persons is proposed[122].

Correctional Facilities (Prisons) in Ghana

There are 43 correctional facilities in the country with a total design capacity of 9,778 inmates distributed among these facilities. Twenty-three of correctional facilities currently exceed their design capacities. Over the long term, facilities that are exceeding their design capacities must be redeveloped or expanded to reduce overcrowding.

Table 17.2: Design Capacity of Correctional Facilities and Numbers of Inmates

Type of Prison	Original Capacity	Current No. of Inmates	Variance	Purpose of Facility
Nsawam Medium (M)	851	3349	-2498	Built as Prison Facility
Kumasi Central (M)	416	1681	-1265	Built as Prison Facility
Sunyani Central (M)	430	897	-467	Built as Prison Facility
Koforidua Central (M)	300	645	-345	Built as Prison Facility
Sekondi Central (M)	412	719	-307	Built as Prison Facility
Ho Central (M)	170	465	-295	Built as Prison Facility
Wa Central (M)	50	225	-175	Built as Prison Facility
Winneba Local	59	232	-173	Not originally a prison facility
Obuasi Local	100	270	-170	Not originally a prison facility
Tamale Central (M)	78	237	-159	Built as Prison Facility
Tarkwa Local	100	251	-151	Not originally a prison facility
Akuse Local	60	208	-148	Not originally a prison facility
Nsawam (F)	71	200	-129	Built as Prison Facility
Kpando Local (M)	150	265	-115	Built as Prison Facility
Kumasi Manhyia Local	120	229	-109	Not originally a prison facility
Navrongo Central	108	199	-91	Built as Prison Facility
Bawku Local	40	84	-44	Not originally a prison facility

[120] 2015/2016 Judicial Service Annual Report
[121] 2015/2016 Judicial Service Annual Report
[122] Compare this to Liechtenstein and Germany at 183.7 and 24.6 respectively in 2013: Source Actually 2017

Type of Prison	Original Capacity	Current No. of Inmates	Variance	Purpose of Facility
Kumasi (F)	30	43	-13	Built as Prison Facility
Amanfrom Settle Camp	140	152	-12	Built as Prison Facility
Salaga Local	30	40	-10	Not originally a prison facility
Tamale (F)	6	15	-9	Built as Prison Facility
Kenyasi Settlement Camp	108	116	-8	Built as Prison Facility
Hiawa Camp	75	81	-6	Not originally a prison facility
Osamkrom Camp	70	70	0	Built as Prison Facility
Ho (F)	18	17	1	Built as Prison Facility
Yendi Local	120	116	4	Built as Prison Facility
Akuse (F)	12	8	4	Not originally a prison facility
Sekondi (F)	30	26	6	Built as Prison Facility
Kete-Krachi Local	250	241	9	Built as Prison Facility
Gambaga Local	46	20	26	Not originally a prison facility
Ahinsan Camp	112	80	32	Built as Prison Facility
Ekuasi Camp	144	108	36	Not originally a prison facility
Sunyani (F)	60	10	50	Built as Prison Facility
Duayaw Nkwanta Camp	150	98	52	Built as Prison Facility
Ankaful CDP	100	27	73	Not originally a prison facility
Ankaful Annex Local	500	363	137	Not originally a prison facility
Awutu Camp	250	107	143	Built as Prison Facility
Senior Correctional Centre	340	155	155	Not originally a prison facility
Yeji Camp	250	81	169	Not originally a prison facility
Ankaful Main Camp	562	314	248	Not originally a prison facility
Forifori Camp	300	40	260	Not originally a prison facility
James Camp	560	270	290	Not originally a prison facility
Maximum Prisons Ankaful	2000	830	1170	Built as Prison Facility

Source: Ghana Prisons Service, 2016

Correctional facilities in Ghana as in most developing countries are largely based on the principle of enforcing reprimand through custodial restrictions for infractions of the law. As such, the physical facilities are skewed towards the incarceration and denial of liberty and hardly direct the reformation and preparation for return to society needs. The main idea behind this philosophy of punishment is towards the construction of more facilities to support custodial sentences.

There is the need to shift the emphasis to reformation and rehabilitation. This could be done by an increase in non-custodial sentencing, i.e. an increased focus on creation of rehabilitation centres where inmates can learn new trades and further their education.

Another issue, which has to be tackled, is the shortfall in housing for prison staff. The Ghana Prisons Service report on the Effiase Project (2015) states that two-thirds of Prisons staff are forced to stay in private residences, and noted that the other third are cramped into small rooms and are forced to leave some of their belongings on the corridors and verandas. Housing for prison officers should be accommodated in the expansion and upgrading of all prison facilities.

17.4.4 Commercial Areas

Retail Space

Commercial and trading activities take place in a wide variety of places and facilities spanning street hawkers through the roadside table-top vendors, the small neighbourhood shops all the way to the upmarket shopping malls. At the lower end of the scale activities are unregulated whilst the large shopping malls at the top end of the scale depict a well-managed structure.

There will be an increasing growth in the demand for commercial facilities as the population grows and demands more services. It is important that in the design and provision of these facilities, the location or ease of reach, nearness to other facilities and services, physical access to the structures (or the area) as well as access to public transport, are considered. Even now, there is an increasing demand for land for commercial purposes within the city cores of major urban areas. Residential developments are therefore, increasingly giving way for mono-functional commercial developments. This is particularly true for Accra, Kumasi, Sekondi-Takoradi and Tamale.

Within the Central Business Districts (CBDs) of key districts within GAMA central places are being gentrified. The need to reintroduce residential functions into urban centres is reinforced by the rapidly sprawling urban landscape with mono-residential areas at the urban peripheries, with its attendant infrastructure provision and city management challenges, although no empirical data exists on the extent of conversion of residential buildings/areas to commercial buildings/areas. This necessitates further research.

Office Accommodation

Many buildings in the major cities and regional capitals which have been specifically designed and constructed for administrative purposes date back from the pre-independence period to the immediate post-independence era. Majority of spaces currently being used as offices, were originally residential buildings, which were purposely so designed, but have been rehabilitated and remodelled to serve administrative purposes. The challenge this poses is the pressure it puts on existing infrastructure which was conceived for residential use, for example, on-street parking.

Going forward, future office spaces must be designed and developed with technology driven environments and flexibility in mind. A recent unique entrant into the provision of purpose built office development in Ghana is the Octagon in Accra. This is a mixed facility, which comprises offices, retail areas, hotel suites and parking. Its uniqueness in Accra is derived from the sale of independent office space in modules in the same way as apartments are sold off. This offers a good model that can be adopted and replicated easily.

In areas like the Osu Oxford street, where streets are very narrow, new buildings that are emerging are incorporating underground parking spaces in their structures. This is another model worth replicating in areas with narrow streets that do not favour on-street parking, in order to ease congestion.

Public Recreation, Technology and Social Amenities

Libraries

The traditional role of the library is to serve as a storehouse of books/knowledge and place for archiving manuscripts, art and important documents. It has been the centre of information given that it houses the foundational building blocks of information.

The library is gradually being transformed into a place, which will reflect the ever-dynamic changes in technology with an increasing reliance on social media, streaming content, and open-source data. In addition to being places of acquiring knowledge and learning about the past and the present they will become places to create the future.

Currently, Ghana is nowhere near the UNESCO recommendation[123] for a threshold of a stock of 9,000 volumes to a literate population of 3,000 for public libraries. The central

[123] UNESCO Study: Standards for Library Service – An International Survey F.N. Withers, 1974

role of the library as a repository of facts and information is going through rapid transformation. It is proposed that each district has at least one public library with an area of not less than 300 m^2.

Green Spaces and Public Open Spaces

There is a general lack of functional green spaces[124] in the country. This situation is compounded by the cessation of the Department of Parks and Gardens. The Greater Accra region with an area of 152,000 hectares has only one functioning public park; i.e. the Efua Sutherland Children's Park, the Achimota Forest and one arboretum, the Legon Botanical Gardens. Kumasi now has the Rattray Park. District and neighbourhood parks are generally not available in the country.

Given the built-up nature and private ownership of property in the primary cities in Ghana, it is proposed that the various sub-metros demarcate land for use as green open spaces through mutual beneficial arrangements with the owners of run down properties and entering into mutually beneficial arrangements for use of the land. The options for acquisition of the land range from outright transfer of ownership to the sub-metros through to joint ownership of the space where the owner would receive some income periodically.

Sports Facilities

The development of sports infrastructure promotes economic development both at the national and local levels. The development of sports infrastructure is also considered a major step towards promoting public health and improving the life expectancy of the citizenry. These facilities do not only provide recreation, but also provide avenues for keeping fit as well. During the planning period, sports infrastructure in the country will be given a lot of attention, not only for the diverse benefits to the local and national economy, but as a way of ensuring the general well being of the citizenry and also to improve the urban landscape.

