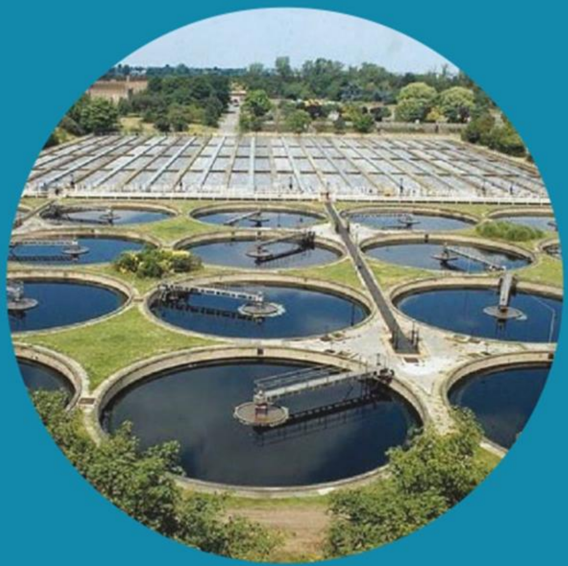




REPUBLIC OF GHANA

WATER INFRASTRUCTURE FRAMEWORK 2018-2047

Republic of Ghana

National Development Planning Commission

WATER INFRASTRUCTURE FRAMEWORK

of the

GHANA INFRASTRUCTURE PLAN

2018-2047

The Ghana Infrastructure Plan is a
companion document of the
40-Year National Development Plan (2018-2057)

It draws substantially from the National Spatial Development
Framework (2015-2035) as a critical complement to
infrastructure delivery through the efficient use of land and the
planning of human settlements, including public transport

ACKNOWLEDGEMENTS

As a long-term document, the Ghana Infrastructure Plan (GIP) is a framework, or a master plan, for the preparation of medium-term and annual infrastructure plans by successive governments up to 2047, 10 years before the completion of its "mother" document, the *40-Year National Development Plan.* It was prepared with the support of many individuals and institutions. The vision and commitment of both the previous and current leadership of the Commission, particularly chairmen P.V. Obeng, Prof. Kwesi Botchwey, Prof. Stephen Adei, Prof. George Gyan-Baffour, and Dr. Nii Moi Thompson, proved highly valuable from the start to the completion of the GIP.

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Last but not least, the staff of the Commission deserve special commendation for burning the proverbial midnight oil to ensure that the contents of the plan conformed to the development aspirations of Ghanaians as outlined in the 40-Year National Development Plan, officially known as "Ghana Rising: Long-term National Development Plan of Ghana (2018-2057).

Dr. Audrey Smock Amoah
Ag. Director-General
National Development Planning Commission
Accra

October 2025

The GIP has been translated into the following frameworks:

1. Energy Infrastructure Framework
2. Transport Infrastructure Framework
3. Water Infrastructure Framework
4. Human Settlements and Housing Infrastructure Framework
5. Social, Civic and Commercial Infrastructure Framework
6. ICT Infrastructure Framework
7. Institutional Development Framework
8. Results Framework
9. Financing Framework

WATER INFRASTRUCTURE FRAMEWORK

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LIST OF ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
AMA	Accra Metropolitan Assembly
APFM	Associated Programme on Flood Management AU
	African Union
AWF	African Water Facility
AWM	Agricultural Water Management
BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
CERSGIS	Centre for Remote Sensing and Geographic Information Services CIDA
	Canadian International Development Agency
CSIR	Council for Scientific and Industrial Research
CWSA	Community Water and Sanitation Agency
DESSAP	District Environmental Sanitation Strategies and Action Plan EPA
	Environmental Protection Agency
ESPA	Environmental Services Providers Association FAO
	Food and Agriculture Organisation
GAMA	Greater Accra Metropolitan Area
GES	Ghana Education Service
GHA	Ghana Highway Authority GhMet
	Ghana Meteorological Agency
GIDA	Ghana Irrigation Development Authority GIIF
	Ghana Infrastructure Investment Fund GIP
	Ghana Infrastructure Plan
GIPC	Ghana Investment Promotion Centre GNI
	Gross National Income
GSGDA	Ghana Shared Growth and Development Agenda
GWCL	Ghana Water Company Limited
HIC	High Income Country
HSD	Hydrological Services Department
IFAD	International Fund for Agricultural Development IGF
	Internally Generated Fund
ISC	Irrigation Service Charge
IWRM	Integrated Water Resources Management JICA
	Japan International Cooperation Agency JMP
	Joint Monitoring Programme
KATH	Komfo Anokye Teaching Hospital
KMA	Kumasi Metropolitan Assembly
KNUST	Kwame Nkrumah University of Science and Technology LI
	Legislative Instrument
LMIC	Lower Middle Income Country
LMS	Limited Mechanised System
LTNDP	Long-term National Development Plan
LUSPA	Land Use and Spatial Planning Authority
MESSAP	Municipal Environmental Sanitation Strategies and Action Plan MESTI
	Ministry of Environment, Science, Technology and Innovation MLGRD
	Ministry of Local Government and Rural Development
MMDAs	Metropolitan, Municipal and District Assemblies MoF
	Ministry of Finance
MOH	Ministry of Health
MW	Megawatt
MWRS	Ministry of Water Resources and Sanitation
NADMO	National Disaster Management Organisation
NEPAD	New Partnership for Africa's Development NESP
	National Environmental Sanitation Policy
NESSAP	National Environmental Sanitation Strategy and Action Plan NGOs
	Non-Governmental Organisations
NRW	Non-Revenue Water
NSEZ	Northern Savannah Ecological Zone
NWP	National Water Policy
O&M	Operation and Maintenance
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development PIDA
	Programme for Infrastructure Development in Africa
PPP	Public-Private Partnership
PSS	Point Source System
PURC	Public Utility Regulatory Commission
PUWSS	Peri-Urban Water Supply System PWD
	Public Works Department
RBBs	River Basin Boards
RCC	Regional Coordinating Council
SADA	Savannah Accelerated Development Authority SDGs
	Sustainable Development Goals
SHC	State Housing Company

SIC	State Insurance Company
SSNIT	Social Security and National Insurance Trust
STWSS	Small Town Water Supply System
TARWR	Total Actual Renewable Water Resources
TDC	Tema Development Corporation
TWR	Total Water Requirement
UAW	Unaccounted-for-Water
UG	University of Ghana
UK	United Kingdom
UMIC	Upper Middle Income Country
US	United States
USD	United States Dollar
UWSS	Urban Water Supply System
VRA	Volta River Authority
WMD	Waste Management Department WMO
	World Meteorological Organisation
WQI	Water Quality Index
WRC	Water Resources Commission
WRI	Water Research Institute
WSSDP	Water Sector Strategic Development Plan WUA
	Water User Association

HIGHLIGHTS

Water is life; clean water means health

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.
- Ghana is endowed with freshwater resources. However, the amount of water available changes markedly from season to season and from year to year.
- An estimated 23 billion m³ out of 53 billion m3 of the total actual renewable water resources originate 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.
- The available internal renewable freshwater resources are enough to support most uses in the country if adequately developed and managed.
- 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, according to the United Nations World Water Development Report, 2015.
- A country is said to be rich in water when it has more than 1,700 m3/cap/year, while a water scarce country is below 1,000 m3/cap/ year. The country becomes extremely water scarce when the water resources per capita are below 500 m3/cap/year.
- Currently, according to the Water Resources Commission, Ghana's freshwater resources per capita is about 1,941 m3/cap/ year. It is anticipated that the annual water availability per capita would drop below the water rich benchmark figure of 1,700 m3 by 2021.
- By 2047, the water availability situation would be critical with annual water availability per capita at about 1,040 m3/cap/year.
- The country would be in a situation of water scarcity after 2049 with the annual freshwater resources per capita at 969m3 by 2053. This analysis was made based solely on surface freshwater availability.
- 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.
- The population of the country, which is expected to double to 57 million by 2057 will create the great¬est pressures on water resources quantity and quality.
- Water demand will increase and exert pressure on water availability, unless there are corresponding increases in water conservation and other management techniques. Hence, a lot of trees will be planted to conserve the nation's water resources.
- 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 Ghana Infrastructure Plan (GIP) has 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 plan.
- 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 hit 400 litres by 2047 (for High Income Countries - HICs).
- Under a "business as usual" scenario, it is estimated that 71.4 percent of water is required to be used for agriculture (irrigation and livestock watering), 21.4 percent for domestic/municipal purposes, and 7.2 percent for industrial uses.
- In terms of water use per capita, Ghana's withdrawal per cap/yr is expected to be 235m3 by 2021, 874m3 by 2029, and reach 943m3 by 2047.
- Additional water resources will be developed through discovery and expansion of new sources to meet water requirement of 48 billion m3 by 2047.
- The unregulated activities of small-scale miners 'galamsey' were primarily responsible for the apparent deterioration in the quality of some water bodies such as the Tano, Birim, Offin and Ankobra.
- The country needs to undertake studies to determine the extent of groundwater reserves. The country must also review underground water resources reports prepared by mining and petroleum companies as sources of data.
- 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.
- 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.
- A total of US$76.25 million will be invested in water resources management for planned programmes up to 2025. This is indicative for the initial phase, which focuses on actions that will serve to strengthen the enabling environment and stabilise the water environment.

WATER SUPPLY

- The vision is to provide adequate, safe, affordable and sustainable water supply for all consumer categories by 2047.
- The water demand per capita will increase from 75 litres per capita per day to about 300 litres per capita per day by 2047.
- Non-revenue water losses will reduce from an urban average of 50 percent to less than 15 percent by 2047.
- A total number of 204 new Peri-Urban Water Supply Systems have been targeted for development during the plan period.
- One hundred and seventy-one (171) Peri-Urban Water Supply Systems have been targeted for upgrading by 2047.
- Seven (7) new Urban Water Supply Systems have been targeted for development during the plan period.
- A total of forty-two (42) Urban Water Supply Systems have been targeted for upgrading during the plan period.
- Safe and adequate water will be delivered to sustain expected benefits from the infrastructure development.
- Effective use of sea water desalination in target developments will be given lower priority due to the availability of adequate freshwater sources and the associated high cost of harnessing sea water.
- An estimated total investment of $9 billion is needed to carry out the required infrastructure developments during the plan period, made up of construction of water treatment plants, transmission and distribution systems, and pumping stations.

INTEGRATED WASTE MANAGEMENT

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

i. Facilities and services for 95 percent source separation and minimisation of waste provided on individual, institutional, commercial, etc., premises.

ii. Infrastructure for 100 percent collection and transportation of municipal waste provided.

iii. Infrastructure for 100 percent effective management of Municipal Electrical and Electronic Waste (MEEW) provided.

- 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.
- 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.
- While the generation rates of municipal solid waste vary across the country based on an average rate of 0.47 kg/person/day, about 13,558 tonnes 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, 0.40kg/person/day and 0.28kg/person/day, respectively, compared with the regional average of 0.51 kg/person/day.
- Currently, a little over 50 percent of the population has access to solid waste collection services, expected to increase to 100 percent by 2047.
- 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.
- 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.
- It is projected that about 32 million tonnes of municipal solid waste would be generated per annum during the plan period, up from about 9 million tonnes.
- The municipalities would generate the most waste during the plan period. Compostable and recyclable fractions of the waste generated is expected to increase from about 6.5 million tonnes to 27 million tonnes per annum by 2047.
- Only about 3.9 percent of the population (3.6 percent urban, 0.3 percent rural) has access to sewerage systems and this generates about 61,500 m³ of sewage a day.
- 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.
- 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.
- 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).
- In the case of rural communities, sewage generation is expected to increase to 106,309m3/day while septage generation declines to 14,700m3/day in 2047.
- Generally, as the country reaches over 70 percent urbanisation by 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.
- It is expected that 70 percent of the urban population and 30 percent of rural population will be served by sewerage system by the end of the plan period.
- A total of about 149,000 km length of urban sewerage pipelines and 8,660 km length of rural and community sewers will be laid by 2047.
- Waste minimisation, reuse, recycling and recovery procedures and practices will be adopted and facilitated in all sectors of society.
- Transfer stations of 300 tonnes per day minimum capacity will 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.
- The organic content of solid waste will reduce during the plan period as income status improves, while the proportion of recyclables like paper, plastic and metal rather increases.
- An estimated 9 km2 of land area would be required for landfilling per annum, assuming that about 15 percent of the waste to be treated is residue for landfilling.
- Local entrepreneurship will be developed and partnerships will be established to take advantage of job opportunities in waste minimisation, recycling and reuse.
- The energy potential and nutrient value of agricultural wastes will be exploited to support industrial and agricultural production.
- Private sector direct investments in infrastructure and services will be facilitated through various contracts that include BOOT, BOT, BOO, etc., to substantially increase sector financing.
- A total investment of US$ 31.1 billion will be required to achieve the objectives and set targets.

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.
- Ghana has a total land area of 23.8 million hectares, however, the cultivable land area is estimated to be 13.6 million hectares.
- The irrigable potential of the country is 1.9 million hectares but only 221,000 hectares (11.6 percent) have been developed by both formal public and private sectors, leaving over 88 percent of the potential untapped.
- 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 categorised under the formal sector; small scale informal irrigation accounts for 189,000 hectares while commercial irrigation accounts for the remaining 21,000 hectares.
- During the plan period, about 822,762 hectares will be put under various irrigation systems, forming about 54.9 percent of the estimated irrigable land available countrywide.
- By making total net revenue projections from four selected irrigated crops, cumulative net revenues of US$ 40 billion will be obtained at the end of the plan period.
- It is envisaged that the country will be self-sufficient in rice, maize, vegetable, sugarcane and fruits by 2036.
- About 300 megawatts of power would be required by the end of 2047 to operate the irrigation systems on 12-hour irrigation cycles per day.
- Public-Private Partnership (PPP) will be exploited fully for the development, management, operation and maintenance of irrigation schemes.
- Agricultural land title policies will be revisited, so as to empower the Ghana Irrigation Development Authority (GIDA) to easily access and own land for irrigation development in the country.
- In order to achieve progressive investment increase in the irrigation sub-sector, the following funding strategies are proposed:

i. Public-Private Partnership (PPP) will be exploited fully for development, management, operation and maintenance of irrigation schemes.
ii. Accessing funds from the Ghana Infrastructure Investment Fund (GIIF) for irrigation development.
iii. 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 will be considered.
iv. Use of land as equity in project development will be considered. This eliminates social tension and allows the descendants of the land owner to benefit from the project so long as the project exits.

- The capital investment required for irrigation infrastructure development alone is estimated to be US$ 7.2 billion.

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.
- Due to rural-urban migration and competition for land for residential development, water courses, wetlands and low-lying areas become places of settlements.
- 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.
- 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.
- There will be provision of underground storm sewers to replace open channels.
- Existing manual gauging sites will be upgraded to modern telemetric gauging sites.
- Flood risk assessment maps will be prepared as additional requirement for development and building permit approval.
- Engineering design and construction of drainage structures will be implemented to control, delay/reduce or withstand flooding.
- Flood data collection and flood studies will be carried out on nation-wide basis.
- Major drainage channels like the Odaw and Aboabo Rivers running through the cities shall be carefully managed to harness efficient land use, urban planning, environmental, economical and tourism potential.
- Civil and cultural systems for water resources management will be developed to ensure the proper planning, evaluation, monitoring and funding of water resources projects that are coming up in the SADA zones.
- New institutional arrangements will be adopted for better coordination of the overlapping activities in the management of drainage, flood control and coastal protection.
- The following strategies will be employed to reduce coastal floods and erosion degradation:

i. An inter-agency group to focus on coastal management programmes will be established.
ii. An integrated approach will be adopted to solve coastal flood shocks requiring coordination among key stakeholders, including traditional authorities and civil societies.
iii. 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.
iv. Coastal communities will be educated on how to combat coastal erosion and adapt to climate change. Local governments and NGOs could play key roles in this direction.

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

Chapter 1 Water Resources Management

1.1 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 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 facilities[1]. 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.

1.1.1 Vision and Goal

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.

1 United Nations World Water Assessment Programme (WWAP), The United Nations World Water Development Report 2015: Water for a Sustainable World (Paris: UNESCO, 2015), 26

1.1.2 Context of Water Resources Management

The two key aspects of water that are germane are the provision of adequate water supply and sanitation services for people and other users, and water as a resource to be developed and managed to sustain economic activity. 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.

Global Water Vision 2050

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. Translating this vision into reality has called for concrete and interrelated actions that go from establishing the legal and institutional framework to ensuring sustainable water management and increasing investments and financing to enhance and improve access to water services.

Africa Water Vision 2025

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. In achieving this vision, the African Union (AU), the highest policymaking body, has recognised the critical position of water in various summit declarations such as the 2008 AU Sharm el-Sheikh Declaration. The declaration identified water infrastructure for economic growth; managing and protecting water resources; water governance; financing; and knowledge, capacity development and water information as key challenges that require urgent action. Also, the nexus between water, food and energy is important and critical for Africa. The AU has accordingly made commitments for member countries to deliver investments in water availability, access, management and optimal use in coordinated and programmatic ways that promote regional integration and optimise long-term growth[2].

2 United Nations World Water Assessment Programme (WWAP), The United Nations World Water Development Report 2015: Water for a Sustainable World (Paris: UNESCO, 2015), 99

A recent regional initiative is the Transboundary Water Resources sector investment of the Programme for Infrastructure Development in Africa (PIDA), which was built on the experiences gained and actions undertaken by the African Water Facility (AWF), to help move to larger infrastructure investments to ensure water security in Africa and achieve the African Water Vision. The PIDA considered investments in physical infrastructure, or “hard” investments, and investments in the enabling environment for regional cooperation, or “soft” investments towards cooperative mobilisation and expansion of transboundary water resources for increased water security, food production, hydropower generation, navigation, and flood control. The “hard” investments were the hydraulic infrastructures having significant transboundary impacts, while the “soft” investments include the creation of new or the strengthening of existing River Basin Organisations, the strengthening of the information and knowledge base, planning capacities and modelling tools, communication and public awareness, and monitoring capacities[3].

Ghana Water Vision 2025

Ghana’s vision for water by 2025 is in step with the Global Water Vision 2050, the Sustainable Development Goals (SDGs), the Africa Water Vision and the African Union policy direction. Two previous studies that sought to address the water resources infrastructure 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.

3 African Development Bank, Study on Programme for Infrastructure Development in Africa (PIDA) - Inception Report (SOFRECO led Consortium, 2010), 7

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.

1.2 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 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. Notable IWRM interventions that have been implemented include the following:

i. A good part of the basic water and environmental policies and plans.

ii. The legal framework for water resources management.

iii. Institutional framework with water resource planning now anchored within a decentralised administrative structure at the river basin level.

iv. Technical tools with a decision support system for water resources assessment and water allocation planning at the river basin.

1.2.1 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 of the country.

1.2.2 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.

1.2.3 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. Specific to water resources management, the RBBs work to ensure and promote water resources management, coordination and collaboration, and planning at the local level. The key tool for the RBBs is the IWRM Plan developed for each of the basins, which serves as a "blue print" with prioritised actions and measures towards local initiatives to address the prioritised problems specific to each basin.

1.3 Situational Analysis of Water Resources (Availability)

1.3.1 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.