It is anticipated that Ghana will bid and host a number of international sporting events, and as part of preparations towards meeting this aspiration, a number of high capacity stadia would be constructed. Towards attaining this venture, the country's energy, water, transportation and housing systems as well as hospitality industries are expected to be strongly in place to support and sustain the event processes and the influx of people from the international community into the country. Also, each town, village or community will be encouraged to have adequate sports infrastructure to promote the physical, mental and social well being of the local inhabitants. Principles that encourage walking and cycling will be incorporated in city and transport planning and designs. Also, the establishment of the green infrastructure network, as proposed by the NSDF and emphasised in Chapter 15 of this document, will not only check unrestricted sprawl, but will afford benefits as walking, hiking, camping and biking. Finally, as a form of improving the well being of the youth and ensuring that children are active, schools must be encouraged to have adequate sporting infrastructure to help kids to exercise and also identify talents that can be tapped into for the future. From pre-school, right up to the tertiary level of education in Ghana, a certain level of sports infrastructure should be defined for institutions to be incorporated among their basic infrastructure.

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[124] This is primarily intended for informal or casual recreation pursuits. Public open spaces could be passive or active and include parks and gardens, palava grounds or durbar ground and small play areas for children.

The "tour du Ghana", which was born out of the desire of the Ghana Cycling Federation in 2014, will be further developed and enhanced to meet international standards in order to have a world class race to contribute to the sports sector. This will encourage healthy living through sports, nutrition and clean environment. It will also help to identify and develop young talents to participate in, and win international awards, while boosting local and international tourism.

Landmarks and iconic buildings in Ghana's cities

Among the many reasons that make a city great is the number of tourists visiting there. Therefore, turning Ghana's cities into new tourist attractions will be a priority of the infrastructure plan. Landmarks and iconic buildings will be developed and built as development agents, for aesthetic purposes and also as tourist's attractions. Generally, historical heritage and monuments were the basis of cultural and architectural tourism. However today, excellent Modern architecture has the same power of attraction.

The Hospitality Industry and Hotel Accommodation

The hospitality industry cannot function without hotel facilities to accommodate tourists and visitors. Ghana's ambition and anticipation to host international sporting events in the near future will ride on the back of a vibrant hospitality industry, thus the hotel industry needs adequate attention to raise it to reflect international standards. An improvement in the hotel industry can be capitalised upon to boost the economy.

The World Economic Forum's Global Competitiveness Report 2014-2015 asserts that for hotel rooms to be deemed adequate, the ratio should be one hotel room to a hundred persons of the particular country's population. Therefore, by the year 2047, when the country's population reaches 5.2million, there should be at least 520,000 hotel rooms available in the country. Currently, with a population of 27 million, Ghana should boast of 270,000 hotel rooms, however, as at 2015, the country had only 44,746 registered hotel rooms, a figure that is irrespective of the star rating of the facility. In fact, while there are more hotel facilities with lower star rating across the country, available data from the Ghana Tourism Authority shows that patrons have a preference for the higher rated facilities than the lower rated ones.

There is the need for government to engage the private sector adequately to develop hotels offering international standards throughout the country, as part of the GIP's implementation.

Cemeteries

Most cemeteries in Ghana were sited at locations that were once on the periphery of the settlements. With the growth of the communities these cemeteries have now become islands surrounded on all sides by settlements with no options for horizontal physical expansion. Cemeteries provide valuable open space and parks whilst offering insights into a community's cultural heritage.

In 2013 there were 209,500 deaths recorded in Ghana[125]. Current planning guidelines (Zoning Guidelines and Planning Standards of November 2011) require that a minimum of 10 hectares should be provided for every 100,000 persons. With a projected population of 52.2 million by 2057, a nationwide requirement of 5,220 hectares is projected for use as cemeteries.

[125] Country Statistics and global estimates by WHO and UN Partners January 2015

17.5 Overview of Proposed Development Strategy

17.5.1 Key Development Goals and Objectives

Over the implementation period, the focus of the development goals will evolve from solving the supply shortages in the short term, to the development of cities that are sustainable in the long term. In the first five (5) years, the goal will be to aggressively resolve the civic and social infrastructure backlog, which involves increasing the pace of delivery of new infrastructure on one hand, and executing the required retrofitting necessary for existing infrastructure on the other hand.

The medium term, in line with the housing sector, will focus on re-engineering existing human settlements to meet sustainable city principles where necessary. Access to such social and civic infrastructural facilities as markets, public parks, health and educational facilities, etc., will be increased to match the intended growth. By the end of the medium term, a substantial proportion of social and civic infrastructure gaps in human settlements will be addressed and existing settlements will emerge as modern sustainable cities. By the long term, the country would have reached a state where spatial management, infrastructure, social systems and housing have evolved to meet the vision of a high-income country.

Table 17.3: Key Development Goals and Objective

GOALS	OBJECTIVES
1. Ensure a healthy and productive population that reproduces itself safely	1.1 Reduce inequalities in access to health, nutrition services and health outcomes
	1.2 Increase access to educational institutions
	1.3 Provide adequate open spaces and public parks
2. Develop robust social and civic infrastructure facilities that are responsive and support society's wellbeing and transition to a high-income country.	2.1 Provide new libraries for communities
	2.2 Improve access to judicial services
	2.3 Decongestion of prisons and other custodial facilities
3. Ensure that people live long, healthy and productive lives and reproduce without an increased risk of injury or death	3.1 Ensure universal access to quality health care, support systems and improve healthy behaviour
4. Regularise and modernise informal commercial facilities and spaces.	4.1 Improve access, functionality and quality of social and civic facilities in settlements
5. Improve environmental quality of urban life.	5.1 Promote spatial integration of urban city hierarchies.
	5.2 Enhance capacity of local governments to effectively manage spatial planning and development

Source: Authors' Construct (2017)

17.6 Programme Implementation Framework

Over the period, four flagship programmes are proposed to hasten supply of social infrastructure. Other initiatives are proposed for implementation as well and are presented in Table 17.4.

Improving Access and Quality of Social Services

Under the "Cities without slums" and the National Urban Regeneration and Economic Renewal Programmes[126], schools, health centres/clinics will be retrofitted within the target areas, and backlogs in the supply of other social sector facilities will be addressed.

Improving Access to Quality Health Care

[126] Discussed in the chapters the Human Settlements Development and Shelter and Housing Systems

Clinics and health centres will be upgraded to the status of district hospitals to provide quality health care. The CHPS compound facilities will be progressively phased out, with those in good conditions upgraded and equipped to serve a larger population and to provide higher level services to beneficiaries.

Improving Access and Quality of Schools

Rundown and dilapidated schools will be rehabilitated, while new building structures will replace schools under trees. All schools will be equipped with ICT equipment and more teachers will be trained in STEM. At the second cycle level, per the dictates of the NSDF, a drove to achieve an even spread of schools across the country will be pursued and achieved.

Provision of Green Spaces, Parks and Cultural Open Spaces

Provide each community with open spaces for recreation and holding of cultural events and activities.

Table 17.4: Proposed Initiatives for Implementation[127]

Initiative	Implementation as sub components of other programmes	Broad Description
Improving access and quality of Social Services	"Cities without Slums"	Schools and health centres/clinics will be retrofitted within the target areas. Shortfalls in the supply of other social sectors facilities will be addressed.
	National Urban Regeneration Programme	Develop market facilities, open spaces and parks, libraries and burial spaces.
Improving access and quality of Health Care		Phase out CHPs compounds, upgrade clinics and health centres to district hospitals for the provision of PHC.
Improving access and quality of Schools		Rehabilitate run down schools, build new schools to replace schools under trees. Equip schools with ICT equipment and train more teachers in STEM.
Provision of green spaces, parks and cultural open spaces		Provide each community with open spaces for recreation and holding of cultural activities.
Civic Facilities		Community meeting halls, libraries to be constructed under this programme. Regional capitals and district capitals to have a museum of at least 500 square metres and 250 square metres.
Commercial Spaces		Constructing of commercial facilities of 4,000 sq. m to serve a catchment population of 10,000 to 15,000.
Use of local materials in Social Infrastructure Facilities	Promotion of Local Building Materials for use in Social Infrastructure Facilities	Use of environmentally friendly building materials in schools, clinics, libraries, community centres.
Conversion of abandoned buildings for civic and cultural use	National Adaptive Re-use of Properties Programme	Inventories will be carried out and abandoned buildings will be converted for use as civic structures: libraries, community meeting spaces, hot spots for internet etc. Conversions will include structural enhancements to ensure safety.

Source: Author's Construct.

[127] The Programmes, under which these initiatives are proposed, have been discussed in the chapters of the Human Settlement Development and the Shelter and Housing systems.

17.7 Outline of Stakeholder Roles and Responsibilities

Several institutions already exist, whose operations are relevant to the Social and Civic Infrastructure Sector. Some of these have been outlined together with their roles and responsibilities.

Table 17.5: Major Stakeholders and Roles in Housing Development

No.	INSTITUTION/AGENCY/DEPARTMENT/ORGANISATION	ROLES AND RESPONSIBILITIES
1.	National Development Planning Commission	Policy formulation and advisory services, coordination, monitoring and evaluation.
2.	**Ministries -** Ministry of Finance and Economic Planning, Ministry of Health, Ministry of Education, Ministry of Justice, Ministry of Interior, Ministry of Local Government and Rural Development, Ministry of Environment, Science and Technology.	Policy, Monitoring and Evaluation
3.	District Planning Authorities, Lands Commission, Ghana Standards Authority, Environmental Protection Agency, Architects Registration Council, Bank of Ghana.	Regulation and supervision
4.	Traditional authorities and customary land secretariats	Facilitation of land delivery for planned spatial projects
5.	Local governments and relevant decentralised departments including TCPD, Department of Parks and Gardens, Ghana Library Board	Planning, design and supervision of project implementation, monitoring and evaluation, project financing
6.	Education and research institutions. E.g. BRRI, KNUST, ILGS, ISSER, NVTIs, CSIR	Research, education and training
7.	Public Service Providers - Ghana Water Company Ltd, Community Water and Sanitation Ltd, Electricity Company of Ghana etc.	Public infrastructure, advisory and servicing
8.	Fire Service, NADMO, Red Cross, Ghana Police Service and the Armed Forces	Disaster management and security

Source: Authors' Construct

Chapter 18 Information and Communications Technology

18.1 Introduction

Ghana is one of the pioneers in national information and communications technology (ICT) reforms in Africa. In 1994, the country became the first on the continent to liberalise the telecommunication sector to encourage competition. Since the 2000s, Ghana has been active in developing ICT policies and strategies to promote socio-economic development.

Following the development of the 2003 ICT Policy for Accelerated Development (ICT4AD), other national policies such as the National Telecommunication Policy (2005) and the National Cyber Security Policy and Strategy (2016) have been developed. In addition, some sector specific policies and strategies, including the ICT in Education Policy (2008) and the E-Health Strategy (2010), have also been developed.

In recent years, Ghana's ICT sector has seen appreciable improvements in mobile and internet penetration, international and inland fibre optic connectivity as well as ICT parks and incubators. However, the country is yet to fully exploit the opportunities offered by these resources, especially for intensive use for e-government, e-business, e-commerce, e-health, e-education, e-research, etc. As the country seeks to become a high-income economy by 2057, there is the need for an ICT infrastructure and policy plan to help achieve this long-term socio-economic goal.

18.1.1 Goal and Objective

The overarching goal of the ICT Infrastructure and Policy Plan is to "build a 21st century digital infrastructure to drive economic growth, improve governance, enhance competitiveness, and support social development, while positioning Ghana to play a leading role in the development and export of technology globally".

The objective is to "ensure that all public and private organisations as well as citizens have access to quality ICT infrastructure and services regardless of location and status".

18.2 Priority Focused Areas

The ICT Infrastructure and Policy Plan is anchored on the following priority areas:

i. Telecommunication infrastructure
ii. ICT facilities
iii. National digital and e-government infrastructure
iv. Geographic information system database
v. ICT infrastructure financing
vi. Areas for ICT policy updates
vii. Areas for ICT laws updates

18.2.1 Telecommunication Infrastructure

Broadband Infrastructure

Broadband access has increasingly become very significant for economic growth of nations. According to the World Bank, in middle-income countries such as Ghana, a 10% increase in broadband penetration leads to a 1.38% increase in economic growth[128]. Telecommunication infrastructure forms the fundamental backbone for broadband penetration in any country. According to the Internet World Statistics[129], Ghana's internet penetration per population as at March 2017 was 27.8%. This rate is below that of leading countries in Africa, such as Kenya (77.8 %), Mauritius (62.7 %), and Morocco (57.3 %). Ghana's penetration rate is also way below that of international leaders such as Norway (96.3%), Netherlands (95.5%), and United Kingdom (91.6%). As Ghana seeks to become a high-income nation, there is the need to do more to catch up with not only our African neighbours, but global leaders in ICT as well.

Required Actions:

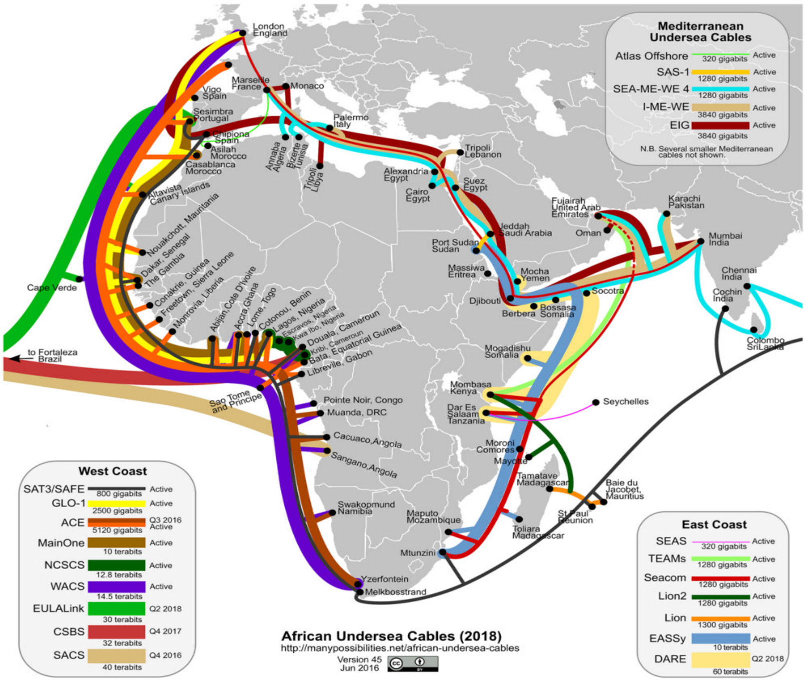
i. Ensure that all households and citizens have access to broadband services;
ii. Ensure that Ghana has the highest internet penetration in Africa;
iii. Ensure that Ghana becomes the leader in broadband development in Africa; and
iv. Ensure that Ghana achieves internet and broadband penetration rates comparable to that of leading economies in the world.

Fibre Optic Infrastructure

In recent years, Ghana has advanced in international and local fibre optic connectivity. The country is now connected to five international submarine fibre optic cables as shown in Figure 18.1.

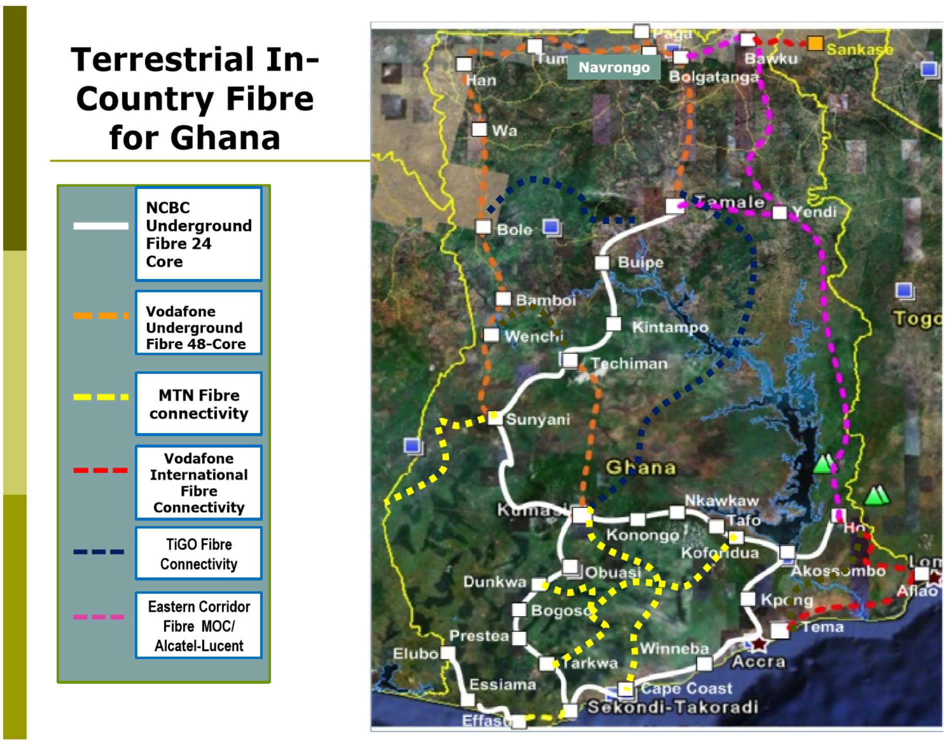
[128] World Bank ICT 4 Development Report 2009
[129] http://www.internetworldstats.com/stats1.htm

Figure 18.1: African Undersea Cables (2018 Project)[130]



Inland fibre optic network connectivity has also improved as shown in Figure 18.2.