Mean annual rainfall in the country is estimated at 283.1 km^3 (1200 mm). Annual potential open water evaporation has been estimated as ranging between 1,350 mm in the south to about 2,000 mm in the north. The mean annual runoff ranges from 51 to 93 m^3/s, representing only about 69 percent 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 (Tables 1.1 and 1.2), with the Volta, south-western and coastal river systems draining 70 percent, 22 percent and 8 percent, respectively (Figure 1.1).

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 1.2).

Table 1.1: 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**

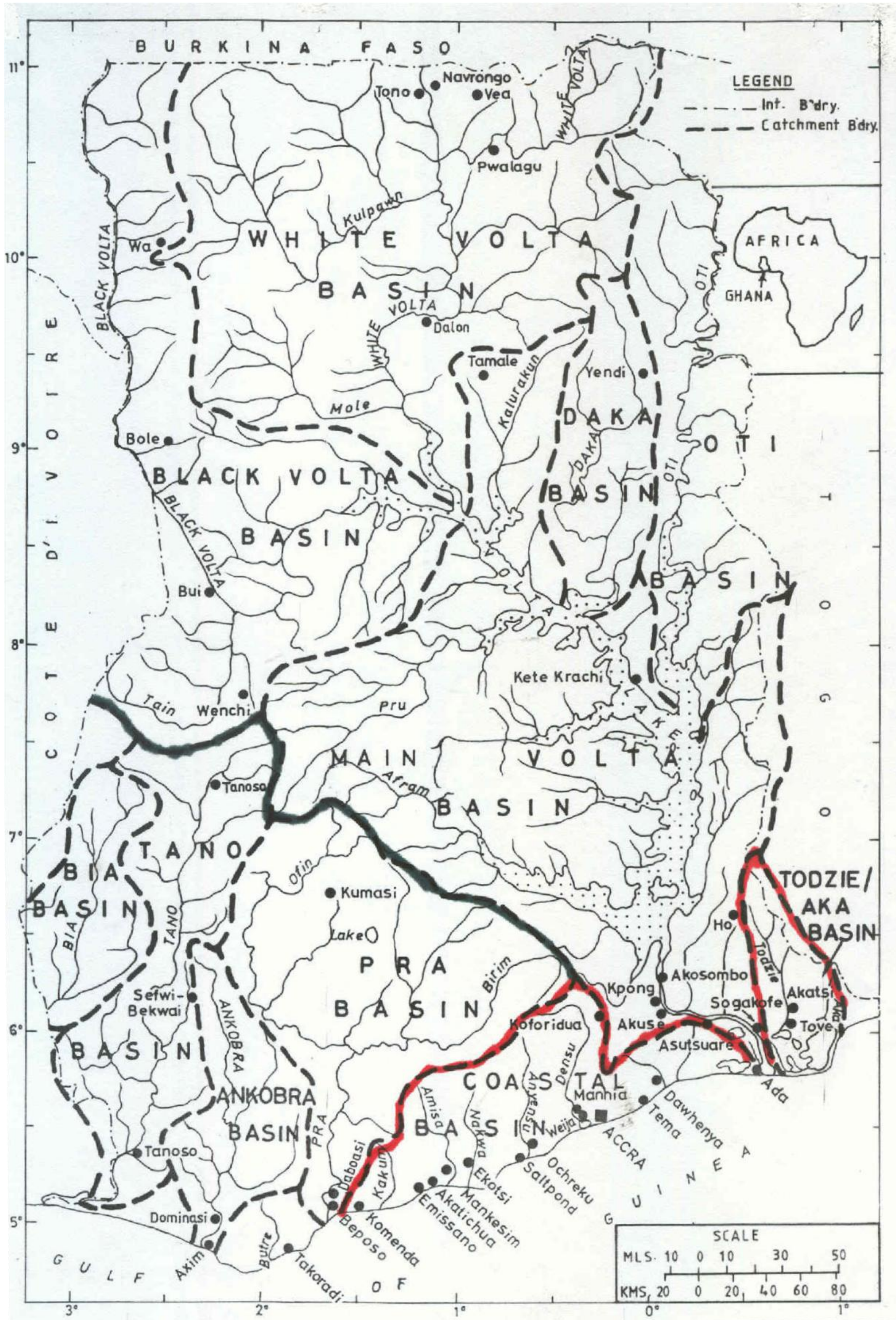
Source: WRC, 2012; FAO/AQUASAT 2005

Table 1.2: 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**

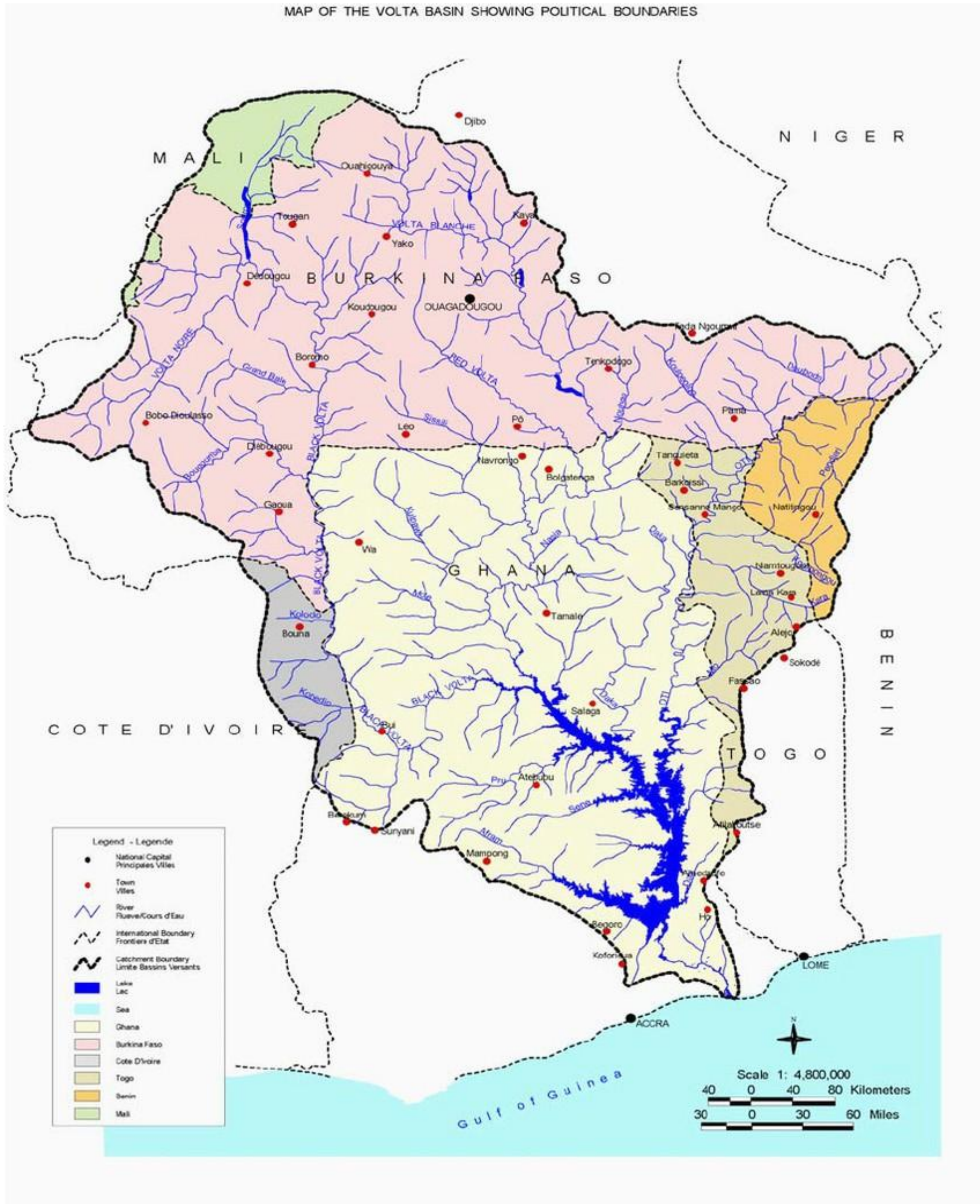
Source: MWH, 1998; WRC, 2012; FAO/AQUASAT 2005.

Figure 1.1: Drainage Map of Ghana showing various River Basins



Source: Water Resources Commission

Figure 1.2: Map of the Volta Basin showing Political Boundaries



Source: Andah and Gichuki, 2003[4]

4 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.

1.3.2 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 percent 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.

1.3.3 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 percent, but constituted 13.4 percent of the water resources generated internally. As presented in Table 1.3, about 3,123 million m^3 of total withdrawals was for irrigation (68 percent), 578 million m^3 for domestic use (20 percent), and 289 million m^3 for industrial purposes (10 percent).

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.

Table 1.3: Water Usage as at 2015

Water Use	2000 (Million m^3)	2010 (Million m^3)	2015 (Million m^3)	% of Total Water Use (2015)	% of Total Withdrawal (2015)
Domestic	324.83	503.63	578.67	1.2	20
Irrigated agric.	617.45	2,132.42	3,123.42	4.8	68
Industrial	162.41	251.82	289.33	0.6	10
Livestock	31.90	49.10	62.95	0.1	2
Energy	37,843	37,843	37,843	93.3	-
Water Transport	N/A	N/A	N/A		
Total Demand	**38,979.59**	**40,779.79**	**41,896.95**		

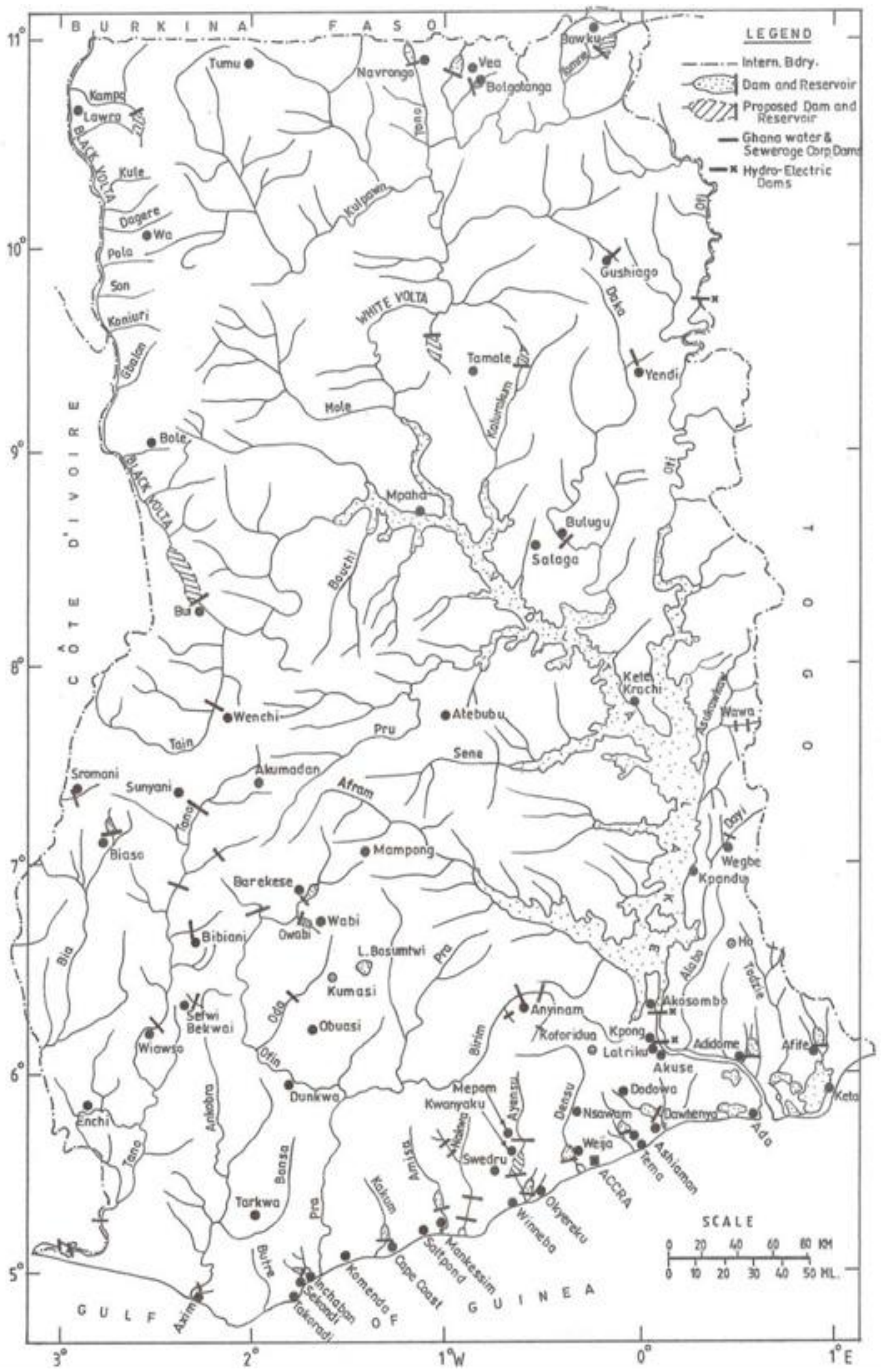
Source: MWH, 1998; WRC, 2015

1.3.4 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 1.3). 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 1.3: L



Source: Water Resources Commission

1.3.5 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 1.4 below.

Table 1.4: 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

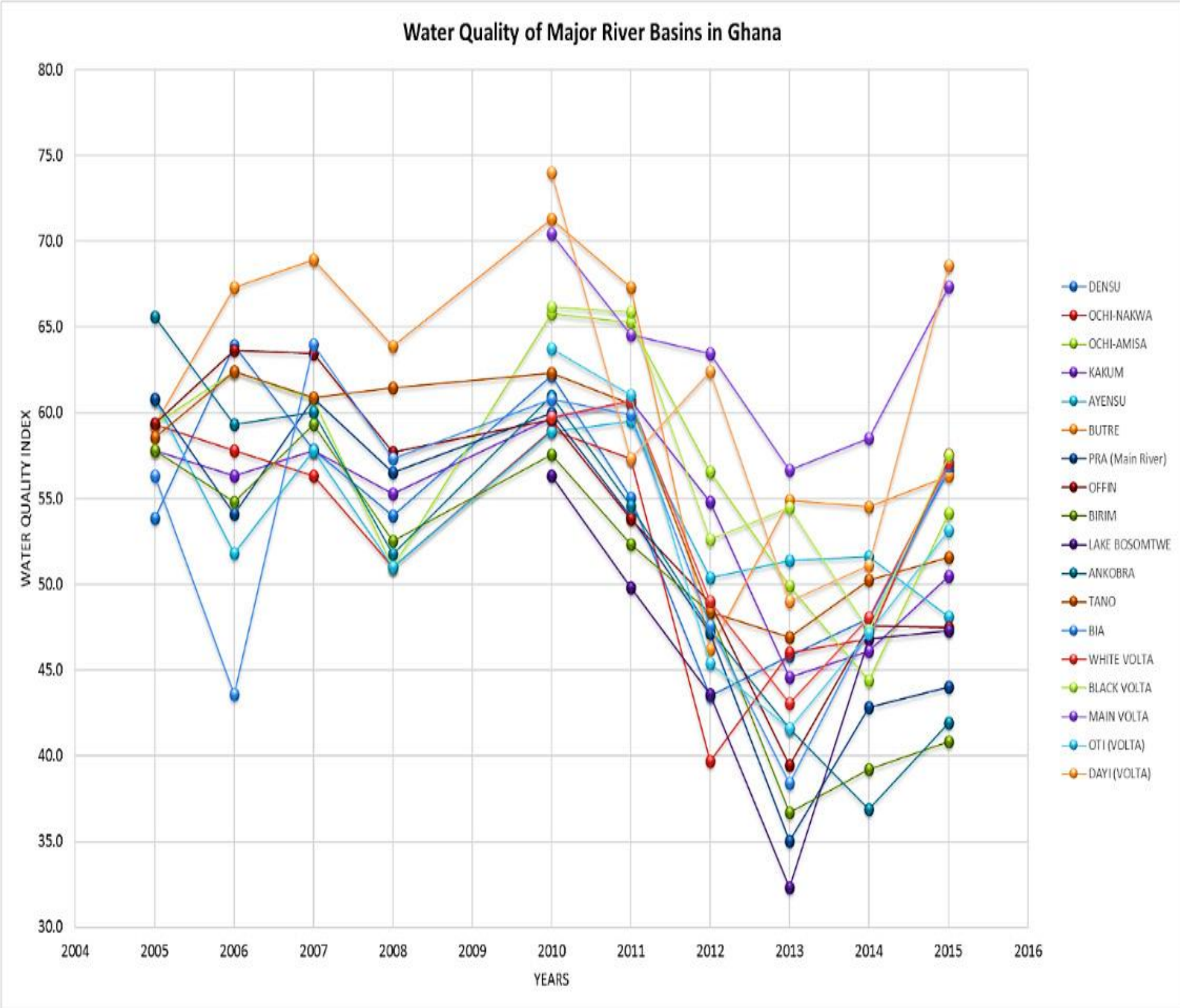
Water ecosystems are not in a healthy state. Many of the rivers deteriorated in quality in 2013 and were found in Class III, i.e. poor water quality. Lake Bosumtwi recorded the minimum WQI score of 32.3, while Ajena in the main Volta Lake had the maximum WQI score of 62.2 (Figure 1.4).

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 percent were of poor quality (Class III), with 15 percent 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.

Drilling records have revealed that on the average, about 20 percent of boreholes drilled for domestic water supplies have high concentrations of manganese, iron, or both metal compounds. A prominent water quality problem with groundwater supply in Ghana is excessive iron concentrations. High iron concentrations in the range 1-64mg/1 have been observed in boreholes in all geological formations. Iron originates partly from the attack of low pH waters on corrosive pump parts and partly from the aquifers. High concentrations of fluoride in the range 1.5-5.0mg/l have been observed in the Upper East, Upper West and Northern regions. High fluoride concentrations in drinking water is known to cause significant health effects, e.g. tooth decayn[5].

5 WRC, Water Quality Monitoring Report (Accra: WRC, 2015)

Figure 1.4: Summary of WQI of major water bodies from 2005 to 2015



Source: Water Resources Commission

1.4 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 percent from the current 51 percent 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 ecosystems.
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 percent 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 percent 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.

1.5 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 (Table 1.5).

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 an additional potential resource base.

Table 1.5: 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

1.5.2 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 percent of water is required to be used for agriculture (irrigation and livestock watering), 21.4 percent for domestic/municipal purposes, and 7.2 percent 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 m3/year representing 17 percent of the internal renewable freshwater resources (IRWR) and 10 percent of TARWR. The domestic, industrial and irrigation water requirements would be 783 million m3/year, 234.8 million m3/year, and 4.11 billion m3/year respectively. The TWR is estimated to increase to 30.12 billion m3/year by 2045, that is 57 percent of the TARWR and 99 percent 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 via 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 1.6 below.

Table 1.6: 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 (Table 1.7).

Table 1.7 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 percent of the IRWR or 57 percent 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 1.7: Estimated Water Requirements Based on Income Level Ratios (2018-2047)

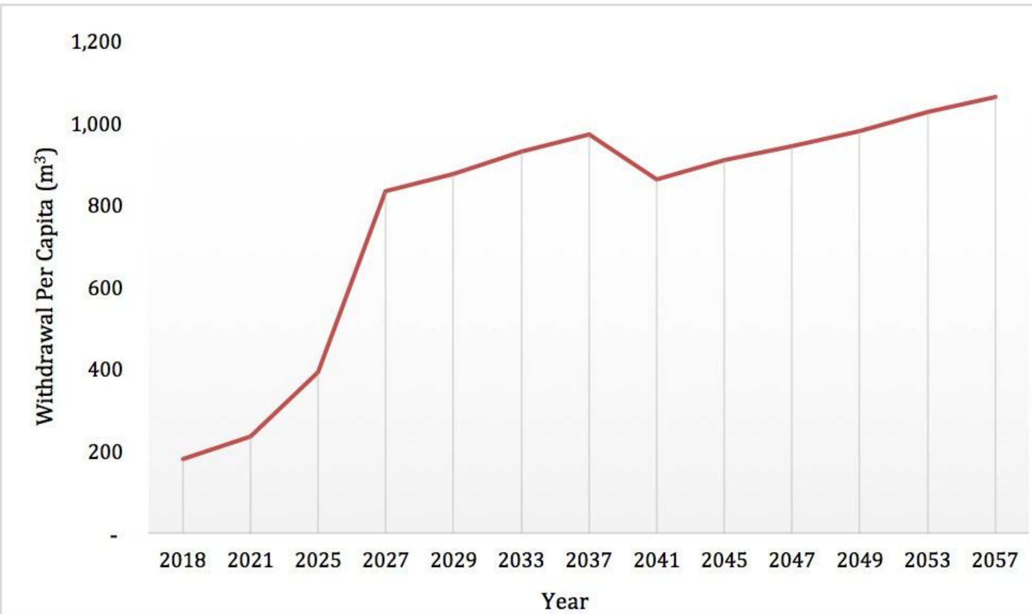
Year	Domestic WR (million m³)	Industrial WR (million m³)	Irrigation WR (million m³)	Total WR (million m³)	TWR as % of IRWR	TWR as % of TARWR
2018	782.80	234.84	4,114.42	5,132.07	17	10
2021	1,716.42	514.93	5,149.27	7,380.62	24	14
2025	3,125.94	937.78	9,377.83	13,441.55	44	25
2027	3,966.86	5,950.29	20,231.00	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 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[6]. 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 235 m3 by 2021, 874 m3 by 2029, and reach 943 m3 by 2047. These figures compare favourably to the corresponding values of 1,025 m3 and 809 m3 for Canada (North America) and Spain (Europe) respectively. Figure 1.5 shows the trend of anticipated water use/withdrawal per cap/yr as the population grows and the economy transitions to a HIC.

Figure 1.5: Trend of anticipated water use per cap/yr



Source: Author's construct

6 Organisation for Economic Co-operation and Development (OECD), Environmental Outlook to 2050: The Consequences of Inaction (Paris: OECD, 2012). doi:10opment, g d international (e. t o ve as frastructure) is not necessarily permanent and acn ds, floodplains, etc. together with.1787/9789264122246-en.

Anticipated Water Use per cap/yr

Note that the water use per cap/yr falls briefly between 2037 (970.9m³) and 2041 (860m³) 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).

1.5.3 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 percent - 600 percent).
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.

1.6 Strategic Framework for Water ResourcesManagement

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.

1.6.2 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 m³ per/cap/year
ii. Meet total water requirement of 48 billion m³/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 (Table 1.8).

Table 1.8: 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

1.7 Implementation Plan

1.7.1 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 1.9.

Table 1.9: 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

1.7.2 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 1.10 below.

Table 1.10: 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 resources	Investigate and develop hydrogeological and groundwater base (i.e. shallow, intermediate and deep aquifers)	Develop multi-purpose conservancy facilities to increase 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	Generate additional water resources from rainwater and flash flood harvesting Develop natural infrastructure "natural harvesters" such as wetlands, and floodplains	Develop inter basin water transfer/ diversion 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

1.8 Financing Strategy

Currently, funding commitment to ensure implementation of water resources management measures is inadequate. Annual budgetary allocations meet less than 15 percent 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 percent of targets. Financing for water resources management needs to be given increased attention, following the support provided for water supply.

1.8.1 Financial Requirements

Financial requirements for water resources management are for planned programmes up to 2025 and are 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

1.8.2 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 percent 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.

1.9 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 1.11 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 1.11: Results Monitoring Matrix of the Water Resources Infrastructure Plan

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.**		
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.		
Objective Indicator	**Progress Indicators/Milestones**	**Planned Projects/Interventions**
1.1.1 Use/withdrawal of water resources increased. Baseline (2018) 80 m³ per/cap/yr Target (2047) 1025 m³ per/cap/yr	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	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.
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.		
Objective Indicator	**Progress Indicators/Milestones**	**Planned Projects/Interventions**
1.2.1 Total water requirement met. Baseline (2018) 5.13 billion m³ Target (2047) 48 billion m³	1.2.1 Number of multipurpose water storage facilities developed 1.2.2 Number of degraded wetlands/ floodplains restored	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
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.		
Objective Indicator	**Progress Indicators/Milestones**	**Planned Projects/Interventions**
1.3.1 Improved water quality of all river basins **Baseline (2018) Mean WQI = 52.5 (fairly good)** **Target (2047) Mean WQI = 80 (good)**	1.3.1 Number of buffer zones created 1.3.2 Water quality monitoring reports produced	1.3.1 Promote clean products and their uses 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

1.10 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 1.12.

Table 1.12: 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 2 Water Supply

2.1 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.

2.1.1 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.

2.1.2 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 are 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.

2.2 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.

2.3 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 as follows:

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 mandates 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 developing infrastructure in the sector over the years. These sector agencies and stakeholders have been categorised mainly for the purposes of this plan (Table 2.1) based on the key statutory mandate/functions and/or areas of operation to facilitate comprehensive identification for effective application of the plan.

Table 2.1: 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

2.4 Existing Water Supply Systems and Facilities

2.4.1 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 percent to 76 percent. 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 2.2: Overall Status of Existing Infrastructure

System Technology	Countrywide Developments
PSS	28,718
STWSS	391
PUWSS	17
UWSSS	71

Source: GWCL and CWSA

2.4.2 Urban Water Supply System

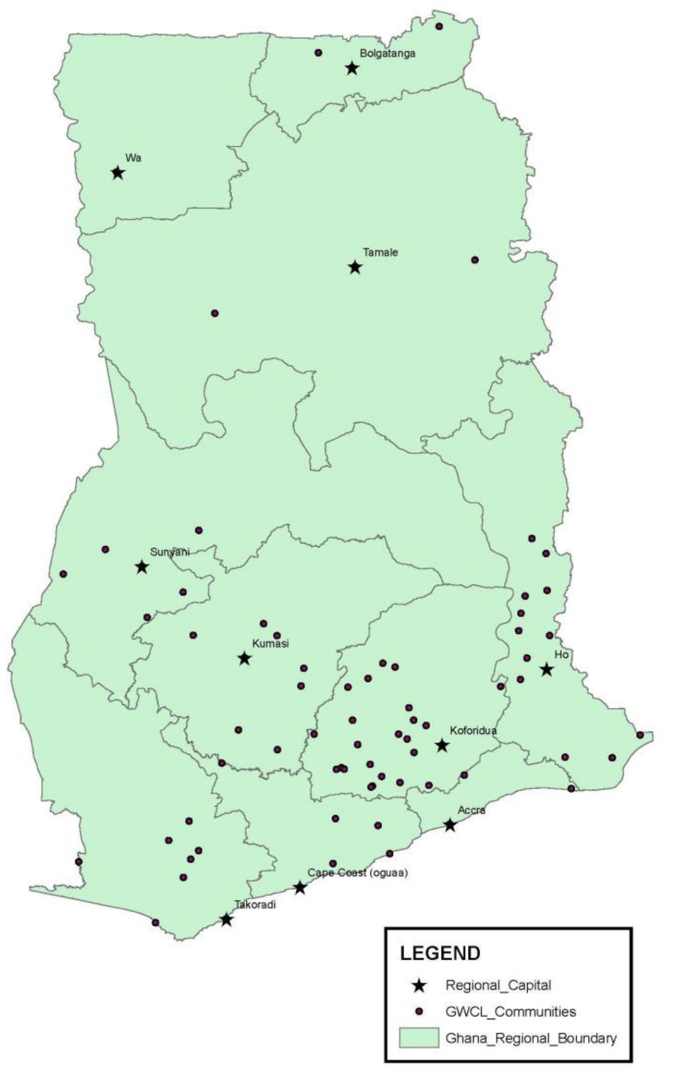
The Urban Water Supply System (UWSS) is the highest level technology for the provision of potable water in the sector. Such systems are developed to serve mainly highly urbanised communities with populations above 50,000. Most beneficiary communities of the UWSS therefore tend to be regional or district 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 2.3 below. Figure 2.1 presents the spatial distribution of the existing UWSS.

Table 2.3: 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 2.1: Spatial Distribution of Urban Water Supply Systems



Source: Author's construct based on GWCL data

2.4.3 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.

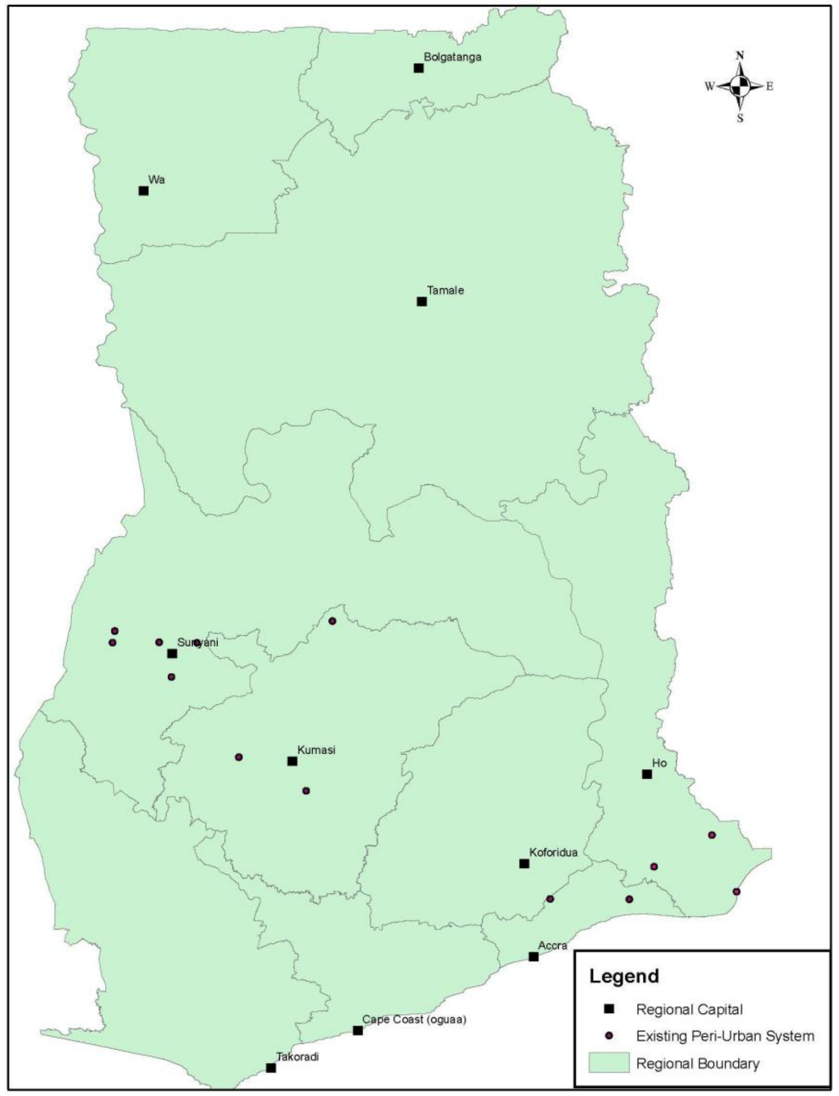
These systems have single or multiple town/ community coverage and simple technology components, particularly for treatment facilities. The systems are managed by the GWCL when it is developed under their mandate. The community or private operator manages it when developed under the CWSA. Currently, there are a total of seventeen (17 No.) PUWSS in operation in the country. Regional distribution of such systems is presented in Table 2.4 below. The spatial distribution of existing PUWSS is also presented (Figure 2.2).

Table 2.4: 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 2.2: Spatial Distribution of Peri-Urban Water Supply Systems



Source: Author's construct based on GWCL data

2.4.4 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 thinly 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. A few of them located in the middle belt of the country are based on surface water sources.

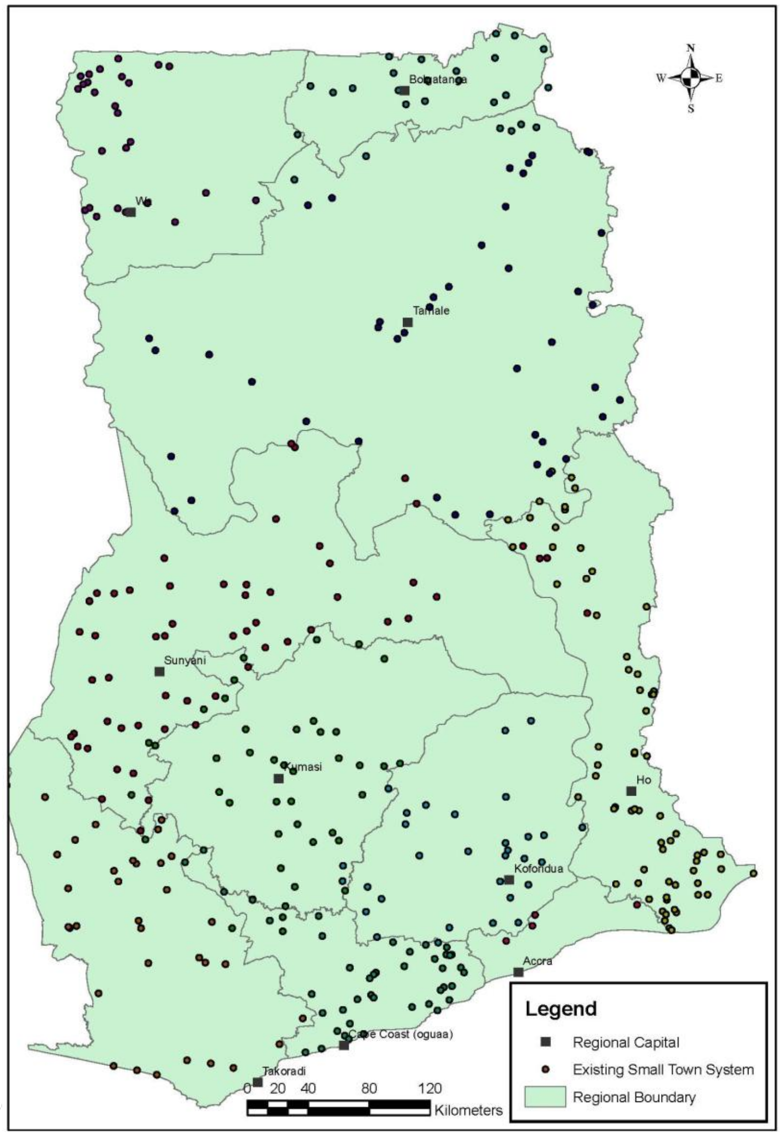
These systems have single town/community coverage and they are operated by simple technology. They are mostly managed by the community or a private operator under the CWSA which also has statutory mandate for facilitation of the system development. Currently, there are a total of 348 STWSS in operation in the country with an overall average of 35 per region (Table 2.5). A map of the spatial distribution of existing STWSS is presented (Figure 2.3).

Table 2.5: 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 2.3: Spatial Distribution of Small Town Water Supply Systems



Source: Author's construct bas

2.4.5 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 2.6.

Table 2.6: 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

2.5 Existing Sources for Water Supply

2.5.1 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 2.7 presents the prevalence of the various source developments across the country.

Table 2.7: 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

2.5.2 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).

2.5.3 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
2.8 for the development of these groundwater sources for various system technologies.

Table 2.8: 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

2.5.4 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 their 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.

2.5.5 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 energy 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. The infrastructure plan therefore does not envisage the effective use of this source in target developments.

2.6 Water Demand Projections

2.6.1 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 2.9.

Table 2.9: 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 2.10.

Table 2.10: 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 2.11).

Table 2.11: 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

2.6.2 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 2.12 below.

Table 2.12: 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 have been presented (Table 2.13). 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 2.13: Outline of Per Capita Consumption

Demand Horizon		2018				
		Per Capita Demand Estimation				
Pop. Range	System Technology	Aggregated Per Capita Demand	Losses		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		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		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		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		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		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		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		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		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		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		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		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

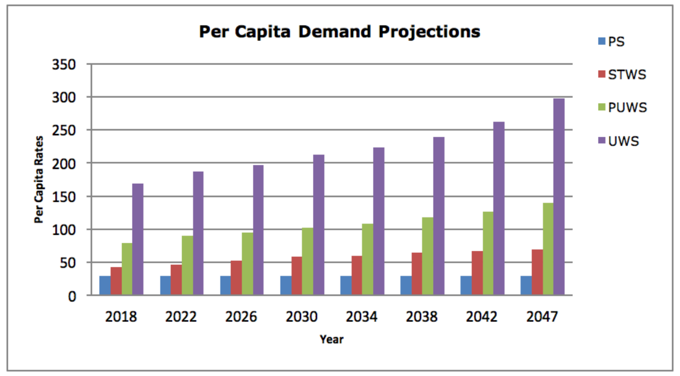
Demand Horizon		2042				
		Per Capita Demand Estimation				
Pop. Range	System Technology Classification	Aggregated Per Capita Demand	Losses		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		l/c/day		l/c/day		l/c/day
<2,000	PSS	23	6	1	1.2	29
2,000 - 15,000	STWSS	53	6	3	1.2	67
15,000 – 50,000	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		Demand Peak Factor	Total Per Capita Demand
			%	Per Capita		
		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 plan period is presented in Figure 2.4 below.

Figure 2.4: Projections of Per Capita Demand



Source: Author's construct

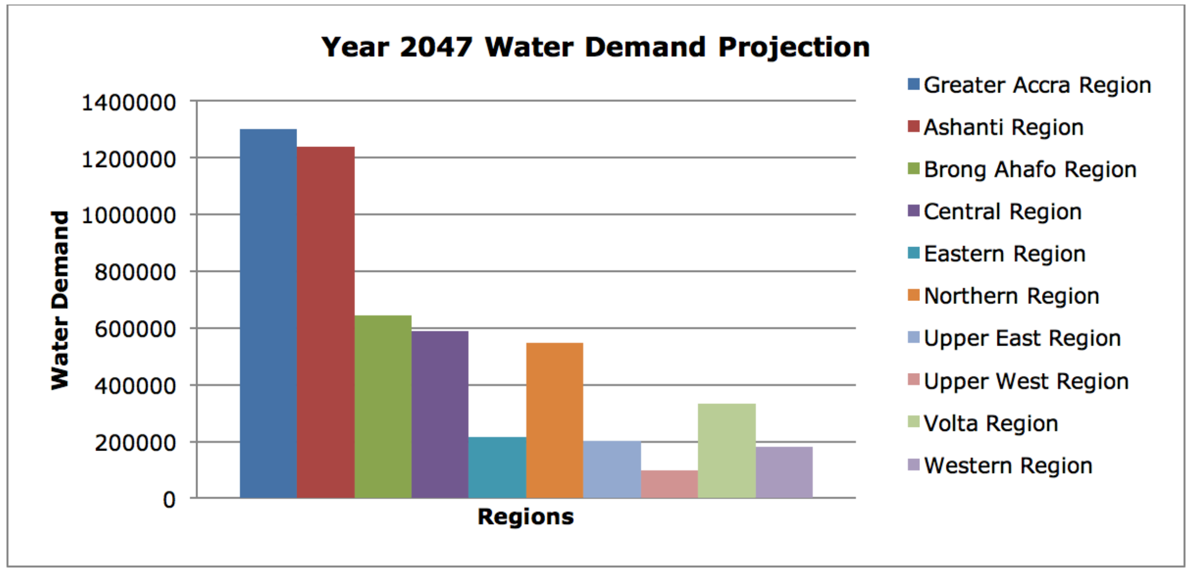
Summary of Regional Water Demand Projections

The summary of regional demand projections is presented in Table 2.14 below. A graphical representation of projected regional population distribution for 2047 is provided in Figure 2.5:

Table 2.14: 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**

Figure 2.5: Water Demand Projection for Year 2047



Source: Author's construct

2.7 Infrastructure Gap Analysis and Targets

2.7.1 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 accessed 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 2.15 below.