Figure 18.2: Terrestrial In-Country Fibre for Ghana



Source: Ministry of Communication

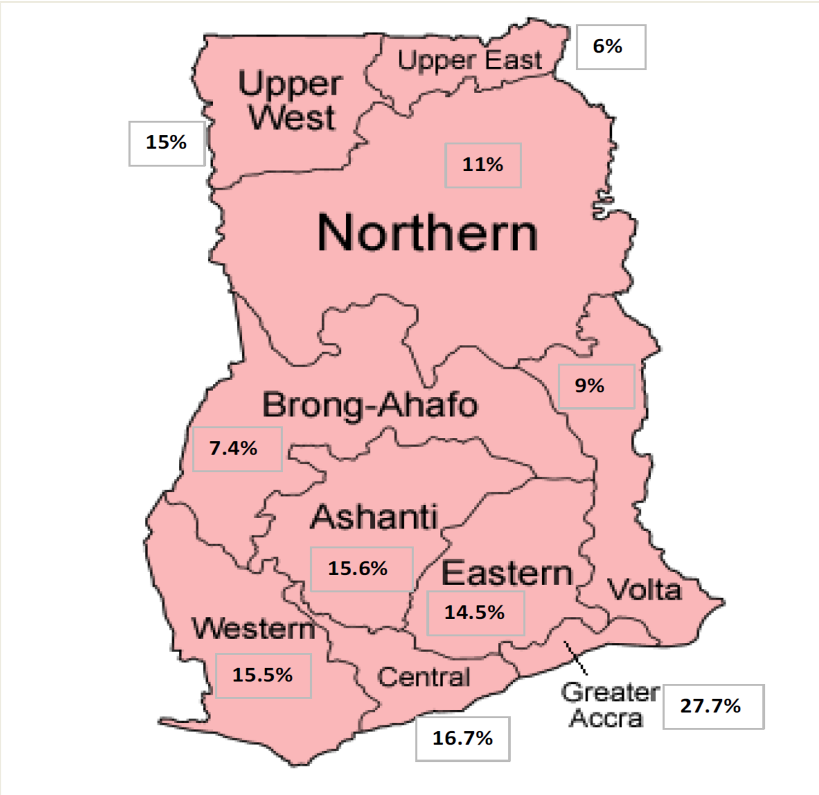
130Source: http://manypossibilities.net/african-undersea-cables

Figure 18.2 shows the coverage of inland fibre optic networks as at the year 2016. The latest achievement was the completion of the Eastern Corridor Fibre Optic Network to connect Ho to Bawku with a link from Yendi to Tamale. This network is expected to connect over 120 rural communities and provide ducts for extension.

Internet Penetration

Notwithstanding the significant improvement in international and inland fibre optic networks, broadband internet access across the country remains low. According to 2017 International Telecommunication Union (ITU) figures, only 17.1% of Ghanaians use the Internet[131]. In addition, there are wide variations in regional access to the internet as shown in Figure 18.3.

Figure 18.3: Internet Penetration in Ghana by Region (2013)[132]

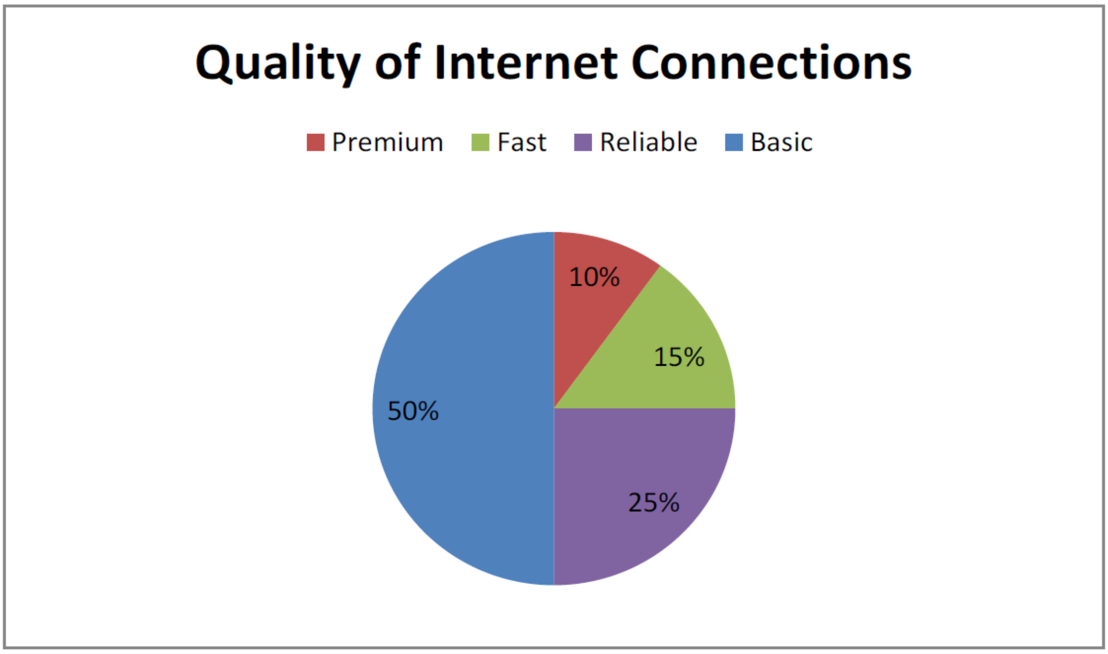


Source: USAID Report for Ministry of Communications and GIFEC, 2013

Also, as shown in Figure 18.4, bandwidth capacity remains low while the usage has largely been for news and social media and less for economic purposes.

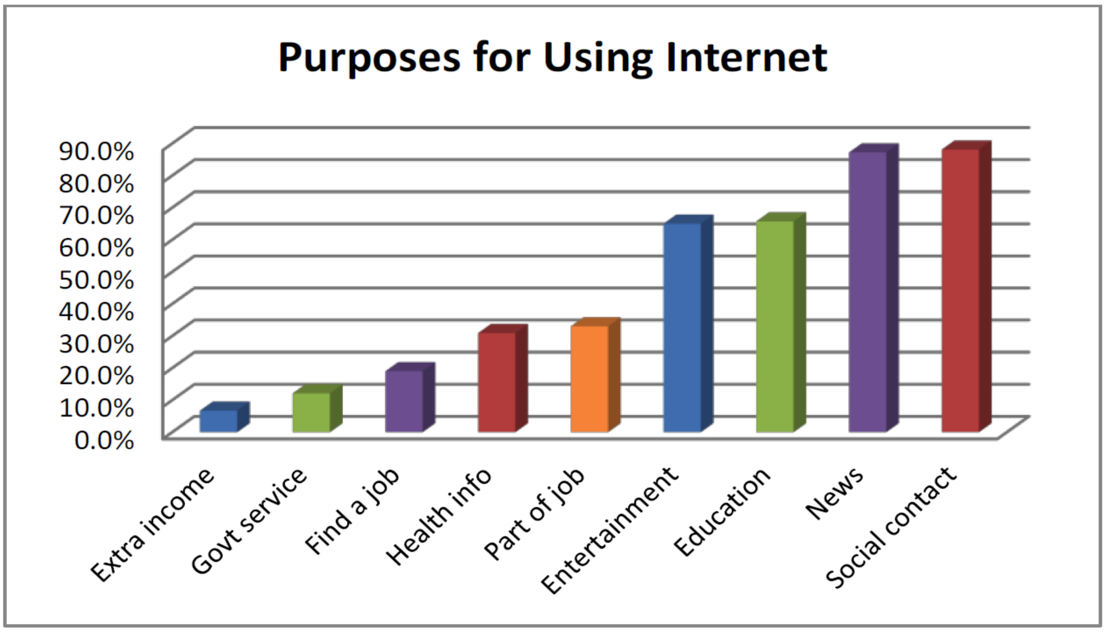
[131] https://www.oecd.org/aidfortrade/casestories/casestories-2017/CS-03-A4AI-Affordable-Internet-in-Ghana.pdf
[132] USAID 2013, Digital divide in Ghana: Analysis and recommendations, Report for the Ghana Ministry of Communications and Ghana Investment Fund for Electronic Communications (GIFEC)

Figure 18.4: Quality level of Internet Connections (2013)[133]



Source: USAID Report for Ministry of Communications and GIFEC, 2013

Figure 18.5: Purposes for Internet Use in Ghana[7]



Source: USAID Report for Ministry of Communications and GIFEC, 2013

Required Actions:

i. Extend fibre optic cables to all rural, remote, and underserved areas;

ii. Extend fibre optic cables to all schools;

[133] USAID 2013, Digital divide in Ghana: Analysis and recommendations, Report for the Ghana Ministry of Communications and Ghana Investment Fund for Electronic Communications (GIFEC)

iii. Extend fibre optic cables to all health facilities;
iv. Extend fibre optic cables to all public places;
v. Extend fibre optic cables to all buildings and homes; and
vi. Provide necessary infrastructure to achieve last mile fibre optic connectivity to remove digital divide.