Table 2.15: Regional Summary of Gap Analysis

Region	Baseline (2016)				Year 2018 Horizon			
	Estmated Coverage Gap		Average % Coverage Gap		Estimated Coverage Gap		Avearge % Coverage Gap	
	Comnunity (No.)	Demand (m³/d)	Community (No.)	Demand (m³/d)	Community (No.)	Demand (m³/d)	Community (No.)	Demand (m³/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

2.7.2 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 2.16: 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 below (Tables 2.17, 2.18, 2.19 and 2.20).

Table 2.17: Target Infrastructure Developments (2018-2022)

	2016 Horizon				2018 Horizon								2022 Horizon							
Region	**Baseline Status**				**Target System Development**				**Target System Upgrading**				**Target Syst. Development**				**Target Syst. Upgrading**			
	PS	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**
Greater Accra	484	3	51	1	48	3	0	0	0	2	0	0	0	0	0	0	0	3	0	0
Ashanti	6501	29	0	0	0	48	1	0	0	38	0	1	0	56	3	0	0	30	4	4
Brong Ahafo	3301	49	0	0	200	31	0	1	0	46	0	3	160	39	1	1	0	0	54	0
Central	2004	46	0	0	150	8	0	0	0	32	0	0	120	12	3	0	0	0	0	0
Eastern	2919	64	0	0	100	41	1	0	0	69	0	0	80	56	7	0	0	0	0	3
Northern	4412	40	0	0	350	37	0	0	0	13	0	0	280	49	8	0	0	0	0	0
Upper East	2879	25	3	3	150	47	3	0	4	32	0	0	120	47	0	0	0	0	0	0
Upper West	1832	24	0	0	150	29	0	0	0	26	0	0	120	30	0	0	0	0	0	0
Volta	2471	67	0	0	100	24	0	0	0	24	1	0	80	35	18	0	0	4	0	0
Western	1865	57	6	2	200	41	7	0	0	31	0	1	160	52	3	1	0	0	0	0
Total	**28,669**	**404**	**60**	**6**	**1448**	**309**	**12**	**1**	**4**	**313**	**1**	**5**	**1120**	**376**	**43**	**2**	**0**	**37**	**58**	**7**

Source: Author's construct

Table 2.18: Target Infrastructure Developments (2026-2030)

	2026 Horizon								2030 Horizon							
Region	**Target System Development**				**Target System Upgrading**				**Target System Development**				**Target System Upgrading**			
	PS	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**
Greater Accra	0	0	0	0	0	3	0	0	0	12	0	1	0	4	4	0
Ashanti	0	62	4	0	0	58	0	1	0	65	7	0	0	58	3	0
Brong Ahafo	128	43	1	0	0	51	2	1	102	48	0	0	0	66	0	1
Central	96	13	0	0	0	29	0	3	77	13	1	0	0	24	0	3
Eastern	64	56	1	0	0	92	0	0	51	59	7	0	0	87	0	1
Northern	224	52	11	0	0	63	0	0	179	51	11	0	0	50	2	1
Upper East	96	44	0	0	0	43	3	1	77	36	1	0	0	44	1	1
Upper West	96	27	0	0	0	15	0	0	77	33	0	0	0	22	0	1
Volta	64	34	0	0	0	51	0	0	51	33	2	0	0	50	23	0
Western	128	50	0	0	0	52	2	0	102	52	10	0	0	77	0	0
Total	**896**	**381**	**17**	**0**	**0**	**457**	**7**	**6**	**717**	**402**	**39**	**1**	**0**	**482**	**33**	**8**

Source: Author's construct

Table 2.19: Target Infrastructure Developments (2034-2038)

	2034 Horizon										2038 Horizon					
Region	**Target System Development**				**Target System Upgrading**				**Target System Development**				**Target System Upgrading**			
	PS	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**
Greater Accra	0	12	0	0	0	4	0	0	0	12	0	0	0	4	0	0
Ashanti	0	63	1	1	0	70	11	3	0	61	0	0	0	70	0	0
Brong Ahafo	104	46	0	0	0	78	0	2	86	49	0	0	0	68	0	0
Central	86	16	0	0	0	24	0	0	72	18	0	0	0	24	0	0
Eastern	104	49	1	0	0	87	1	0	86	32	0	0	0	82	0	0
Northern	86	53	0	0	0	72	1	0	72	53	0	0	0	72	0	0
Upper East	52	7	1	0	0	45	1	0	43	10	1	0	0	48	2	2
Upper West	86	23	0	0	0	22	0	0	72	18	0	0	0	21	0	0
Volta	52	38	0	0	0	1	0	0	43	41	0	0	0	66	0	0
Western	86	29	0	0	0	65	1	2	72	27	2	0	0	21	1	0
Total	**657**	**336**	**3**	**1**	**0**	**468**	**15**	**7**	**547**	**321**	**3**	**0**	**0**	**476**	**3**	**2**

Source: Author's construct

Table 2.20: Target Infrastructure Developments (2042-2047)

			2042 Horizon								2047 Horizon					
Region	**Target System Development**				**Target System Upgrading**				**Target System Development**				**Target System Upgrading**			
	PS	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**	**PS**	**STWS**	**PUWS**	**UWS**
Greater Accra	0	12	0	0	0	3	4	0	0	12	0	0	0	4	2	0
Ashanti	0	65	20	0	0	66	0	1	0	64	9	0	0	98	0	3
Brong Ahafo	72	54	0	0	0	81	0	1	60	47	15	0	0	62	2	4
Central	60	10	0	0	0	24	0	0	50	8	6	0	0	24	3	0
Eastern	72	28	1	0	0	82	0	0	60	26	20	2	0	68	1	1
Northern	60	55	0	3	0	72	0	0	50	49	6	0	0	68	5	2
Upper East	36	10	0	0	0	57	2	0	30	12	0	0	0	52	3	2
Upper West	60	24	0	0	0	17	0	0	50	26	5	0	0	26	0	1
Volta	36	39	0	0	0	60	0	1	30	39	0	0	0	65	24	0
Western	60	18	0	0	0	34	0	2	50	30	5	0	0	50	8	2
Total	**456**	**315**	**21**	**3**	**0**	**495**	**6**	**5**	**380**	**313**	**66**	**2**	**0**	**517**	**48**	**15**

Source: Author's construct

2.8 Systems Management Performance

2.8.1 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, direct and indirect in the past decade, NRW continues to assume a sizeable magnitude of urban water production. During the 30 year plan period, a number of measures shall be made to reduce NRW from 50 percent to less than 15 percent. Thus, the strategy presented herein is based upon initiatives to fully address human settlements and spatial planning systems, 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% by 2025. 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, in volumes, from the physical water system. Leakages may occur as overflows on reservoirs and storage tanks; on transmission mains and distribution systems; 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 invisible background leaks 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 20 metre of water column (mwc) 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 of all valves and joints for leakage and minor leaks that may be difficult to detect. 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.

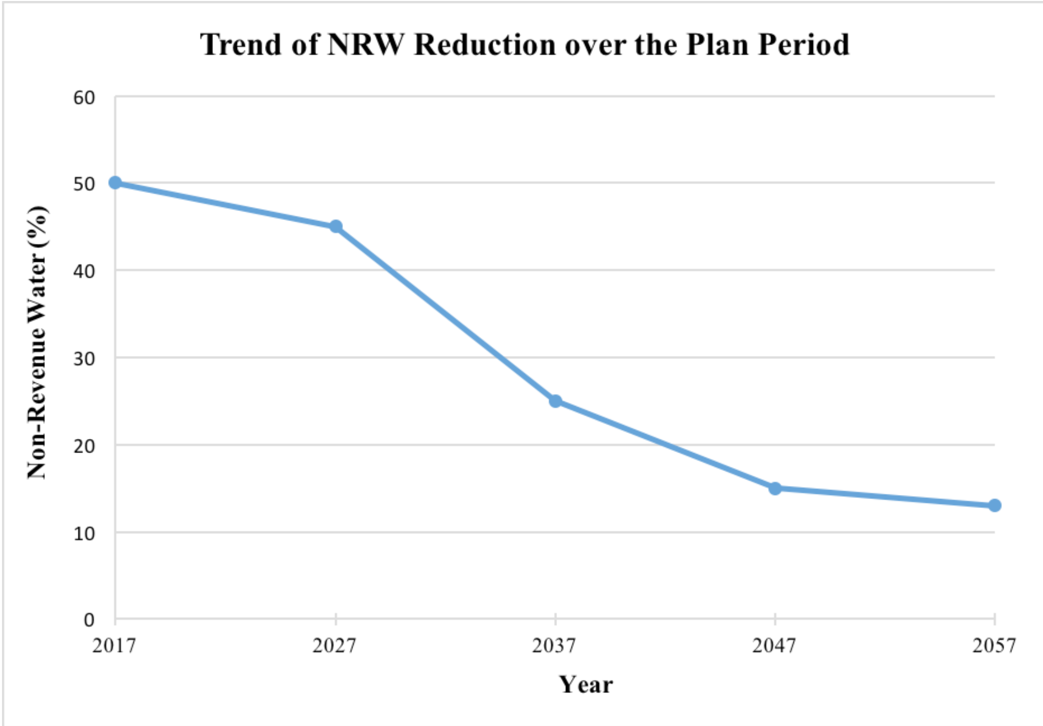
Capacity Building

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.

Figure 2.6: Non-Revenue Water Target



Source: Author's construct

2.9 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 2.21 shows the typical component configuration and key works components of water supply infrastructure.

Table 2.21: 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 2.22 and 2.23).

Table 2.22: 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 2.23: 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

2.10 Risks and Mitigation Measures

The identification of potential implementation risks is absolutely crucial to the smooth implementation of the proposed intervention and particularly for assuring optimum outcomes. Specific measures proposed for risk management together with recommended institutional arrangements for effective execution are outlined in Table 2.24 below.

Table 2.24: Risks and Mitigation Measures Matrix

Identified Risks	Mitigating Measure	Institutional Support
Deficient projects formulation and packaging	• Ensure compliance with project planning frameworks • Vetting of project formulation by sector ministry	• Sector agency to ensure compliance with planning framework. • MWRS to provide monitoring support
Inadequate development of institutional support mechanism for project implementation	• Identify stakeholders and properly define roles and responsibilities • Develop coordination mechanism for effective stakeholder participation	• Sector agency to play lead role in stakeholder coordination. • MWRS to provide monitoring support
Lack of mechanism for effective management of the overall project implementation processes	• Implementing agency supported by the sector ministry to establish overall Project Monitoring Unit	• Sector agency to ensure compliance with planning framework. • MWRS to provide monitoring support
Deficient stakeholder consultations on goals and objectives of the project and stakeholder roles Poor institution of collaboration between implementing agency and utility agencies.	• Identify stakeholders and properly define roles and responsibilities • Develop coordination mechanism for effective for effective stakeholder participation	• Sector agency to play lead role in stakeholder coordination. • MWRS to provide monitoring support
Inappropriate selection of technology and system design	• Framework procedures shall be ensured by implementing agency	• Review of selection by implementing agency • MWRS to provide monitoring support
Inappropriate design of linkages or connections to existing facilities Inadequate provision of site data/ information	• Services for design shall ensure adequate use data on site and existing facilities. • Review of designs should assure effective incorporation of existing facilities	• Design services provider • Review by implementing agency • MWRS to provide monitoring support • Stakeholder consultations
Poor facilitation of coordination between works contractor and relevant utility agencies	• Identify and adequately inform all relevant utility agencies. • Identify coordination links for facilitation of the works execution	• Review by implementing agency • MWRS to provide monitoring support
Excessive resettlement issues	• Prior to finalisation of project formulation should identify and assess in detail, potential resettlement requirements and proposed measures to redress • Adequate resource provision should be made for resettlement arrangements	• Design services provider • Review/Facilitation by implementing agency • MWRS to provide monitoring support • Stakeholder consultations
Ineffective monitoring of project execution /implementation	• Well-structured monitoring mechanism with well-defined stakeholder roles and responsibilities	• Implementing agency should play lead role in establishing mechanism • MWRS to provide monitoring support
Lack of institutional support for the planning and implementation of the project	• Establishment of mechanism for effective facilitation of stakeholder participation	
Inadequate funding for operation & maintenance (O&M)	• In-depth assessment of specific project O&M requirements required at project formulation and planning stage • Establish mechanism for provision of funding for O&M including institutional support for effective O&M • Develop mechanism for resource allocation and monitoring	

Source: Author's construct

Chapter 3 Integrated Waste Management

3.1 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 (MLGRD) 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 a comprehensive framework to facilitate the effective development of an integrated waste management system to meet global and national development goals cannot be overemphasised.

3.1.1 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.

3.2 Policies and Institutional Framework

3.2.1 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)

3.2.2 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 3.1.

Table 3.1: 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

3.2.3 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 for 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.

3.2.4 Financial Management Framework

The framework that guides MMDAs in their financial management of resources is based on the following:

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).

3.2.5 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 3.2.

Table 3.2: 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

3.2.6 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[1]. 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.

1 National Environmental Sanitation Policy, 2010

The relevant targets provided by the NESP are presented in Table 3.3. The table indicates 100 percent solid waste collection in the five major cities by 2020 and in the other municipalities/cities by 2025. In addition, up to 90 percent of all communities shall be provided with primary separation facilities and
services by 2035. The NESP also targets up to 90 percent coverage of all rural communities.

Table 3.3: 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

3.3 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.

3.3.1 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[2]. Tema is the only metropolis with a comprehensive sewerage system serving about 38 percent of the total metropolitan population[3]. Accra, the national capital has a sewerage system covering only about 6 percent of the metropolitan population[4].

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[5]. Overall access to improved sanitation is only about 15 %[6].

2 Multiple Indicator Cluster Surveys (MICS), 2011
3 National Environmental Sanitation Strategy and Action Plan (NESSAP), 2010
4 Accra Sewerage Improvement Project (ASIP) Appraisal Report, 2016

Table 3.4: 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).

5 EAWAG/Water Research Institute (WRI), 1998
6 Joint Monitoring Programme (JMP), 2015 Updated

Table 3.5: 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

3.3.2 Treatment and Disposal

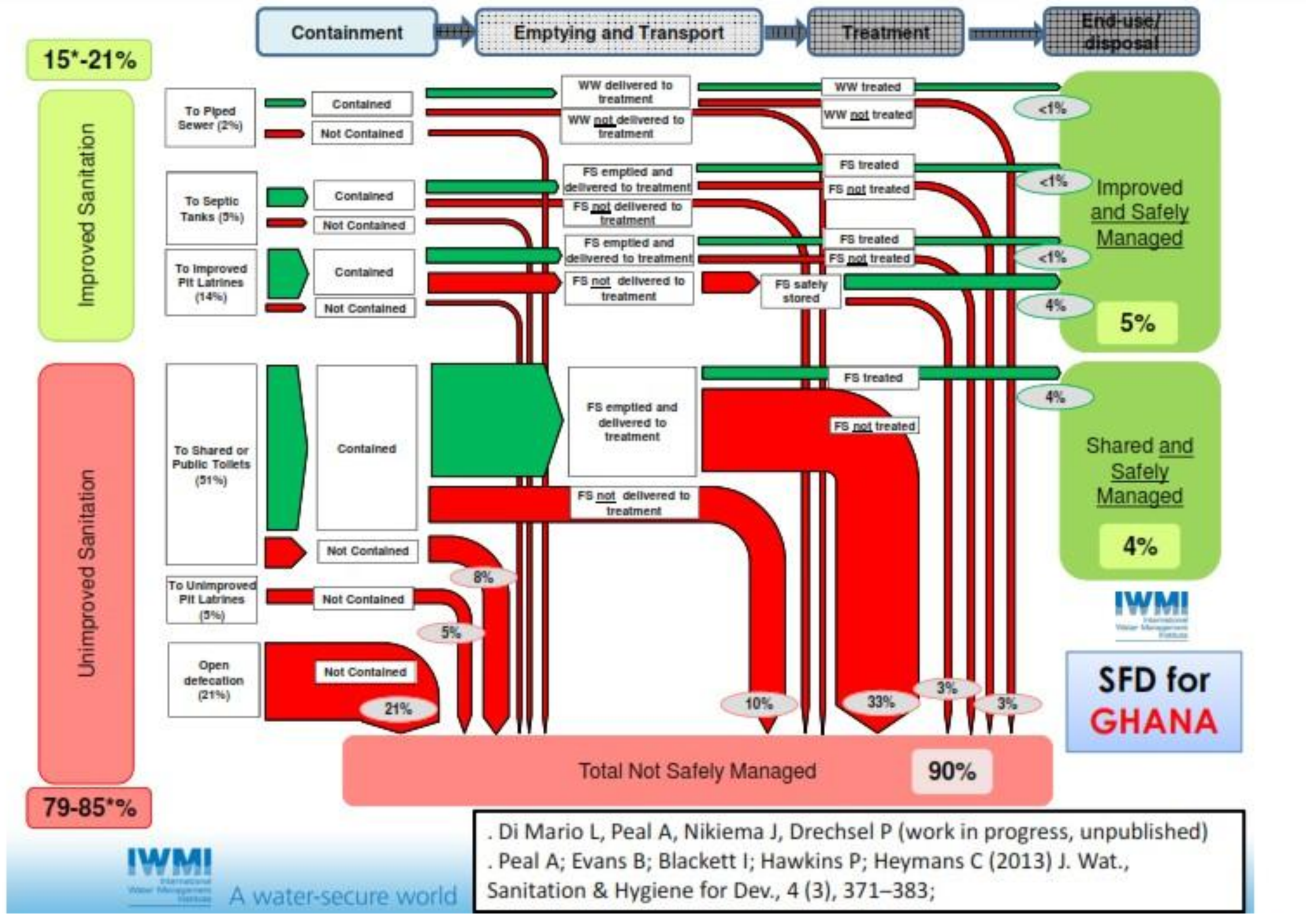
Over the years, the MMAs have not been able to keep up with their mandate to provide, operate and maintain adequate waste treatment infrastructure and services in accordance with the Local Government Act (1993). The result is increasing discharge of untreated liquid wastes (septage and sewage) in the urban built environment. In the Greater Accra Metropolitan Area (GAMA), for example, less than 10 percent of the total quantity of septage and sewage generated is treated and safely disposed of as shown in Figure 3.1. 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[7].

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 efforts to improve treatment capacity have 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 3.1: Septage/Sewage Flow Diagram



Source: IWMI, 2014

3.3.3 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 m³ 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 3.6 presents some selected wastewater treatment facilities in the country.

7 National Environmental Sanitation Strategy and Action Plan (NESSAP), 2010

Table 3.6: 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	Min. 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
Burma Camp	Trickling Filter + Waste Stabilization 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	Inhoff 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 Hosp	Imhoff Tank + Trickling Filter	1954	MOH/PWD	Government Subvention	Rehabilitated 1990
Presec School	Stabilization 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 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

3.4 Current State of Solid Waste Management

3.4.1 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.

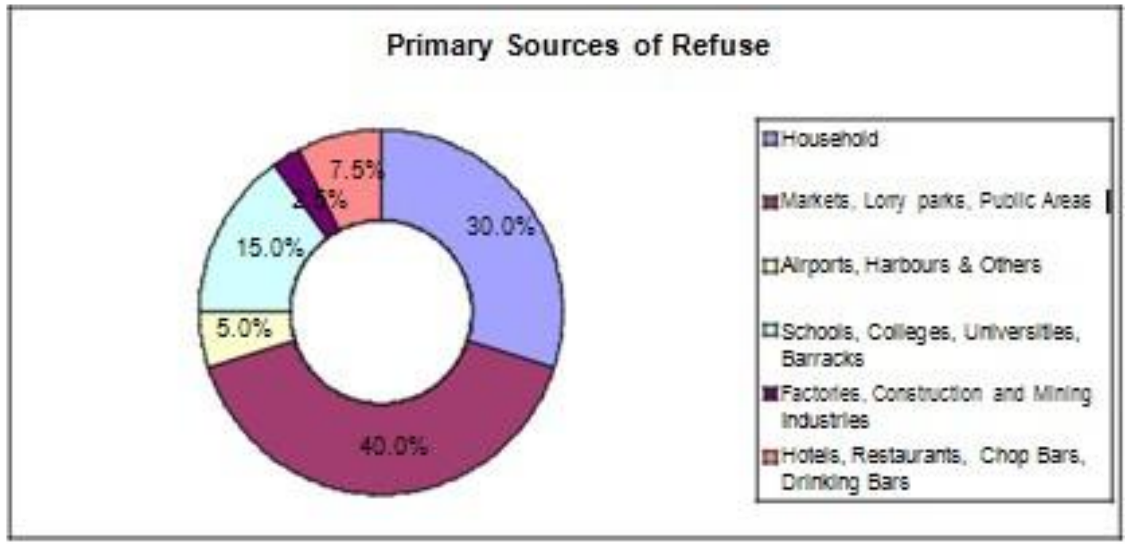
Municipal Solid Waste

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, 0.40kg/person/day and 0.28kg/person/day, respectively, compared with the regional average of 0.51 kg/person/day[8].

The average composition of domestic waste in Ghana is 61 percent organics, 14 percent plastics, 6 percent metals and glass, 6 percent inert, 5 percent paper, 5 percent miscellaneous, and 3 percent textiles, leather and rubber. Over the last three decades, there has been a significant increase in plastics from 3 percent (1989 -1999) to over 8 percent (1999-2009) according to the 2010 NESSAP report, implying the need for serious attention. Generally, with an average moisture content of about 50 percent 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 3.2.

8 K. Miezah et al, 2015

Figure 3.2: Sources of Solid Waste Generation



Source: NESSAP, 2010

Only a little over 50 percent 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. Efforts to improve on collection capacity by increasing vehicular fleet numbers 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[9]. 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 percent 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 heavy and light industrial concerns mainly located within industrial enclaves in the major urban centres.

9 Quartey & Chýlková, 2012

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 9 kg Electrical and Electronic Equipment Waste (WEEE)) was imported into Ghana, of which about 50 percent reached the collection system[10].

Generation of e-waste and other hazardous wastes appears to be increasing, particularly in the major urban areas where over 87 percent 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.

10 SBC e-Waste Africa Project Report, 2011

3.4.2 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.

3.4.3 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 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.

3.5 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.

3.6 Strategic Approaches for Development

3.6.1 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 3.7 below.

Table 3.7: Per Capita Waste Generation by Income Level [11]

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

3.6.2 Alternative Approaches for Solid and Liquid Wastes Management

A number of alternative approaches towards development of the sector are defined and assessed in Tables 3.8 and 3.9.

Table 3.8: 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

11 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.

Table 3.9: 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

3.6.3 Adopted Approach, Strategic Objectives and Actions

Adopted Approach

The key elements of the alternative approaches adopted for Solid Waste Management and LWM include:

- Privatised solid wastes collection and minimisation with source separation, resource recovery/reuse.
- Extensive delivery of simplified/small bore sewers coupled with improved septage haulage.
- Increased privatisation of treatment and resource recovery infrastructure based on sustainable technologies,
- Adoption of principle of full or partial cost recovery.
- Awareness programs on waste minimisation and resource recovery/reuse.

Strategic Actions

Table 3.10 presents the strategic actions for both solid and liquid waste management based on the objectives.

Table 3.10: Strategic Action for Solid and Liquid Waste Management

Objective	Strategic Action
Sustainable waste minimisation/reduction, reuse, recycling and recovery	• Develop programmes to encourage cleaner industrial production and separation at source. • Identify and implement mechanisms to reduce waste quantities disposed of at landfill sites. • Implement appropriate mechanisms to formalise operations of informal scavengers (waste pickers). • Facilitate adoption of waste minimisation, reuse, recycling and recovery procedures and practices by all sectors of society. • Develop local entrepreneurship and establish partnerships to take advantage of job opportunities in waste minimisation, recycling and reuse. • Create awareness and build capacity among beneficiary communities, public sector institutions, civil society, etc., on issues relating to waste minimisation, reuse, recycling and recovery. • Develop and implement appropriate regulatory and enforcement mechanisms. • Develop and implement appropriate financing mechanisms.
Innovative and affordable technologies for accelerated delivery of household sanitation	• Identify and review appropriate technologies for household sanitation in the urban and rural context to enable full sanitation coverage and provide opportunities for reuse benefits. • Develop and implement programmes for accelerated delivery of approved household sanitation technologies, particularly simplified/small bore sewers in urban communities. • Develop and implement appropriate financing instruments including incentives.
Treatment and safe disposal of wastes	• Extend basic solid and liquid waste management services, including collection and conveyance to all residential, institutional, commercial and industrial areas. • Evaluate and adopt alternative treatment and disposal technologies for solid and liquid wastes. • Evaluate, select and acquire suitable sites for development of regional and shared treatment and disposal infrastructure to meet long-term needs. • Need for compliance of all waste treatment and disposal infrastructure with relevant legislation regarding development, permitting, operation and closure.
Integrated planning to promote provision of shared infrastructure	• Develop consolidated regional integrated waste management plans based on MESSAPs and DESSAPs. • Build capacity of all key stakeholders relevant to the implementation of the IWMP. • Ensure adequate regional level performance monitoring of the IWMP implementation.
Sustainable system for waste data gathering, reporting and performance monitoring	• Establish a waste management information system that enables adequate data gathering, storage, retrieval and sharing for tracking and informed decisions on waste generation, minimisation, treatment and disposal, waste recovery and reuse, etc. • Establish adequate monitoring and reporting protocols. • Ensure capacity building for all key personnel along the data management chain.
Awareness raising and capacity building in support of waste management initiatives	• Develop and implement a communication and public awareness plan for integrated and sustainable wastes management that covers minimisation, resource recovery, social and environmental impacts of unsafe disposal, including littering, illegal dumping, etc. • Develop and implement capacity building programmes for public sector regulators and private sector providers of services along the value chain. • Develop and implement outreach programmes for public awareness and education. • Establish partnerships with stakeholders to effectively implement the outreach programmes.

Objective	Strategic Action
Effective enforcement through sanctions to ensure compliance with regulations	• Review bye-laws and sanctions for recalcitrant offenders. • Conduct systematic monitoring and create a culture of compliance with bye-law regulations. • Establish a citizen's feedback and complaint mechanism, including an anonymous non-compliance reporting system. • Ensure adequate prosecution of waste offenders. • Ensure adequate resourcing of regulatory institutions for enforcement and compliance.
Adequate budgeting and financing of waste management infrastructure and services	• Ensure adequate financial planning for integrated waste management services. • Ensure adequate financial resource mobilisation through partnership arrangements with external support agencies, financial institutions, private sector entities, etc. • Ensure adoption of principle of full cost recovery and accounting for integrated waste management services. • Ensure adequate tariffs are charged for all basic services.

Source: Author's Construct

3.6.4 Expected Outcomes and Targets

Expected Sanitation Outcomes

i. Affordable and sustainable household and public sanitation facilities and appropriate technologies for 100 percent 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 3.11.

Table 3.11: 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 3.12:

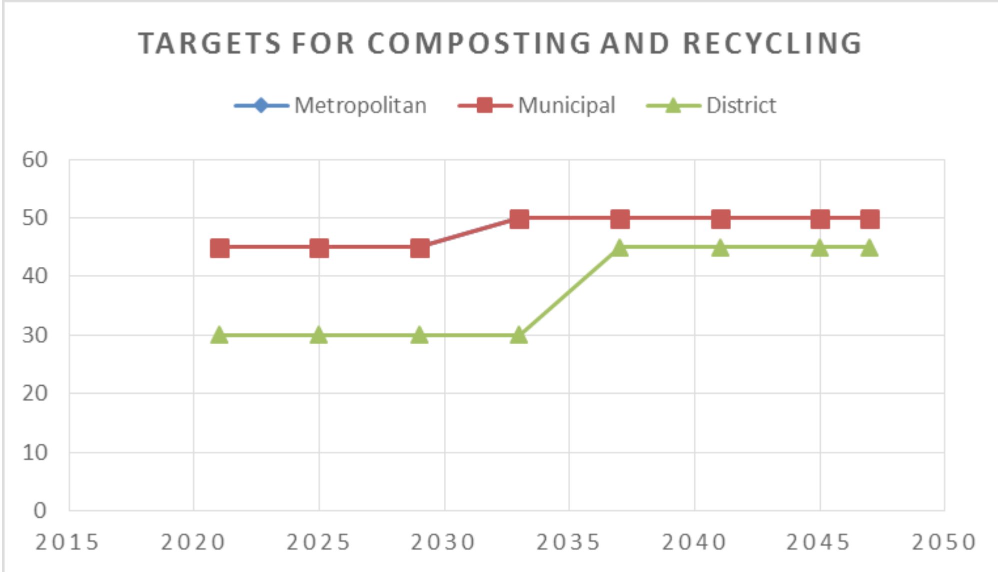
Table 3.12: Expected Targets for Solid Waste Management

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

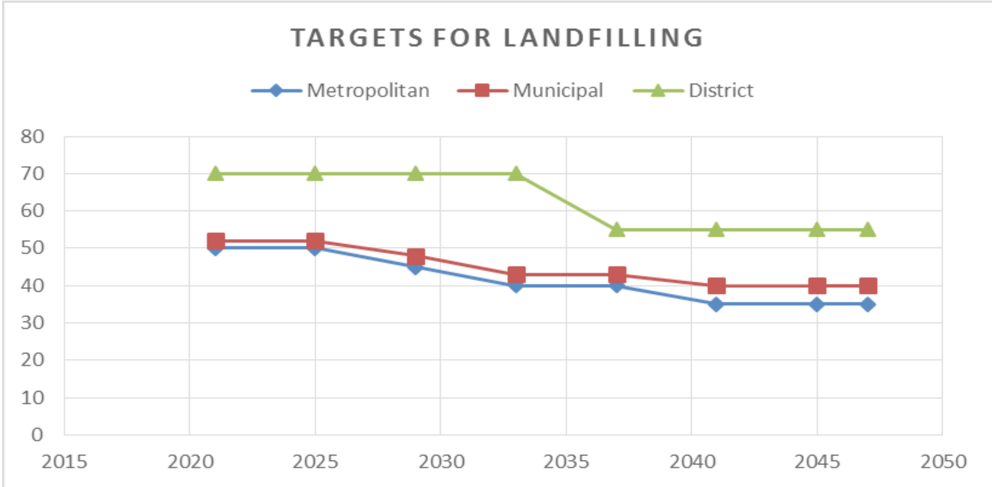
Figures 3.3, 3.4 and 3.5 indicate the various targets for composting and recycling, landfilling, and waste to energy respectively.

Figure 3.3: Expected Target for Composting and Recycling



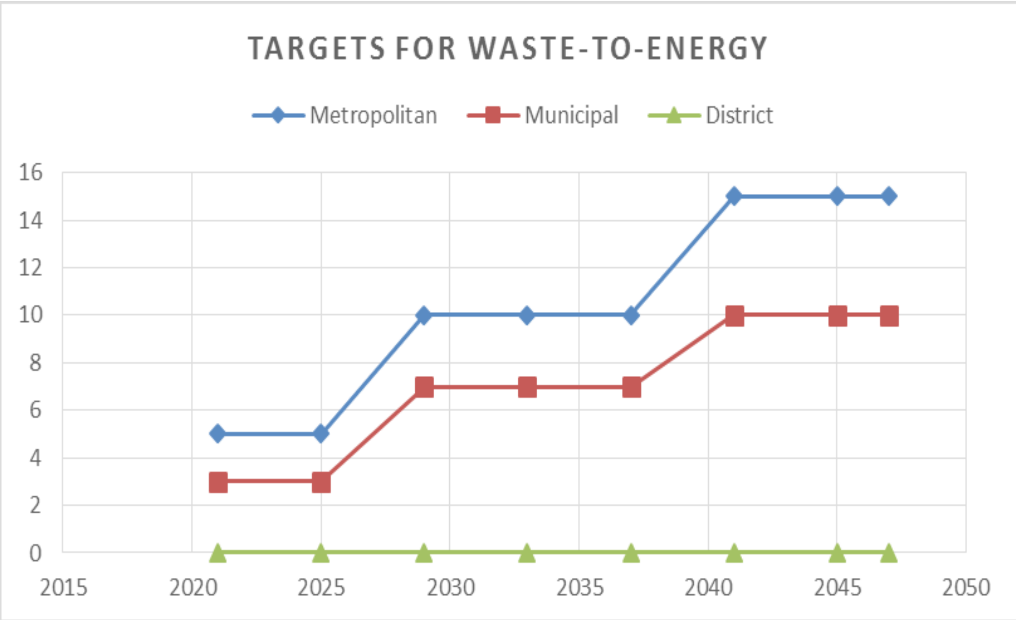
Source: Author's Construct

Figure 3.4: Expected Target for Landfilling



Source: Author's Construct

Figure 3.5: Expected Target for Waste-to-Energy



Source: Author's Construct

Table 3.13: Expected Service Targets for Urban Population

Year		Collection System/Technology				
		Sewerage	**Improved On-site Sanitation**	**Shared (Improved) On-site Sanitation**	**Unimproved On-site Sanitation**	**Open Defecation**
2018 (Base Year)	2015 % Coverage (JMP, 2015)	3.6	11.4	60	6	19
	Added Population Coverage	-	-	-	-	-
	Cumulative Population Coverage	584,301	1,850,287	9,738,352	973,835	3,083,812
2021	% Coverage Targets	5	40	30	15	10
	Added Population Coverage	284,522	5,100,294	(4,525,416)	1,632,633	(1,346,166)
	Cumulative Population Coverage	868,823	6,950,581	5,212,936	2,606,468	1,737,645
2025	% Coverage Targets	10	45	20	20	5
	Added Population Coverage	1,082,767	1,831,572	(1,309,757)	1,296,711	(761,851)
	Cumulative Population Coverage	1,951,590	8,782,153	3,903,179	3,903,179	975,795
2029	% Coverage Targets	20	60	20	0	0
	Added Population Coverage	2,518,667	4,628,615	567,077	(3,903,179)	(975,795)
	Cumulative Population Coverage	4,470,256	13,410,768	4,470,256	-	-
2033	% Coverage Targets	30	70	0	0	0
	Added Population Coverage	3,300,209	4,720,316	(4,470,256)	-	-
	Cumulative Population Coverage	7,770,465	18,131,084	-	-	-
2037	% Coverage Targets	40	60	0	0	0
	Added Population Coverage	4,143,447	(260,217)	-	-	-
	Cumulative Population Coverage	11,913,912	17,870,868	-	-	-
2041	% Coverage Targets	50	50	0	0	0
	Added Population Coverage	5,099,810	(857,146)	-	-	-
	Cumulative Population Coverage	17,013,722	17,013,722	-	-	-
2045	% Coverage Targets	60	40	0	0	0
	Added Population Coverage	5,214,600	(2,194,840)	-	-	-
	Cumulative Population Coverage	22,228,322	14,818,882	-	-	-
2047	% Coverage Targets	70	30	0	0	0
	Added Population Coverage	5,595,244	(2,894,496)	-	-	-
	Cumulative Population Coverage	27,823,566	11,924,385	-	-	-

Source: Author's Construct

Table 3.14: Expected Service Targets for Rural Population

Year		Collection System/Technology				
		Sewerage	**Improved On-site Sanitation**	**Shared (Improved) On-site Sanitation**	**Unimproved On-site Sanitation**	**Open Defecation**
2018 (Base Year)	2015 % Coverage (JMP, 2015)	0.3	8.7	45	12	34
	Added Population Coverage					
	Cumulative Population Coverage	39,838.71	1,155,322.72	5,975,807.17	1,593,548.58	4,515,054.30
2021	% Coverage Targets	1	30	45	12	12
	Added Population Coverage	102,332	3,109,807	421,887	112,503	(2,809,003)
	Cumulative Population Coverage	142,171	4,265,129	6,397,694	1,706,052	1,706,052
2025	% Coverage Targets	1	35	45	14	5
	Added Population Coverage	(12,065)	288,579	(542,926)	115,432	(1,055,522)
	Cumulative Population Coverage	130,106	4,553,709	5,854,769	1,821,484	650,530
2029	% Coverage Targets	5	50	30	15	0
	Added Population Coverage	471,659	1,463,944	(2,244,177)	(16,188)	(650,530)
	Cumulative Population Coverage	601,765	6,017,652	3,610,591	1,805,296	-
2033	%	10	60	25	5	0
	Added Population Coverage	443,385	253,249	(997,716)	(1,282,721)	-
	Cumulative Population Coverage	1,045,150	6,270,901	2,612,876	522,575	-
2037	% Coverage Targets	15	65	20	0	0
	Added Population Coverage	251,929	(650,225)	(883,437)	(522,575)	-
	Cumulative Population Coverage	1,297,079	5,620,676	1,729,439	-	-
2041	% Coverage Targets	20	80	0	0	0
	Added Population Coverage	23,389	(338,804)	(1,729,439)	-	-
	Cumulative Population Coverage	1,320,468	5,281,872	-	-	-
2045	% Coverage Targets	30	70	0	0	0
	Added Population Coverage	451,355	(1,147,619)	-	-	-
	Cumulative Population Coverage	1,771,823	4,134,253	-	-	-
2047	% Coverage Targets	0	0	0	0	0
	Added Population Coverage	(1,771,823)	(4,134,253)	-	-	-
	Cumulative Population Coverage	-	-	-	-	-

Source: Author's Construct

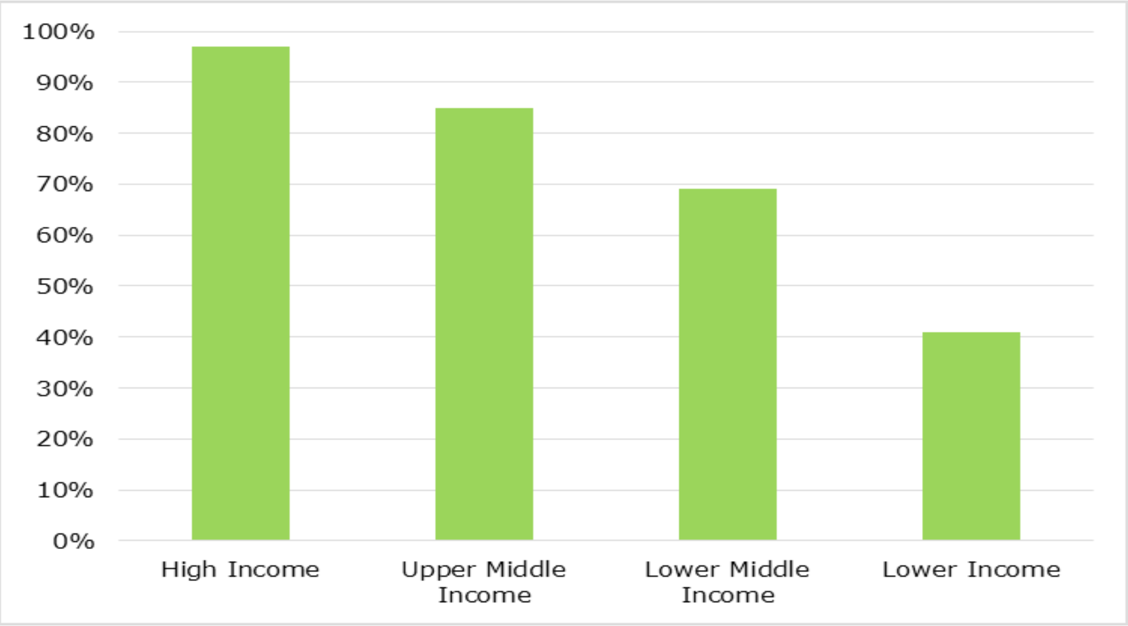
3.6.5 Design Norms and Assumptions

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 percent collection by 2047 and beyond, consistent with the collection rates for high income countries as envisioned (Figure 3.6).