Wireless Infrastructure

Ghana's telecommunication sector is dominated by wireless connectivity. According to the National Telecommunication Agency's (NCA) statistics for December 2016 [134], subscriptions for mobile telephones stood at 136.34% while that of fixed lines was 0.90%. Nevertheless, there are a number of challenges with wireless infrastructure and services, including, mobile subscription being largely for voice and less for data; some locations in the county experience poor quality service; lack of order and bureaucracy for siting mobile telecommunication masts; limited use of advanced wireless technologies such as radio frequency identification (RFID) and Internet of Things (IoT) for data capturing and communication.

Required Actions:
i. Use incentives to ensure universal mobile access delivery throughout the country;
ii. Encourage use of data services to promote mobile business and commerce;
iii. Develop a comprehensive policy to streamline telecommunication mast siting and co-sharing; and
iv. Promote the use of embedded RFID and IoTs for direct data capturing and communication.

18.2.2 ICT Facilities

ICT facilities such as innovation parks, incubators and community information centres (CICs) have become important resources for socio-economic development in digital economies.

ICT Parks

The development of science and technology parks has become an important national strategy for technological innovation and job creation. These ICT parks house clusters of technology companies and provide synergies for both local and global companies to promote a vibrant industry for software, hardware and communication devices.
In 2016, the construction of Ghana's first ICT Park began in the Tema Free Zone Enclave. The layout design is shown as follows.

[134] http://www.nca.org.gh/assets/Uploads/Voice-Statistics-December-2016.pdf

Figure 18.6: Design Layout for the Tema ICT Park

Source: Ministry of Communications

When completed, the park is expected to generate revenue and employment. More of such parks are needed in other parts of the country to help promote a vibrant ICT industry to manufacture ICT products and provide services for local consumption and export.

Required Actions:

i. Establish one ICT park in each regional capital
ii. Establish one special purpose ICT innovation Park to collaborate with KNUST to promote local manufacturing of computer, mobile, and network devices.

ICT Incubators

ICT incubators, including mobile hubs (mHubs) and mobile laboratories (mLabs), help to nurture start-ups and young entrepreneurs to develop innovative ideas in concrete products and services. These incubators provide office spaces, utilities, internet facilities, shared resource centres, training etc., and help establish networks of entrepreneurs, industry professionals, trainers and investors to promote ICT development, innovation and job creation. Ghana as a country, however, is yet to take full advantage of ICT incubators. The few ICT incubators in the country are: Meltwater Entrepreneurial School of Technology (MEST) with private and foreign ownership, Ghana Multimedia Incubation Centre (GMIC) and KNUST Business incubator.

Required Actions:

i. Establish one ICT incubator in each ICT Park created;
ii. Establish at least one ICT incubator in each regional capital; and

iii. Get each University or Polytechnic offering Computer Science, IT or Information Systems programme to establish at least one ICT incubator on campus.

Business Processing Outsourcing

Business Processing Outsourcing (BPO) has increasingly become a significant socio-economic sector, especially in emerging economies such as India and South Africa. It is estimated that as at 2013, South Africa's BPO sector was generating over USD 1.5 billion and 54,000 direct jobs while that of Morocco was also generating about USD 1 billion and over 60,000 jobs[135].

In 2016, the Accra Digital Data Centre, established through a renovation of 12 old warehouses of the Public Works Department, was completed and inaugurated to provide BPO services. The centre is expected to provide digital jobs and thereby help to generate revenue as well as reduce unemployment.

Figure 18.7: Accra Digital Centre

Source: Ministry of Communications

Given the potential role of BPOs for revenue generation and job creation, there is the need to establish more of such centres in various parts of the country.

Required Action:
Establish at least one BPO centre in each regional and district capital for job creation and revenue generation.

[135] McKinsey Global Institute (2013), Lions go digital: The Internet's transformative potential in Africa

Community Information Centres

Over the years, the Ministry of Communication, through its implementation agency, GIFEC, has established many CICs. By 2016, over 120 CICs with Internet access had been established in various rural, underserved and remote communities as well in some government institutions. Despite the growing number of CICs in various underserved communities, access to fast Internet services remains a challenge for most of them. It is therefore important to extend fibre optic networks and broadband Internet services to such areas.

Required Actions:

i. Ensure all underserved communities and institutions have CICs;
ii. Extend fibre optic connectivity to all CICs; and
iii. Provide broadband Internet access to all CICs.

Smart Cities

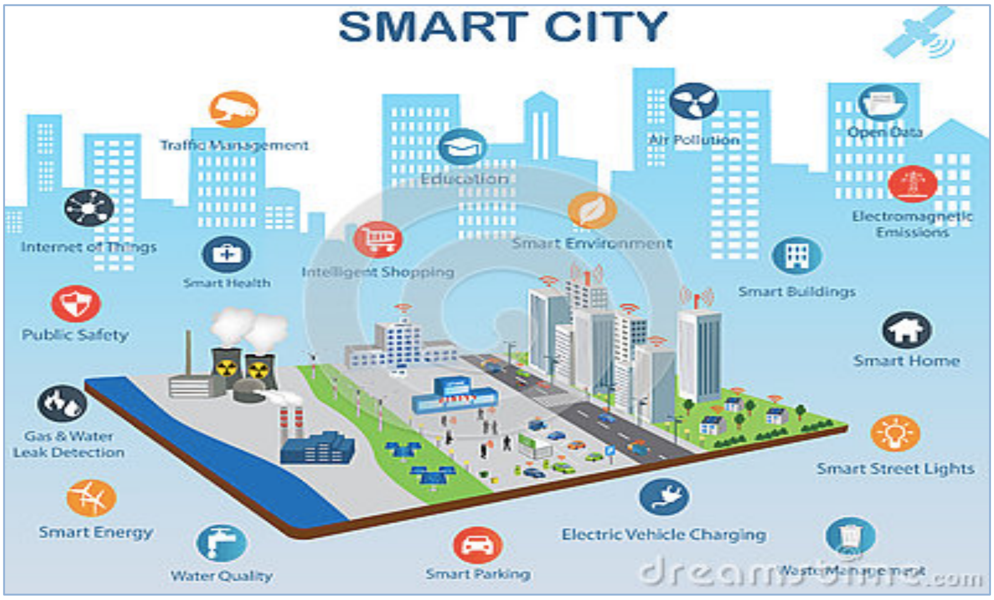
Smart cities are ICT-based urban development innovations that depend critically on Internet of Things (IoTs). Smart city innovation uses digital technology to plan, design and monitor occurrences in urban areas. Because of their usefulness, smart cities are becoming popular in advanced economies as the preferred strategy for sustainable urban planning, development and management[136]. Unfortunately, Ghana is yet to take advantage of the smart city innovation. Some of the problems in our cities can be solved through smart city innovation, such as water pipe bursts, cabling cuts, traffic congestion, fire outbreaks, defective vehicles on roads and streets, building without permits, managing street lights, detecting and managing potholes, crime monitoring etc.

Figure 18.8 shows a conceptual model of a smart city with various components and requirements.

Figure 18.8: Smart City Concept[137]

[136] United Nations E-Government Survey 2016: E-Government in Support of Sustainable Development

[137] Source: https://www.dreamstime.com/stock-illustration-smart-city-concept-internet-things-different-icon-elements-modern-design-future-technology-living-image78407701



Required Actions:

i. Develop national policies and guidelines for smart city development;
ii. Upgrade the national capital into a smart city; and
iii. Upgrade all regional capitals into smart cities.

ICT in Public Places

ICT facilities in public places are almost non-existent in Ghana. Beyond the community information centres, which are largely sited at rural and underserved communities, most public places such as transport terminals, recreational centres, schools, hospitals and libraries do not have Internet facilities. As Ghana seeks to achieve high-income status, it is important that such places are connected to the Internet for use, especially by people on the move.

Required Actions:

Connect the various public places to broadband Internet services:

Transport terminals:

i. Airports,
ii. Seaports,
iii. Train Stations,
iv. River Ports,
v. Bus Terminals, etc.

Inside transport access:

i. Trains,
ii. Buses,
iii. Airplanes,
iv. Boats,
v. Ships, etc.

Recreational centres:

i. Stadia,
ii. Tourist Sites,
iii. Theatres,
iv. Public Parks, etc.
v. Community centres;
vi. Educational Facilities;
vii. Correctional Facilities;
viii. Health Facilities;
ix. Libraries, etc.

Once such places are connected, Internet cafes, public kiosks and business centres can be setup to provide commercial services to generate revenue and employment.

18.2.3 National Digital and E-Government Infrastructure

The ongoing E-Transform Ghana Project being funded by the World Bank[138, 139] is expected to provide the necessary ICT infrastructure for an effective, efficient and transparent e-government and economic system. The project, which began in 2014 with a 2019 deadline, is expected to cover several areas, including:

i. National Identification System
ii. E-Government Portal
iii. National Data Centre
iv. E-Payment Gateway
v. Public Key Infrastructure
vi. Open Data Repository
vii. E-Parliament System
viii. E-Immigration System
ix. E-Procurement System
x. E-Justice System
xi. Digitisation of Paper Records
xii. Integrated E-Health System
xiii. Educational Portal
xiv. E-Services
xv. Tertiary Institutions Access (TIA) System
xvi. Innovation Incubators
xvii. Enterprise Architecture and Interoperability Framework etc.

The project is in various stages of finalisation and will be completed by the deadline.

Required Action:
Complete the e-transform project and all related components by the 2019 deadline.

[138] See: http://projects.worldbank.org/P144140/gh-etransform-ghana?lang=en&tab=overview
[139] http://nita.gov.gh/eGhana-Project

18.2.4 Geographic Information System Database

Location infrastructure in Ghana remains problematic because reliable online infrastructure and services for identifying places, buildings and facilities such as houses, streets, roads, installations, etc., are very limited. Available maps are also largely paper-based and therefore do not support online and mobile access.

In 2015, the National Spatial Development Framework was developed. The related action plan is to translate the framework into an online GIS database with the details in Table 18.1.

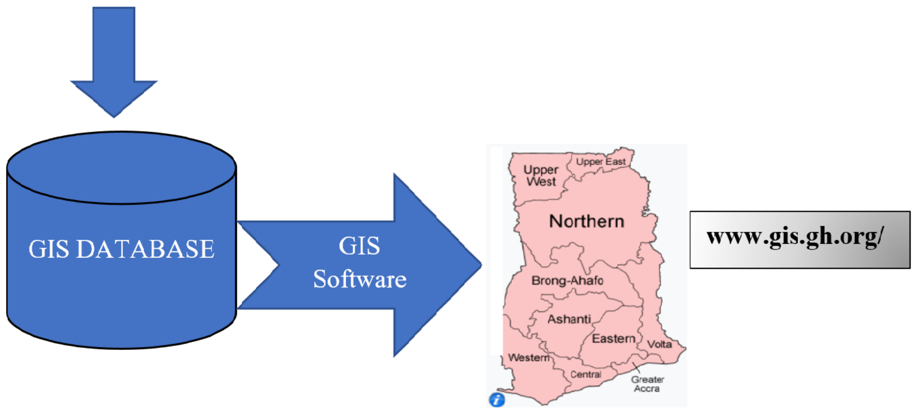
Table 18.1: GIS Database Layers

Layers	Attributes	Feature Types	Comments
Administrative Coverage	Code, name, location, feature, representation, last updated date	Regions, districts, towns, villages etc.	Nested design—towns and villages are in districts, which themselves are in regions.
Political Coverage	Code, name, location, feature, representation, last updated date	Regions, constituencies, polling stations and sub-stations etc.	Nested design—polling station in electoral area, which is in a constituency and constituency in a region.
Buildings	Code, name, location, feature, current owner, representation, last updated date	Residential, commercial, state etc.	Owner linked to national identification database. Has a transaction table that contains changes in ownership over time.
Transportation Network	Code, name, type, segments, representation, date of last update	Street, road, railway, waterway, airway etc.	Include both current and existing plans. Capture and update data on density, speed and delays.
Cable Network	Code, name, type, segments, representation, last updated date	Fibre, telephone, television, electricity etc.	Map out and capture data on cable networks for analysis and updates
Pipe Network	Code, name, type, segments, representation, last updated date	Water, oil, irrigation, drainage, sewerage, milk etc.	Capture and update data on paths, flow, blockage etc.
River Network	Code, name, type, segments, representation, last updated date	Streams, tributaries, major rivers, floods etc.	Monitor the flow direction of rivers and any barrier impeding flow. Analyse upstream and downstream activities.
Land Use	Code, location, last updated date	Farming, settlement, mining, recreation, tourism, irrigation	Use satellites and GPS capture and update land use data.
Spatial Coverage	Code, name, type, density, representation, last updated date	Population data, vegetation coverage, weather coverage, disease coverage, soil type coverage, etc.	Use remote sensing and digital genesis innovation to capture and update special coverage data.

Source: Author’s construct

Figure 18.9: High level GIS Database Design Framework

Database Layers
Administrative/Political layers
Transportation layers
Forest and vegetation spatial data
Amenities distribution channel spatial data (water, electricity, milk, fuel)
Telecommuting mast and installation spatial data
Posicode data
Tourism spatial data
Weather data- current and forecast
Land Use data
Satellite data
Population settlement and density spatial data

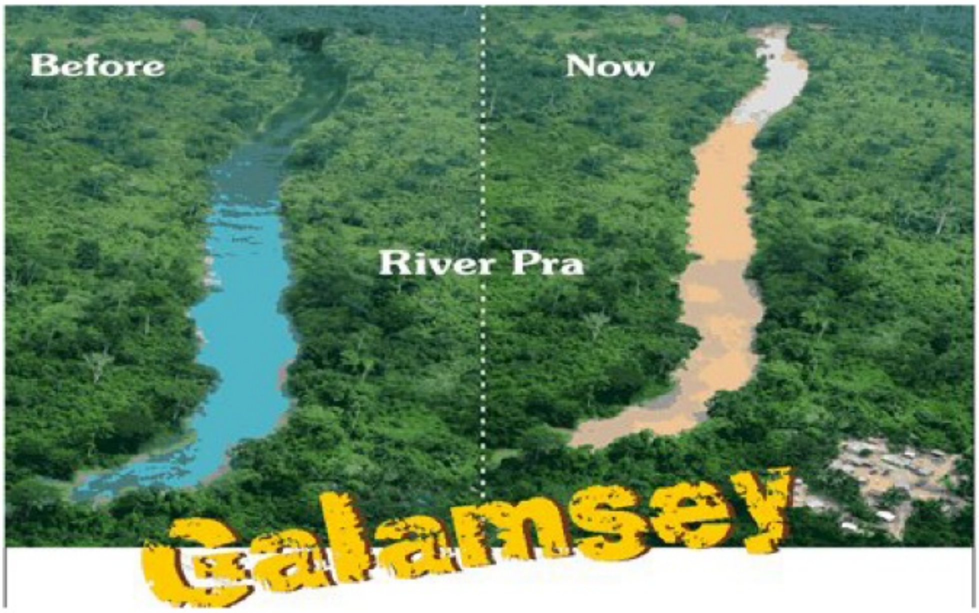


Source: Author's construct

Figure 18.9 presents a high level architecture for mapping the GIS database to online access via a digital map of Ghana through a designated web address.

Given the dynamic nature of spatial data, the GIS database is expected to capture and store space and time-based data to provide opportunities for trend and time series analysis. Thus, feature attributes and their representations will be periodically updated with new images and dimensions with date/time data to show changes and trends, to inform policymaking and analysis. For example, the GIS database should be able to provide reference of the state of the Ankobra river at a given historical time and its status given the intensive pollution from "*galamsey*" activities by 2016 as shown in Figure 18.10.

Figure 18.10: Comparative Aerial Photograph of River Ankobra between two time period**s**



Source: Ghana News Agency, 2016

Required Actions:

i. Develop and implement the online GIS design; and
ii. Develop and implement the GIS online application.

National ICT Survey Database

In modern times, national surveys have been extended to provide statistics on ICT infrastructure, access, usage and economic contribution. With feedback from national surveys, a country can monitor and evaluate trends and usage of ICT by citizens as well as private and public-sector organisations. Such statistics also provide feedback on ICT investments as well as scientific data for measuring progress and benchmarking with regional and international standards.

An annual ICT survey is yet to be fully established in Ghana as an essential and regular activity to provide the necessary statistics for ICT performance measurement and comparison with other countries and global trends. The 2010 population census by the Ghana Statistical Service (GSS) provided some data on household ownership of desktop and laptop computers as well as internet access by gender, age and geographical location. However, given the limited scope of the indicators used and outdated nature of the results it is difficult to use them for monitoring and evaluation.