Figure 3.6: Waste Collection Rates



Source: Hoornweg & Bhada Tata, World Bank, 2012

ii. Organic content of solid waste reduces over the 30 year planning horizon 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 3.15.

Table 3.15: 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 3.16: Adopted Waste Composition Based on Economic Development

Description	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)[12]

iii. Landfilling, recycling and composting, and incineration account for about 45 percent, 33 percent and 22 percent of the total waste load disposed of in high income countries, compared with the corresponding proportions of about 97 percent, 2 percent and 1 percent in low income countries (Table 3.17).

Table 3.17: Municipal Solid Waste Disposal (Million Tonnes)

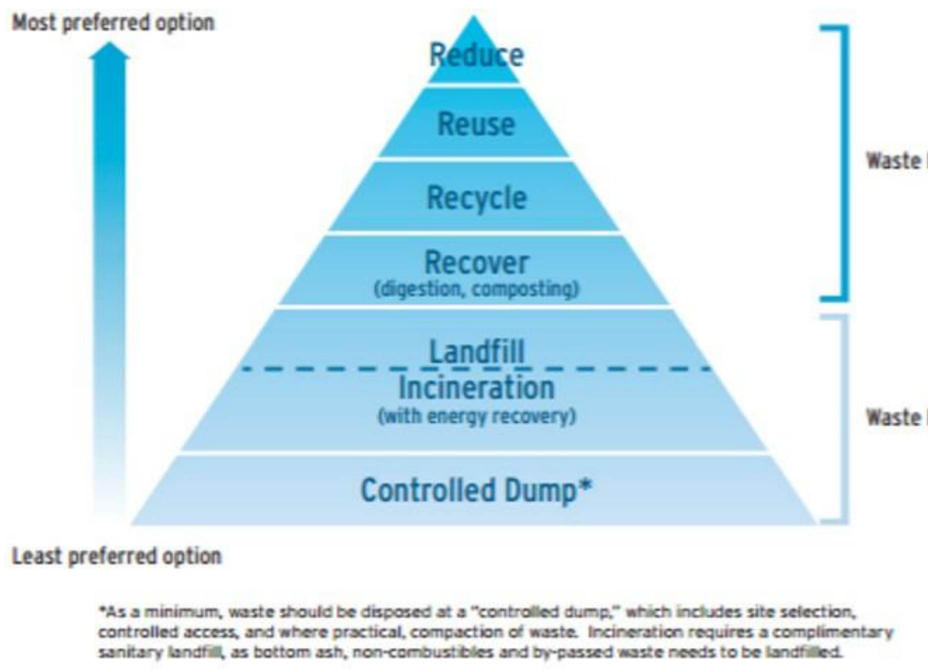
High Income		Upper Middle Income	
Dumps	0.05	Dumps	44
Landfills	250	Landfills	80
Compost	66	Compost	1.3
Recycled	129	Recycled	1.9
Incineration	122	Incineration	0.18
Other	21	Other	8.4
Low Income		**Lower Middle Income**	
Dumps	0.47	Dumps	27*
Landfills	2.2	Landfills	6.1
Compost	0.05	Compost	1.2
Recycled	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 emphasises waste minimisation, reuse and resource recovery in preference to landfilling, dumping and incineration.

12 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 3.7: 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 plan period as shown in Table 3.18:

Table 3.18: Per capita generation rate with planning horizon

Description	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[13]

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 3.19:

Table 3.19: 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

13 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.

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 3.20.

Table 3.20: 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 5.0 m per person shall be provided, particularly in urban communities with minimum 5,000 inhabitants.
ii. Treatment infrastructure shall be provided as shown in Table 3.21.

Table 3.21: Treatment Infrastructure

Description	Number of People Served
Centralised Sewage Treatment	200,000 – 250,000
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.

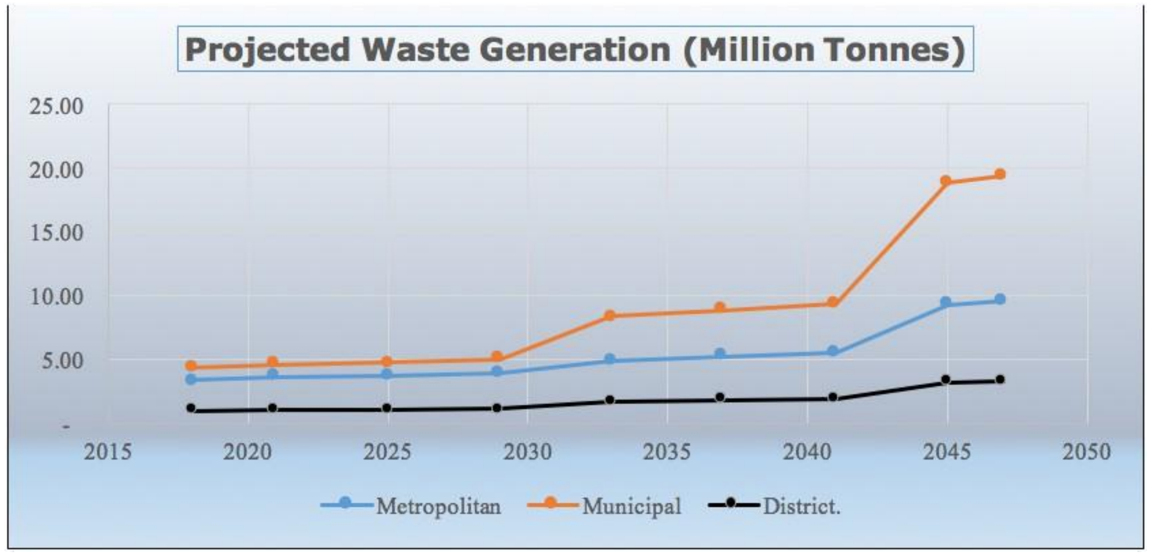
3.7 Projections and Infrastructure Requirements

3.7.1 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. 3.8).

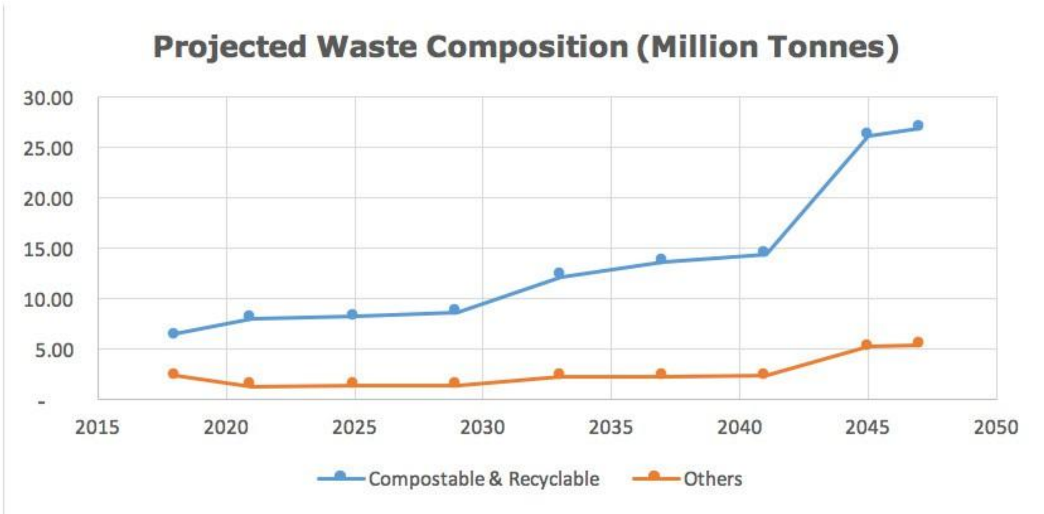
Figure 3.8: Projected Solid Waste Generation (2018-2047)



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 3.9.

Figure 3.9: Projected Waste Fractions (2018-2047)

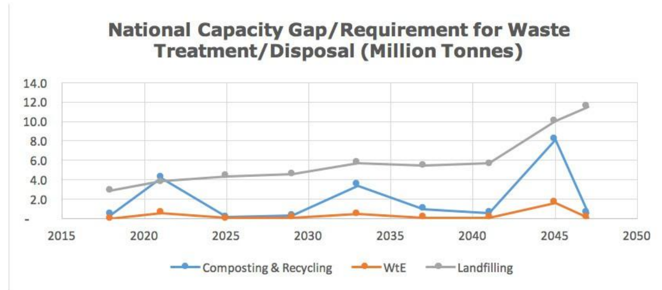


Source: Author's Construct

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 percent 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 3.10.

Figure 3.10: 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 3.22). Due to the 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 3.22: 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.

3.7.2 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 3.23). Septage generation would decrease from about 22,350 m³/day to 11,500 m³/day in 2047 due to the expected shift from onsite systems to off- site systems (sewerage).

Table 3.23: Urban Wastewater Generation

Description		Liquid Waste Generation (m³/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 106,309 m³/day while septage generation declines to 14,700 m³/day in 2047 (Table 3.24). Generally, as the country reaches over 90 percent 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 3.24: Rural Wastewater Generation

Description		Liquid Waste Generation (m³/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 3.25. A total of about 149,000 km length and 8,660 km length of sewers are required for urban and rural communities respectively, by 2047. In addition, nationwide, 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.

Table 3.25: 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

Table 3.26: Additional Treatment Capacity Required for Urban Communities

Year	Waste Treatment Requirement	
	Sewage	Faecal Sludge/Septage (m³)
2018	35,058	22,301
2021	17,071	(2,318)
2025	64,966	509
2029	151,120	1,860
2033	198,013	(4,220)
2037	248,607	(260)
2041	305,989	(857)
2045	312,876	(2,195)
2047	335,715	(2,894)

*Figures in bracket indicate that there is excess/surplus capacity for that year and hence no capital investment required for that technology
Source: Author's construct

Table 3.27: Additional Treatment Capacity Required for Rural Communities

Year	Waste Treatment Requirement	
	Sewage	Faecal Sludge/Septage (m³)
2018	2,390	14,700
2021	6,140	4,066
2025	(724)	(682)
2029	28,300	(3,041)
2033	26,603	(3,025)
2037	15,116	(2,940)
2041	1,403	(3,798)
2045	27,081	(1,148)
2047	(106,309)	(4,134)

*Figures in bracket indicate that there is excess/surplus capacity for that year and hence no capital investment required for that technology
Source: Author's construct

3.7.3 Agricultural Waste

Table 3.28 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 3.28: Projected Crop Residue Over Planning 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.

3.8 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 3.29).

Table 3.29: Estimated Financial Requirements for Integrated Waste Management

Plan 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

3.9 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 4 Drainage, Flood Control and Coastal Protection

4.1 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 percent 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 systems. The resultant high rainfall-runoff concentration puts pressure on existing low capacity drainage channels and subsequently causes 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.

4.1.1 Vision

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

4.2 Overview of Ghana's Drainage and Flood Control Situation

4.2.1 The Drainage System of Ghana

Ghana's drainage system is dominated by the Volta River basin which covers nearly 70 percent 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 4.1.

Figure 4.1: Drainage Map of Ghana

Source: Maps of World, 2013

4.2.2 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.

4.3 Institutional Structure of the Drainage Subsector

4.3.1 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.

4.3.2 Role of Institutions in Drainage and Flood Control Activities

Table 4.1 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 4.1: 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

4.4 Existing Drainage, Flood Control and Coastal Stability Plans

4.4.1 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 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 a 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 4.2 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 4.2: Existing Drainage Master Plans for Urban Centres

Year	City	Initiating Ministry	Project	Prepared by	Area of Coverage
1963	Tema	Communication Works and	Drainage Master Plan for Tema	NEDECO, The Hague- Holland	Communities 1-12
1963	Accra	Communication Works and	Overall drainage master plan for Accra	NEDECO, The Hague-Holland	Main water courses within Accra Central
1967	Accra	Communication Works and	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

4.5 Flood Management Practices

4.5.1 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
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
viii. Use of economic tools, such as compensation and insurance

4.5.2 Structural Measures

Even though WMO-APFM provides a combination of structural and non-structural measures for flood management, the nation's flood management practices are skewed towards structural measures. The structural measures involve the construction of designed artificial waterways to remove, transport, detain or retain floods to bring relief to 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.
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's 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 discharge 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 percent 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 4.3 below shows the major channels in Accra which have encountered major floods even though some level of channel improvement works have taken place.

Table 4.3: 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**

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.

The Water Resources Commission (WRC) is responsible for watershed management in the country. Areas covered nationwide are very limited 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.

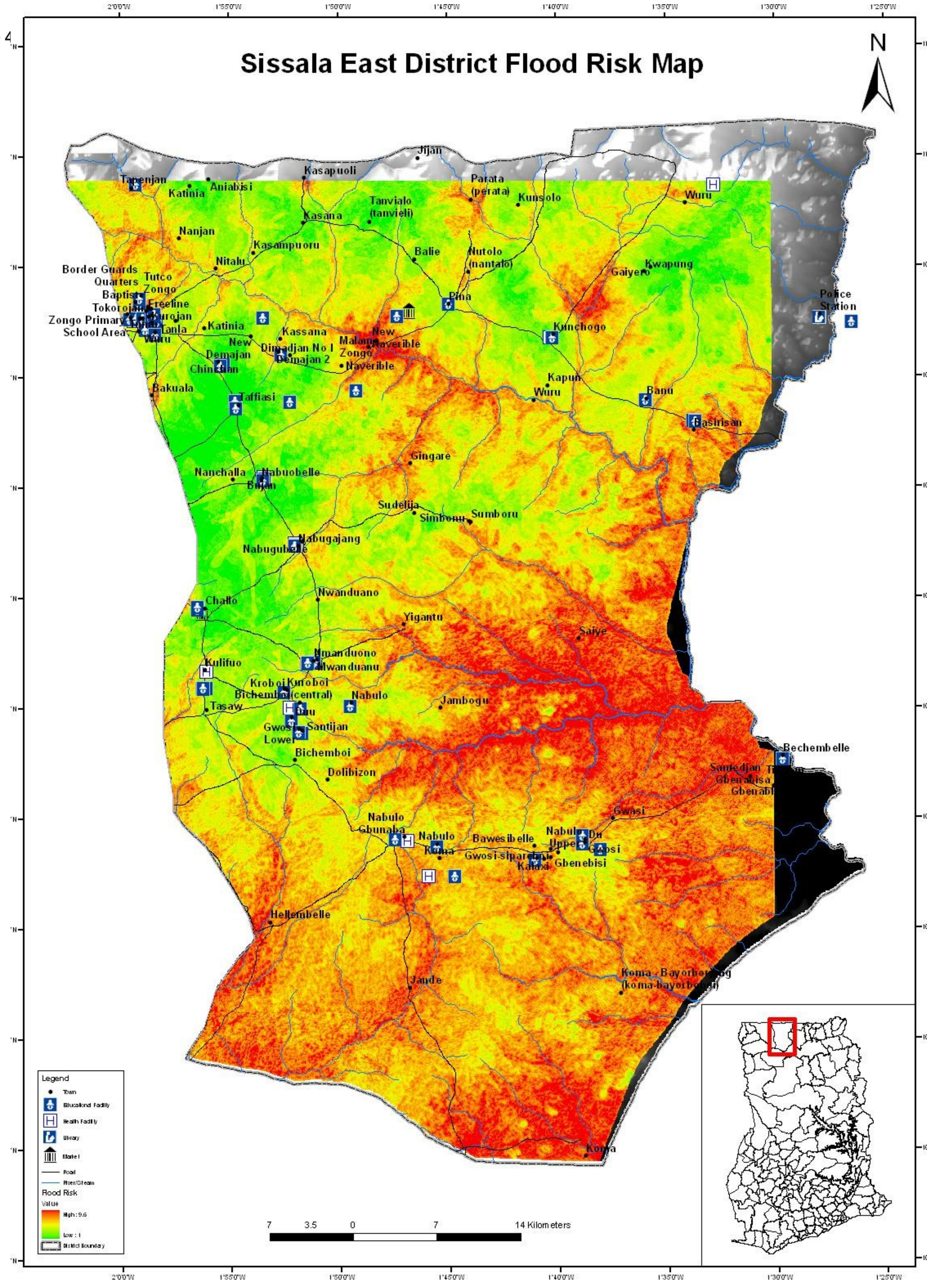
4.6 Development Strategy Framework for Drainage, Flood Control and Coastal Protection

4.6.1 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 documents 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 4



Source: Community Resilience through Early Warning (CREW) Project, UNDP/NADMO, 2016

4.6.2 Strategies for Reduction of Flooding in the 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[1]. 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[2]. 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 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 the VRA to facilitate the communication of dam releases from the Republic of Burkina Faso in order to increase early warning system in the zone.

4.6.3 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, 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. Overlay
ii. 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.

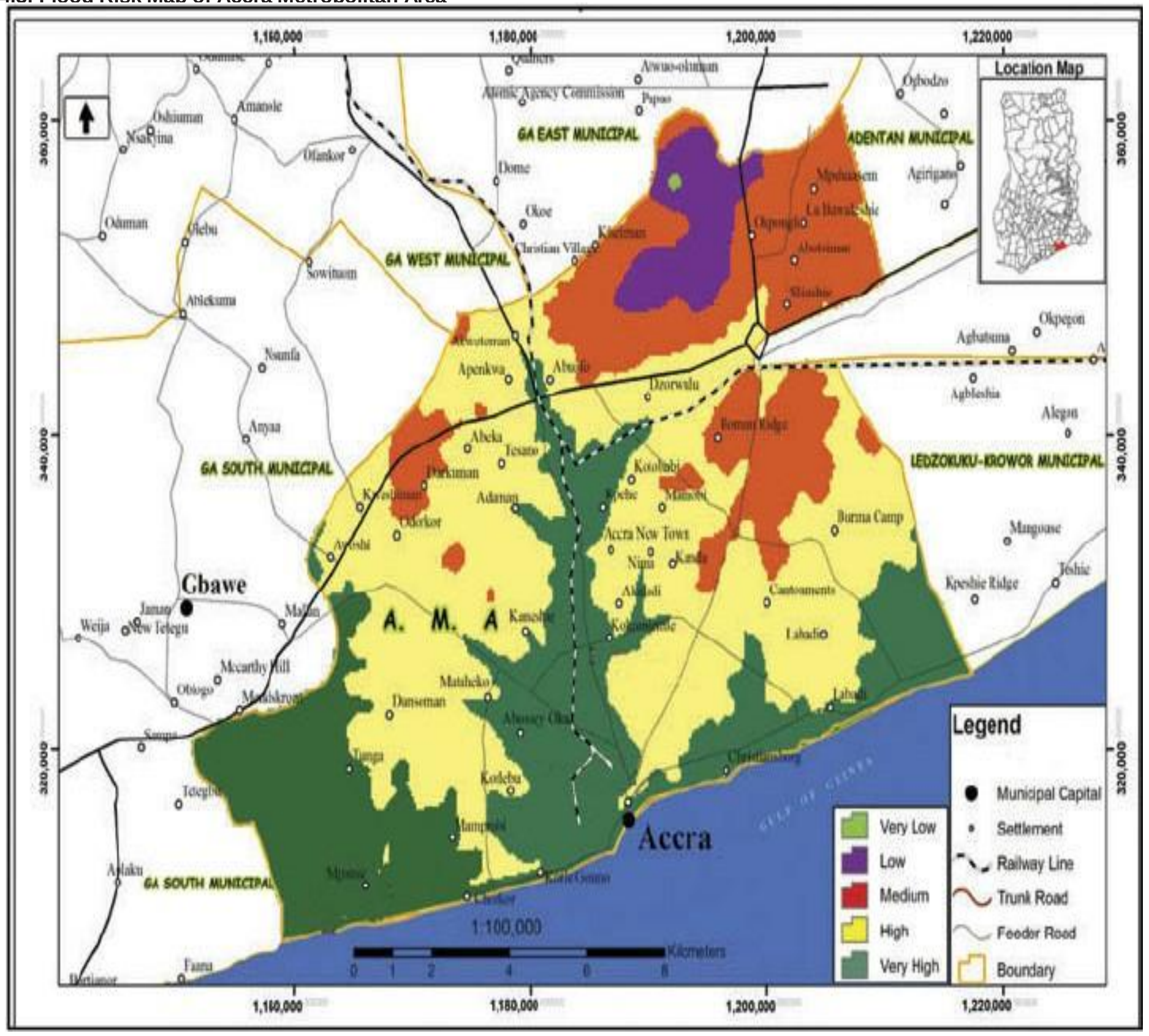
1 Northern Savannah Ecological Zone- Concept Master Plan Report Draft Version, December 2016
2 Technical Feasibility Studies on Investment in Land Development for Commercial Agriculture in the SADA Zone, 2014

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 4.3 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 4.3: 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.

Figure 4.4: Map of Ghana showing areas of Coastal Erosion

Source: Hydrological Services Department, 2007

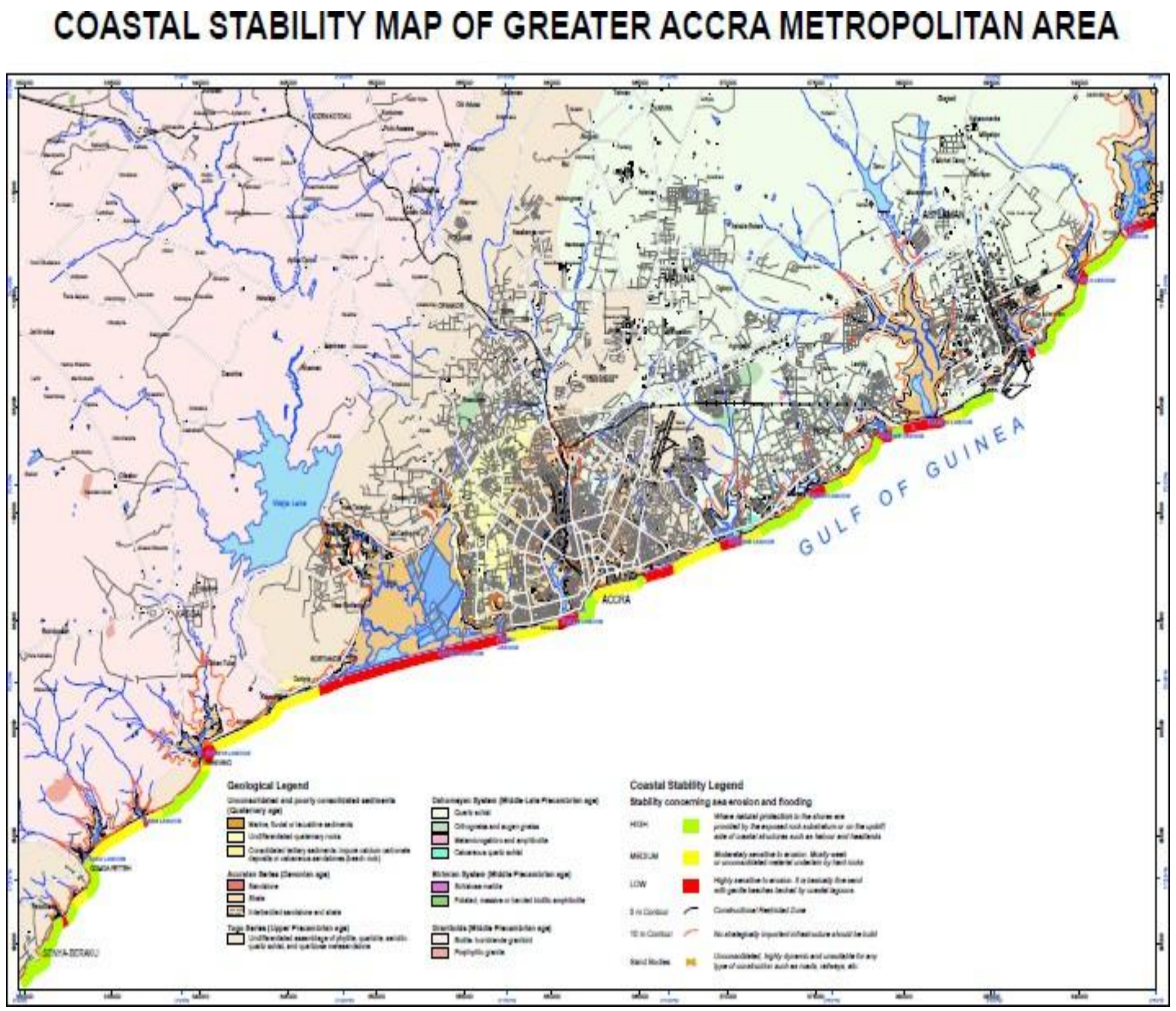
4.6.4 Strategies for the Reduction of Coastal Floods and Erosion Degradation

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[3].

3 Hydrological Services Department, 2007

Figure 4.5: 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

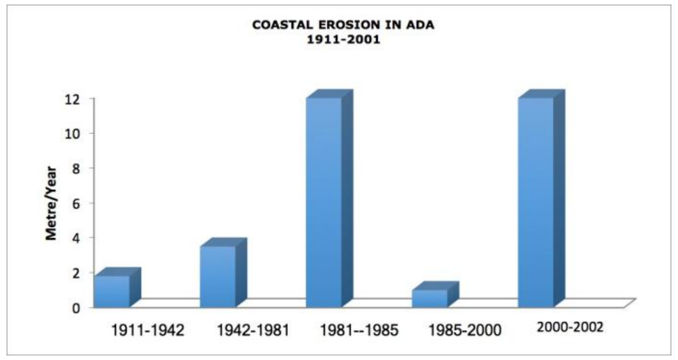
The coastal storms which sweep the coast often destroy homes, fishing boats, outboard motors, fishing nets and other fishermen's equipment. Such destruction underscores the vulnerabilities of many shorefront communities to coastal hazards due to changing climate and rising sea levels. The destruction 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[4].

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 4.6 below shows the coastal erosion in Ada from 1911 – 2001.

Figure 4.6: 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 percent and 30 percent respectively. According to the studies, the impact of climate change on the coastal zone in the country is such that, a total of 1,110 km² of land area may be lost as a result of a 1.0 m 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.

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 percent (30%) of Ghanaians live on six percent (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 (Local Government Act, 1993) and Act 480 (National Development Planning (System) Act, 1994) 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:

4 SIC Skagen Innovation Centre, (2007)

i. Barriers to coordinated action against coastal erosion and flooding need to 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 an integrated approach to solving coastal flood shocks requiring coordination among key stakeholders, including traditional authorities and civil society groups.
v. 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.
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.

4.7 Flood Forecasting Framework

4.7.1 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.

4.7.2 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.

4.8 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.

4.9 Institutional Arrangements for Flood Control and Coastal Protection Management

4.9.1 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 4.4 summarises the proposed responsibilities with regards to the institutions.

Table 4.4: 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-meteorological 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

4.9.2 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 decisions 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 information.

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 in- vestment would not be cost effective. Adaptation measures to address climate change and flood risk will enhance capacity in early warning sys- tems 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, adapta- tion measures include avoiding development in waterways, flood-proof building construction and resettlement of emerging peri-urban slum areas.

4.9.3 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. Govern- ment 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 con- tributors 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 plan period (Table 4.5).

Table 4.5: 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 5 Irrigation Infrastructure

5.1 Introduction

Ghana is endowed with natural resources in the form of fertile land and fresh water resources which are evenly distributed across the country, making it suitable for irrigated crop production. Approximately 49 percent 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, especially with staples such as 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 percent of its potential developed. Just about 5 percent 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.

5.1.1 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.

5.2 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 provide 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 5.1 stipulates the roles and responsibilities of collaborating partners in the irrigation sub-sector.

Table 5.1: Roles and Responsibilities of Collaborating Institutions

Item	Institution	Role	Responsibility
1	Ghana Irrigation Development Authority (GIDA)	Lead Agency	Lead agency in all irrigation activities in the country. Management of headworks, main canals and bulk water supply
2	Ministry of Food and Agriculture (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

5.3 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 percent of the potential untapped. The level of irrigation development in the country is rather negligible compared to international coverage figures 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.

5.3.1 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.

5.3.2 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 percent 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 5.2. 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 5.2: 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
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**		

5.3.3 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 5.3: 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

5.4 Strategic Relevance of Irrigation

5.4.1 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[1].

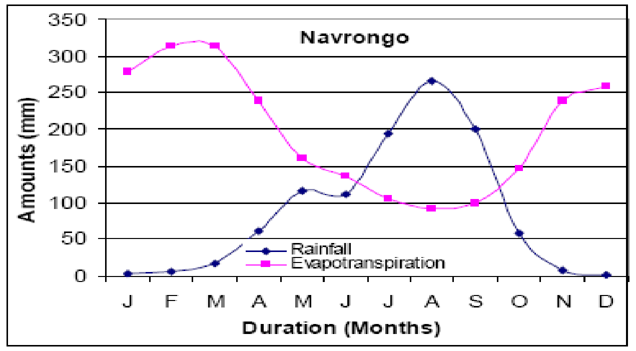
5.4.2 Food Security

Agricultural production in Ghana has been growing since independence but improvement in terms of factors of productivity such as land and labour has been 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.

1 United Nations World Water Assessment Programme, 2015

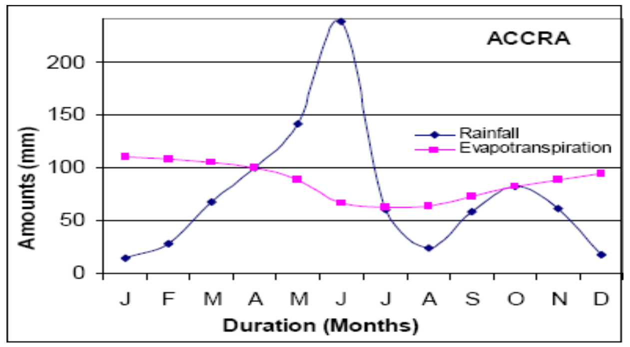
Ghana's population has quadrupled since independence from 6.7 million to 27.043 million by 2014 according to MoFA, and the population continues to grow. Yet the production of most staple foods, e.g., cereals, has lagged population growth significantly, making Ghana a net importer of these food crops. Moreover, population growth corresponds to shrinkage of the available agricultural lands as more cultivable lands are converted to housing. The danger is that food insecurity becomes even more pronounced as climate change impacts result in water shortages. The savannah and the transitional agro-ecological zones which experience unimodal rainfall and perennial water deficits do not support all- year-round agriculture (Figures 5.1-5.3). These conditions provide a setting for agricultural intensification which can best be realised presently under irrigation and AWM.

Figure 5.1: Rainfall and Evapotranspiration in the Northern Savannah Agro-Ecological Zone (Navrongo Synoptic Station)



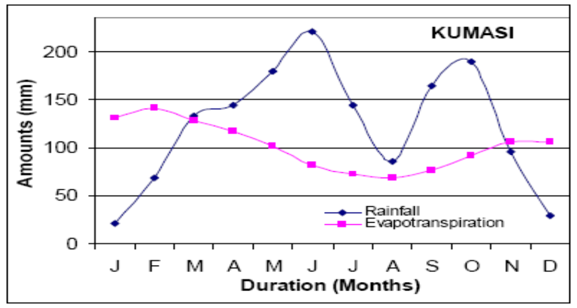
Source: GIDA

Figure 5.2: Rainfall and Evapotranspiration in the Southern Savannah Agro-Ecological Zone (Accra Synoptic Station)



Source: GIDA

Figure 5.3: Rainfall and Evapotranspiration in the Middle Belt (Kumasi Synoptic Station)



Source: GIDA

5.4.3 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.

5.5 Irrigation Potential and Infrastructure Baseline

5.5.1 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.

5.5.2 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 percent 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 1,200 m^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 percent 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 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.

Groundwater 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.

5.5.3 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.

5.6 Unlocking Ghana's Irrigation Potential

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.

5.6.1 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.

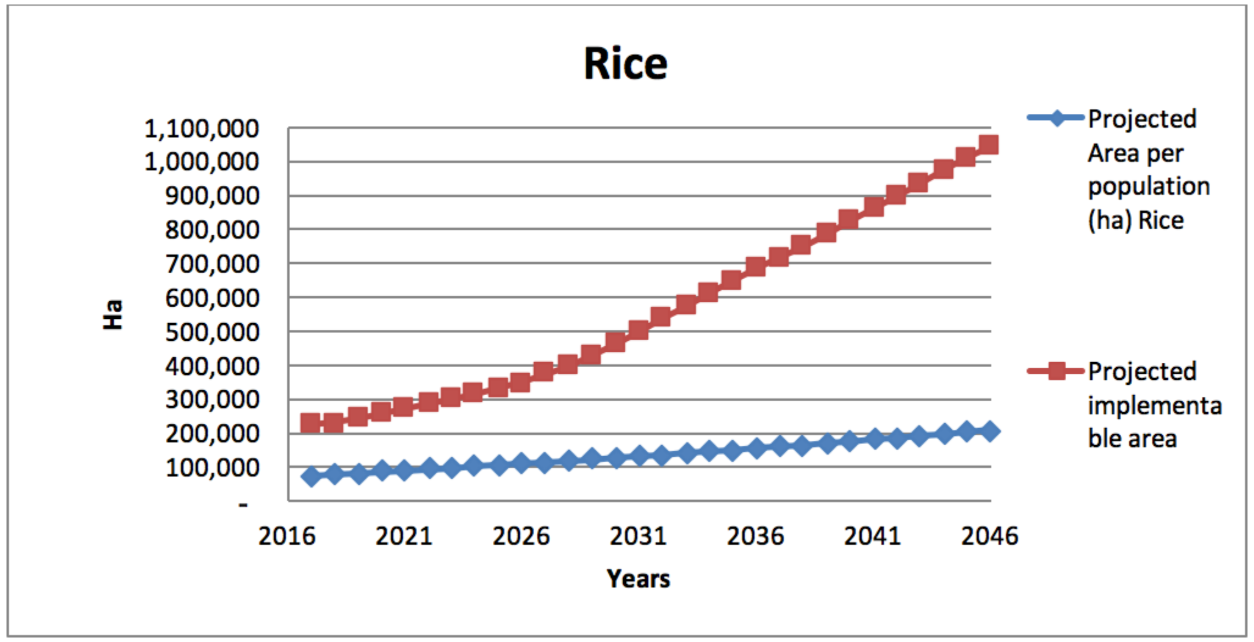
Much of the rice consumed currently is imported. This constitutes a substantial drain on the country's foreign exchange earnings which could have been used in development of other sectors of the economy. Yet increased and sustained local rice production of high quality will conveniently result in import 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 5.4 and Figure 5.4).

Table 5.4: 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 5.4: Projected Rice Cultivation and Total Acreage Development



Source: Author's construct

5.6.2 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[2].

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 5.5 and 5.6 present the projected vegetable and fruit demand respectively that must be put under irrigation during the plan period. Also, Figures 5.5 and 5.6 present the projected vegetable and fruit cultivation in terms of total acreage development respectively for the plan period.

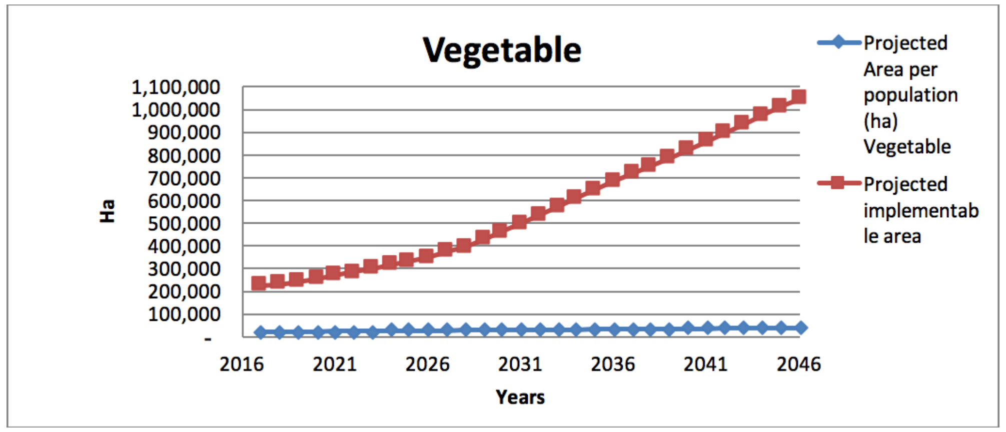
2 Boachie-Danquah B. and I. Sulaiman (2015). Ghana's Tomato Processing Industry: An Attractive Investment Option in 2016.