Generally, the absence of annual survey data makes it difficult to measure ICT contribution to employment and GDP[140]. Given the growing importance of national ICT survey data therefore, it is imperative to establish the necessary database infrastructure and institutions for the collection, analysis and reporting of annual ICT statistics for the socio-economic development of the country.

[140] http://www.mofep.gov.gh/?q=news/210610

Required Actions:

i. Establish comprehensive ICT indicators in line with international standards;
ii. Institutionalise publication of annual ICT survey report; and
iii. Deploy a national database infrastructure for ICT survey data.

18.2.5 ICT Infrastructure Financing

ICT infrastructure provision requires huge capital expenditure for initial setup and maintenance. The global trend for alternative funding besides government sources include: Public Private Partnership (PPP), Loans, Private Equity (PE) and Universal Service Fund (USF). Among these sources, PPP remains the most popular option. However, to ensure maximum government ownership, it is important that PPP and PE arrangements incorporate Build Operate and Transfer (BOT) arrangements so that ownership can be transferred to the government after expiration of the agreement period. Another variation of the PPP agreement is buy build and operate, which can be used for assets that have become obsolete and therefore need capital injection for rejuvenation.

In 2004, Ghana established a universal service fund, which is managed by the Ghana Investment Fund for Electronic Communications (GIFEC) as the implementation agency of the Ministry of Communications to provide financial resources for ICT infrastructure and services to remote and rural communities. By 2014, GIFEC had funded several projects.

Apart from direct funding, GIFEC has also used PPP arrangements to fund some projects. In line with its mandate, GIFEC funding has been limited to underserved and remote communities and organisations. For example, its school ICT projects have focused mainly on basic, secondary, technical, and some colleges of education. Universities and Research Institutions that require more intensive fibre optic and broadband connectivity are yet to benefit immensely from such projects. Thus, the need for alternative sources of funding continues.

In most developing countries, Public Private Partnerships (PPP) arrangements in the form of build, operate and transfer (BOT)/special purpose vehicle (SPV) continues to be the preferred option for financing national ICT infrastructure requirements.

Required Action:

Develop and implement a comprehensive Public Private Partnership policy and guidelines for ICT infrastructure financing.

18.2.6 Areas for ICT Policy Updates

Several ICT related policies and laws have been developed in the country over the years. The 2003 ICT for Accelerated Development (ICT4AD) Policy was the first of its kind. The tables below show the various policies with their publication years at the national and sectoral levels.

Table 18.2: National ICT Policies

Year	Title
2003	ICT for Accelerated Development (ICT4AD) Policy (2003)
2005	National Telecommunication Policy (2005)
2015	National Cyber Security Policy and Strategy (2016)

Source: Author's construct

Table 18.3: Sectoral ICT Policies and Strategies

Year	Title	Sector
2008	ICT in Education Policy (2008)	Education
2010	National E-Health Strategy	Health
2016	Interconnect Clearing House Policy, 2016	Telecommunication

Source: Author's construct

While the National Cyber Security Policy and Strategy as well as the Interconnect Clearing House Policy are recent and thus reflect current trends in ICT, the other policies such as ICT4AD are obsolete and must be revised to meet current trends.

Required Actions:

i. Implement the National Cyber Security Policy;
ii. Implement the National Interoperability Framework;
iii. Implement the National Enterprise Architecture;
iv. Review, update and add to existing ICT policies and strategies to meet modern trends taking into account the policy pillars below; and
v. Develop related sectoral policies to direct ICT transformation at the MDA and MMDA levels.

The following policy pillars (as depicted in Table 18.4) have been defined to ensure that Ghana emerges as a technologically advanced country, with digital governance systems, digital societies and a digital economy.

Table 18.4: Policy Pillars

No.	Policy Pillar	Description
1	E-Personal Identification	Establish a comprehensive single, unified and multi-purpose e-identity for citizens and foreign residents.
2	E-Property Identification	Develop a comprehensive online accessible database of landed and movable properties such as vehicles, houses and lands to help reduce conflicts on ownership and transfers.
2	E-Location System	Develop a comprehensive online GIS system to support physical delivery, place location, courier and security (police and fire) service access.
4	E-Government	Use ICT to e-transform public sector operations and process to make the government more transparent, accountable and open to citizens.
5	Cashless Economy	Advance existing online, mobile and card-based payment systems to transition the economy from a cash-based to a cashless economy by gradually reducing the use of physical money and cheques.
6	E-Commerce	Promote online buying and selling by easing current constraints in online transactions and promote online sales of made in Ghana goods.
7	Digital Inclusive Society	Ensure that every citizen regardless of location or status has electronic access to government information and services through mobile and internet channels.
8	E-Employment	Use the opportunities provided by ICT to create job opportunities for the unemployed and the underemployed and provide ready access to information for job seekers.
9	E-Voting	Transition Ghana's democracy into a reliable and secured electronic voting platform to avoid violence and risks associated with elections.
10	E-Education	Promote the use of ICT resources at all levels of academic and professional education and ensure that all schools and have adequate ICT skills and resources.
11	E-Health	Use ICT to extend health services to the doorstep of all citizens and general health information for research to prevent diseases and epidemics.
12	ICT Industry	Promote the ICT sector to move from mere support to development of hardware and software products and improve training and professionalism.
13	E-Capability	Ensure the adequacy and availability of highly skilled professionals in software development, hardware manufacturing and data analytics.
14	E-Agriculture	Use ICT to provide the necessary information for the agricultural sector and ensure that farmers have readily available information about crops, pricing and storage right from their farms.
15	E-Research	Use modern ICTs such as big data, analytics and internet of things to collect and analyse national data on epidemiology, mortality, employment/unemployment, to inform the strategic direction of the country as well as connect various research teams to create knowledge for the development of Ghana economy.
16	ICT for Rural Development	Extend CIC to all rural communities and develop local information portals as well as connect them to the national and sector portals.
17	Legal and Regulatory Framework	Ensure that the right laws are developed and regularly updated to be abreast with advancements in the ICT sector.
18	Sectoral strategies and frameworks	Ensure that MDA and MMDAs develop sectoral ICT strategies in line with the national ICT policy.

Source: Author's construct

18.2.7 ICT Laws

Since 2005, some ICT laws have been passed to support legitimate use of the technology as shown in Table 18.5. However, most of the laws are not up-to-date given the year of passage and current developments.

Table 18.5: ICT Related Laws

Year	Laws
2005	Copyright Law (2005)
2008	Electronic Transactions Act, 2008 (Act 772)
2008	National Information Technology Act
2008	Electronic Communications Act, 2008 (Act 775)
2012	Data Protection Act, 2012 (Act 843)

Source: Author's construct

Required Action:

Review, update and extend available ICT Laws

In line with the long-term National Development Plan, the ICT plan period is from 2018 to 2047. The following action plan is proposed for the period.

Table 18.5: Long-term Action Plan

STRATEGIC GOAL	INDICATOR	2018-2021	2022-2025	2026-2029	2030-2033	2034-2037	2038-2041	2042-2045	2046-2049*
1. TELECOMMUNICATION INFRASTRUCTURE									
Ensure that all households have access to broadband Services	Achieve over 90% broadband penetration for households								
Ensure that all citizens have access to broadband Services	Achieve over 95% broadband penetration for citizens								
Make Ghana become the leader of internet penetration in Africa	Become the leader in internet penetration in Africa								
Make Ghana become the leader of broadband penetration in Africa	Become the leader in broadband penetration in Africa								
Make Ghana achieve an internet penetration rate comparable to that of world leaders	Catch up with world leaders in broadband penetration								
Fibre Optic Connectivity									
Fibre optic connectivity in all rural, remote and underserved areas	% Of communities with fibre optic connectivity								
Fibre optic connectivity in all schools	% Of schools with fibre optic connectivity								
Fibre optic connectivity in all health facilities	% Of health facilities with fibre connectivity								
Fibre optic connectivity in all public places	% Public places with fibre optic connectivity								
Fibre optic cables in buildings and homes	% Of buildings and homes with fibre optic connectivity								
Provide necessary infrastructure to achieve last mile fibre optic connectivity for all	% Of national fibre optic connectivity								
Wireless Connectivity									
Achieve universal access to mobile services									
Develop clear policy on telecom mast siting and co-location									
Promote intensive use of wireless technologies such as RFID and IoTs for data capture and communication									

STRATEGIC GOAL	INDICATOR	2018-2021	2022-2025	2026-2029	2030-2033	2034-2037	2038-2041	2042-2045	2046-2049*
2. ICT FACILITIES									
ICT Parks									
Establish one ICT park in each regional capital	% Of regional capitals with ICT parks								
Establish one Innovation Park in KNUST to locally produce ICT devices and accessories	One park for local devices and accessories production established								
ICT Incubators									
Establish an ICT incubator in each ICT Park created									
Establish at least one ICT incubator in each regional capital									
Each University and Polytechnic to establish an ICT incubator									
Business Processing Outsourcing (BPO)									
Establish at least one BPO centre in each region									
Community Information Centre (CIC)									
Ensure all underserved communities and institutions have CICs									
Extend fibre optic connectivity to all CICs									
Provide broadband internet access to all CICs									
Smart Cities									
Upgrade Accra into a smart city	Accra made a smart city								
Upgrade all regional capitals into smart cities	Number of regional capitals that are made smart cities								
Define policies and standards for smart city development	Policies and guidelines defined								
ICT In Public Places									
Provide broadband in transport terminals									
Provide in-transport broadband services									
Provide broadband in tourist/recreational centres									
Provide broadband in all CICs									
Provide broadband in all schools									
Provide broadband in all prisons									
Provide broadband in all hospitals									
Provide broadband in all libraries									

STRATEGIC GOAL	INDICATOR	2018-2021	2022-2025	2026-2029	2030-2033	2034-2037	2038-2041	2042-2045	2046-2049*
3. E-TRANSFORM GHANA PROJECT									
Complete e-transform Ghana project by 2019 project deadline	E-transform project components completed by 2019								
4. GIS DATABASE									
Develop and implement the GIS physical database design	GIS physical database design implemented								
Develop and implement the online application for the GIS database	Online application for GIS database implemented								
Complete the E-Transform Ghana Project by 2019	% of components completed by 2019								
5. ICT INFRASTRUCTURE FINANCING									
Develop and implement a policy on ICT infrastructure financing	Policy developed								
Review and revise ICT policy on infrastructure financing	Policy reviewed and revised								
6. ICT POLICIES, STRATEGIES AND LAWS									
Implement the Cyber Security Policy and Strategy	Strategy implemented								
Develop ICT policies/strategies for sectors without such	Policy/strategy developed								
Review and revise ICT4AD Policy every 5 years	Policy reviewed and revised								
Review and revise Telecommunication Policy every 5 years	Policy reviewed and revised								
Review and revise ICT in Education Policy every 5 years	Policy reviewed and revised								
Review and revise National E-Health Strategy every 5 years	Strategy reviewed and revised								
Review and revise Copyright Act every 5 years	Act reviewed and revised								
Review and revise Electronic Transaction Act every 5 years	Act reviewed and revised								
Review and revise Information and Communication Technology Act every 5 years	Act reviewed and revised								
Review and revise Electronic Transactions Act every 5 years	Act reviewed and revised								

Source: Author's construct

APPENDIX B: Definition of Terms

Term	Definition
General	
Population	All residents regardless of legal status or citizenship, except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin
Urbanisation Rate	The exponential change in urban population for a given period
Deforestation	The permanent conversion of natural forest area to other uses, including shifting cultivation, permanent agriculture, ranching, settlements, and infrastructure development. Deforested areas do not include areas logged but intended for regeneration or areas degraded by fuel wood gathering, acid precipitation, or forest fires. Negative numbers indicate an increase in forest areas. (Food And Agriculture Organisation)
Deforestation Rate	The measure, frequency or extent to which a natural forest area is converted to other uses.
Shelter	
Household	A person or a group of people who live together in the same house or compound, sharing the same housekeeping arrangements and recognize one person as the head of the household. They may not necessarily be related by blood, but belong to a single consumption unit. (PHC, 2010)
Household size	The total number of persons in a household irrespective of age, sex or residential status.
Dwelling Unit	Also referred to as a living quarter, is defined as a specific area or space occupied by a particular household. It does not necessarily refer to the entire house of which the dwelling unit may be a part. (PHC, 2010)
Rooms	Proportions of space within a building, enclosed by walls, a floor and a ceiling, that is partitioned from other areas and is usually meant for lodging.
Secure Housing	Any form of shelter, dwelling unit or lodging, that is: 1. Legal: Has full security of tenure on the land, with proper documentation and registration; 2. Safe: Has stability of construction and secure from the risk of collapse or from natural events like storms, earthquakes and flooding; and 3. Unthreatened: Has no land litigation or ownership disputes; penalties and fines from breaching building codes or lacking development permits; …and provides adequate services for the protection of the dignity of its occupants.
Slums	A group of individuals living in an urban area and lack one or more of the following: 1. Durable housing of a permanent nature that protects against extreme climate conditions; 2. Sufficient living space which means not more than three people sharing the same room; 3. Easy access to safe water in sufficient amounts at an affordable price; 4. Access to adequate sanitation in the form of a private or public toilet shared by a reasonable number of people; 5. Security of tenure that prevents forced evictions. (UN-HABITAT)
Energy	
Generation Capacity	The amount of energy produced by transforming other forms of energy into electricity.
Electric Power Consumption Per Capita	The production of power plants and combined heat and power plants, minus transmission, distribution and transformation losses and own use by heat and power plants plus imports minus exports divided by mid-year population. (International Energy Agency)
Electricity Production/ Generation	This is the amount of electricity produced or generated from different forms of energy (fossil fuels, nuclear power plants, hydro power plants, geothermal systems, solar panels, biofuels, wind, etc). It includes electricity produced in electricity-only plants and in combined heat and power plants. This is commonly expressed in kilowatt-hours (kWh) or megawatt-hours (MWh). (Organisation for Economic Cooperation and Development and Wikipedia)
Electricity Losses	This is the amount of electric energy lost as electricity travels through power lines.
Renewable Energy	The form of energy that is derived from naturally replenished sources that do not get depleted with continual use (eg. Solar, wind, hydro power, geothermal heat etc)
Renewable Energy Stock	The supply or quantity of Renewable Energy sources accumulated or available for future use.
Fresh Water Supply	
Freshwater resources	The total renewable resources, which include flows of rivers and ground water from rainfall in the country, and river flows from other countries. Freshwater resources per capita are calculated using World Bank's population estimates. (The World Resources Institute)
Freshwater withdrawals	The total water withdrawal, not counting evaporation losses from storage basins. Withdrawals also include water from desalination plants in countries where they are significant source. Withdrawals can exceed 100 percent of total renewable resources where extraction from nonrenewable aquifers or desalination plants is considerable or where there

Term	Definition
	is significant water reuse (The World Resource Institute)
Internal Freshwater resources per capita	These include rivers and ground water from rainfall in the country but exclude river flows from other countries, divided by midyear population. (FAO)
Water and Sanitation	
Access to improved water source	Population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, or rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 liters a person a day from a source within one kilometer of the dwelling. (WHO; UNICEF)
Access to safe/improved sanitation	Population with adequate access to excreta disposal facilities (private or shared, but not public) that can effectively prevent human, animal and insect contact. Improved facilities range from simple but protected pit latrines to flush toilets with sewerage connection. To be effective, facilities must be correctly constructed and properly maintained. (WHO; UNICEF)
Access to flush toilet	Population with adequate access to a toilet facility (whether for sitting or for squatting) that disposes of human excreta (urine and faeces) by using water to flush it through a drain pipe to another location for disposal, thus maintaining a separation between humans and their excreta. (Wikipedia)
Sewerage Network System	A complex system comprising of pipes, manholes, pumping stations etc. responsible for the removal of waste materials.
Solid Waste	Any garbage, refuse, sludge… and other discarded materials including solid, liquid, semi-solid or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations and from community activities
Telecommunications	
Mobile Telephone subscribers	Subscribers to a public mobile telephone service using cellular technology. (International Telecommunication Union)
Internet users	The people with access to the worldwide network (International Telecommunications Union)
Broadband Subscribers	People with a digital subscriber line, cable modem or other high-speed technology connection to the Internet. (International Telecommunication Union)
Personal Computers	Self-contained computers designed to be used by a single individual. (International Telecommunication Union)
Forests and Agriculture	
Agricultural Land	Arable land, land under permanent crop cultivation (land cultivated with crops that occupy the land for a long time, and need not to be replanted after each harvest, eg. Cocoa, Coffee, Rubber, etc.) and permanent pastures. Land abandoned as a result of shifting cultivation is excluded.
Forest Area	Land under natural or planted stands of trees, whether productive or not. (FAO)
Irrigated Land	Areas purposely provided with water, including land irrigated by controlled flooding. Crop land refers to arable land and land used for permanent crops (FAO)
Transportation	
Road Density	This is the ratio of a country's total road network per the total land area (less area covered by water)
Paved roads	These are roads surfaced with crushed stone (macadam) and hydrocarbon binder or bitumen, with concrete or cobblestones as a percentage of all the country's roads, measured in length. (International Road Federation)
Length of road network	This is the extent of the entire system of interconnected roads designed for vehicular and pedestrian traffic in the country.
Road network in good condition	Proportion of all interconnected roads designed for vehicular and pedestrian traffic in the country, which are motorable all year round.