Table 5.5: 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
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 5.5: Projected Vegetable Cultivation and Total Acreage Development



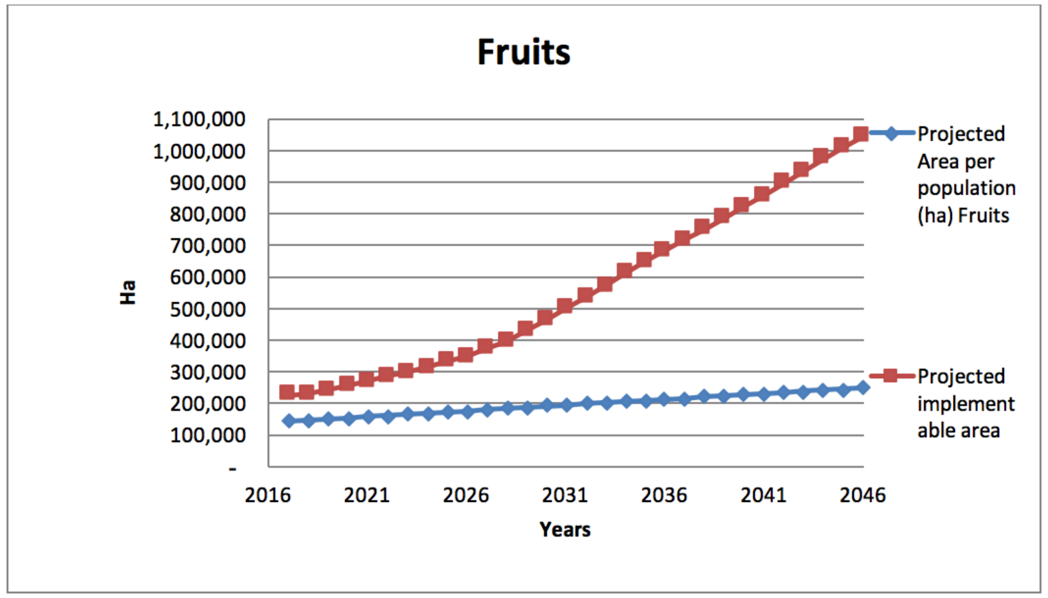
Source: Author's construct

Table 5.6: 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 5.6: Projected Fruit Cultivation and Total Acreage Development



Source: Author's construct

5.6.3 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.

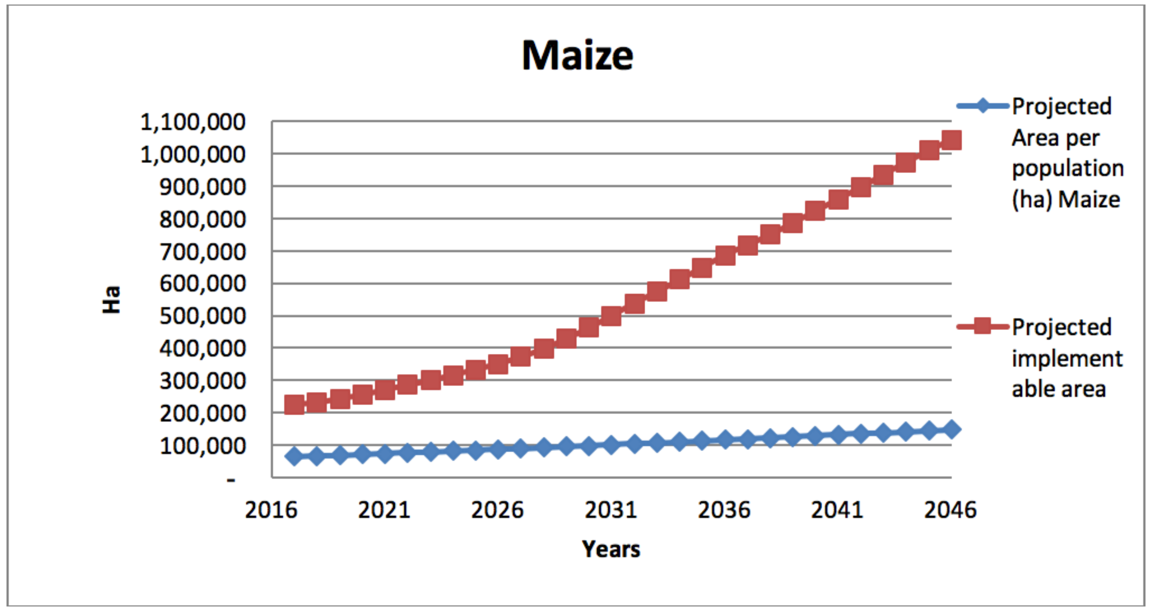
Conversely, cultivation of these grains under irrigation transforms low-energy extensive cultivation to high-energy levels and makes it possible to use improved varieties of the grains, and increased use of fertilizers and agro-chemicals that bring about increased cropping intensity and higher yields. Table 5.7 presents the projected maize demand that must be put under irrigation during the plan period. Also, Figure 5.7 presents the projected maize cultivation in terms of total acreage development for the plan period.

Table 5.7: 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 5.7: Projected Maize Cultivation and Total Acreage Development



Source: Author's construct

5.6.4 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.

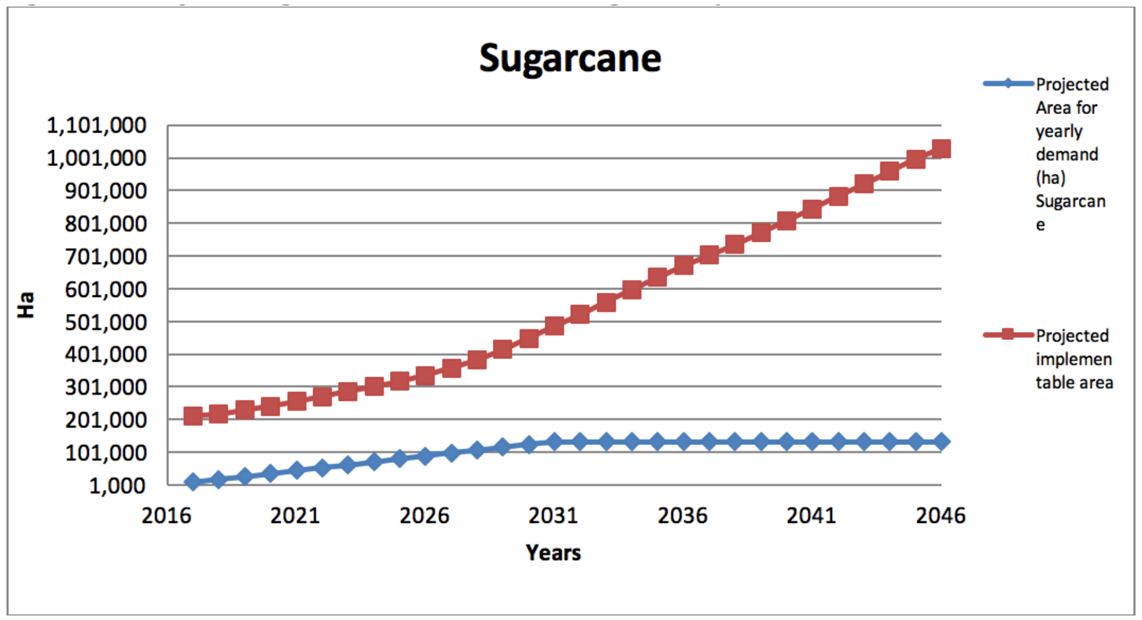
Table 5.8 presents the projected sugarcane demand that must be put under irrigation during the plan period. Also, Figure 5.8 presents the projected sugarcane cultivation in terms of total acreage development for the plan period. Also, the projected individuals crops curves and total acreage development is presented in Figure 5.9.

Table 5.8: 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**		

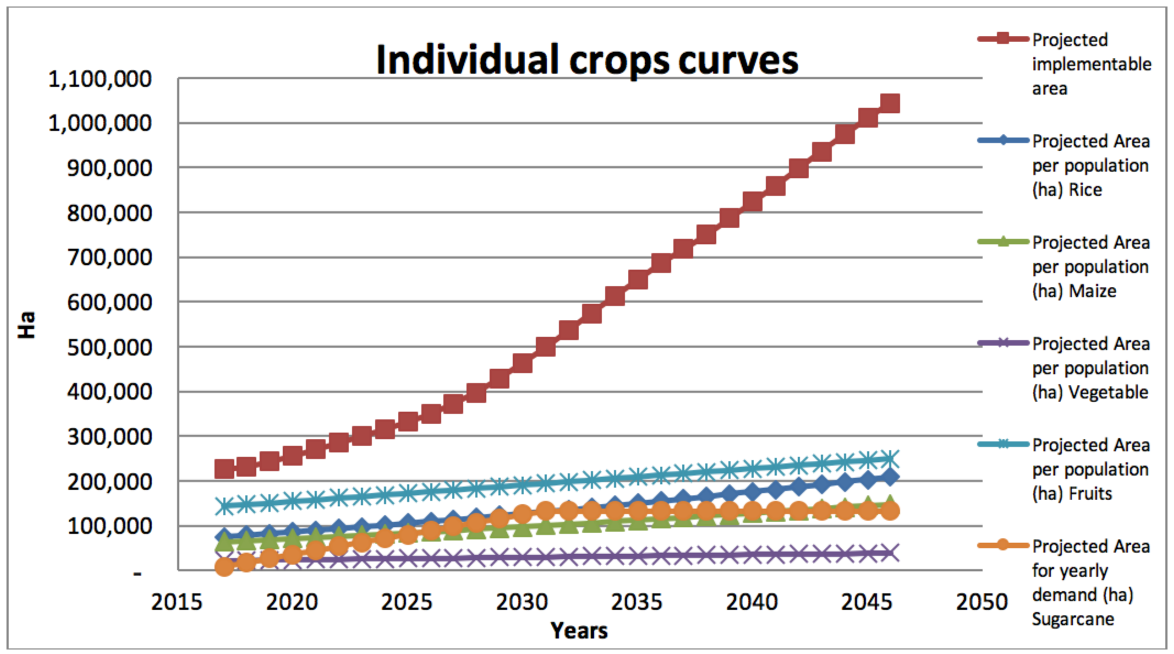
Source: Author's construct

Figure 5.8: Projected Sugarcane Curve and Total Acreage Development



Source: Author's construct

Figure 5.9: Projected Individuals Crops Curves and Total Acreage Development



Source: Author's construct

5.6.5 Production of Combination of Crops under Irrigation

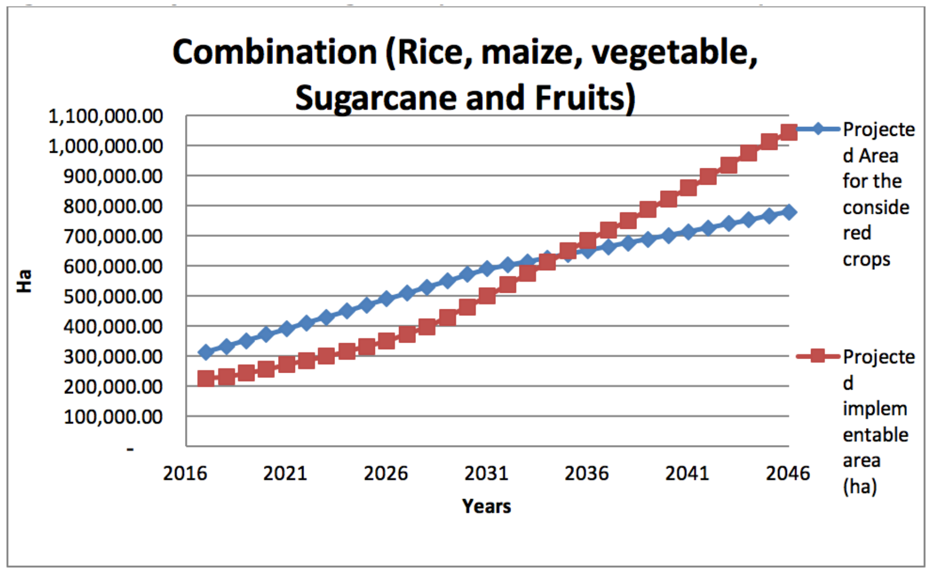
It is envisaged that the country will be self-sufficient in five (5) crops (rice, maize, vegetable, sugarcane and fruits) by 2036. Table 5.9 and Figure 5.10 present the projected total acreage development for the combination of crops.

Table 5.9: 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 5.10: Projected Total Acreage Development for the Combination of Crops



Source: Author's construct

5.7 Ghana's Irrigation Development Framework

GIDA has developed a framework for institutional collaboration for sustainable management and use of water, land and the environment for irrigation. The National Irrigation Policy, Strategies and Regulatory Measures of 2011 covers the entire framework needed for implementation and development of irrigation in Ghana.

5.7.1 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 5.10 below.

Table 5.10: Project, Area and Indicative Cost of Implementation

	Project Title	Region	Order of Priority	Estimated Cost (US$ Million)	Potential Area (ha)	Description
1	Bui irrigation project	Brong Ahafo	Medium term	360	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	48	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	1,800	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	92	7,640	Pre-feasibility study completed, awaiting construction.
5	Small-scale/Micro-scale Irrigation and Drainage Project	National	Medium term	384	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	18	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	45.6	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	18	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	18	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	13.2	110	Feasibility study completed and awaiting design-build contract for infrastructure development on area of 110 ha
11	Rehabilitation of Libga irrigation scheme	Northern	Short term	0.38	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	1.2	100	Conduct feasibility study and develop infrastructure on pilot area of 100 ha
13	Construction of Tamne irrigation scheme	Upper East	Long term	24	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	1.8	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	2.4	200	Extension of existing scheme by 200 ha to bring total area under cultivation to 1,080 ha

	Project Title	Region	Order of Priority	Estimated Cost (US$ Million)	Potential Area (ha)	Description
16	Nasia-Nabogo irrigation project (Tamaligu – 5,800 ha; Zoggo – 2,800 ha; Bogdoo – 2,500 ha)	North	Long term	133.2	11,100	Pre-feasibility study completed for infrastructure development on area of 11,100 ha
17	Nasia-Nabogo water management project	North	Medium term	240	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	168	14,000	Conduct feasibility study and implement irrigation scheme on 14,000 ha
19	Pwalugu Multipurpose Dam project (Irrigation Component)	North	Medium term	240	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	36	3,000	Conduct feasibility study and implement irrigation scheme on 3,000 ha
21	Fumbisi Valley water management project	Upper East	Long term	300	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	600	50,000	Feasibility study completed and on–going construction on pilot area of 400 ha
23	Passam irrigation project	North	Medium term	14	1,200	Feasibility study and subsequent development of area of 1,200 ha
24	Mpaha irrigation project	North	Long term	66	5,500	On-going feasibility study and subsequent construction on pilot area of 100 ha
25	Lamassa irrigation project	North	Long term	38.4	3,200	Feasibility study and subsequent construction on area of 3,200 ha
26	Extension of Mankessim irrigation scheme	Central	Medium term	3.96	330	Feasibility study and subsequent construction on additional area of 330 ha
27	Katanga valley water management project	North	Long term	600	50,000	Conduct feasibility study and implement irrigation scheme on 50,000 ha
28	Karaga irrigation scheme	North	Long term	270	22,500	Conduct feasibility study and implement irrigation scheme on 22,500 ha
29	Daka Valley irrigation project	North	Medium term	210	35,000	Feasibility study and subsequent construction on area of 3,000 ha
30	Fumbi Valley Water Conservation project	Upper East	Medium term	700	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	240	20,000	Feasibility yet to start
32	Komenda Sugarcane Irrigation Project	Central Region	Long Term	480	40,000	
	TOTAL			7,166.14	822,762	

Source: GIDA

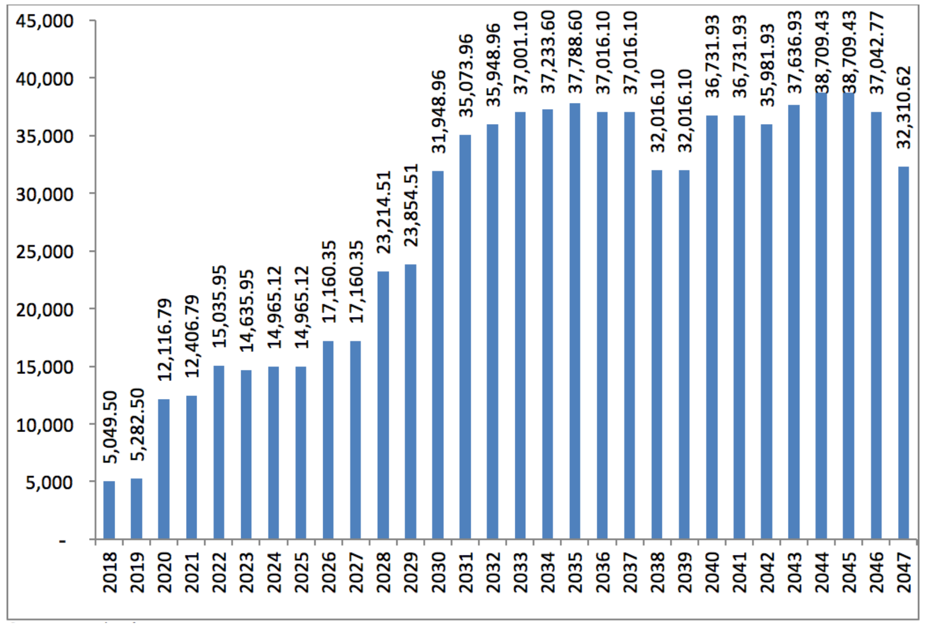
The project locations are as shown in Figure 5.11.

Figure 5.11: 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 percent of the estimated irrigable land of 1.9 million hectares available countrywide.

Figure 5.12: Annual Projected Irrigable Area Development



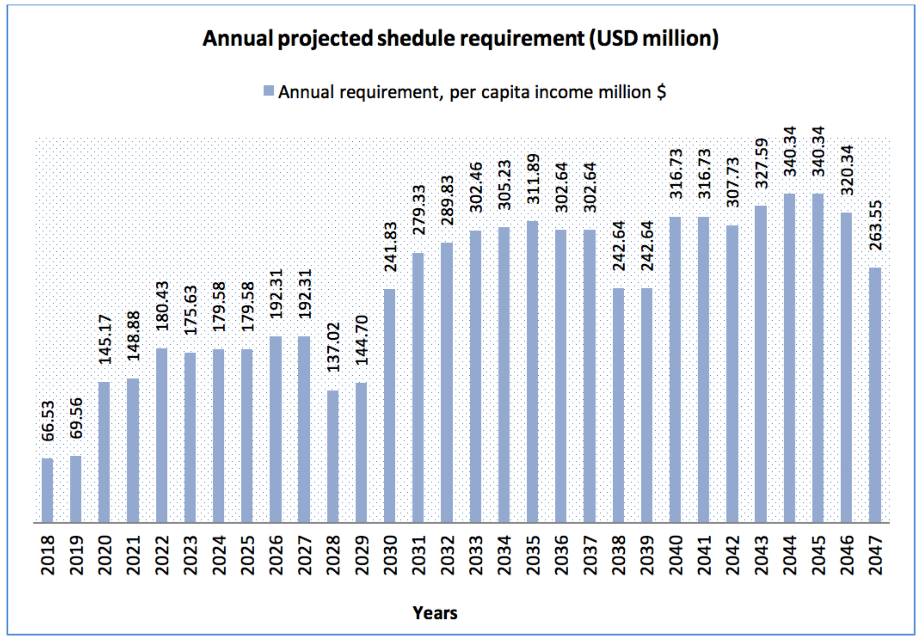
Source: Author's construct

5.7.2 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:

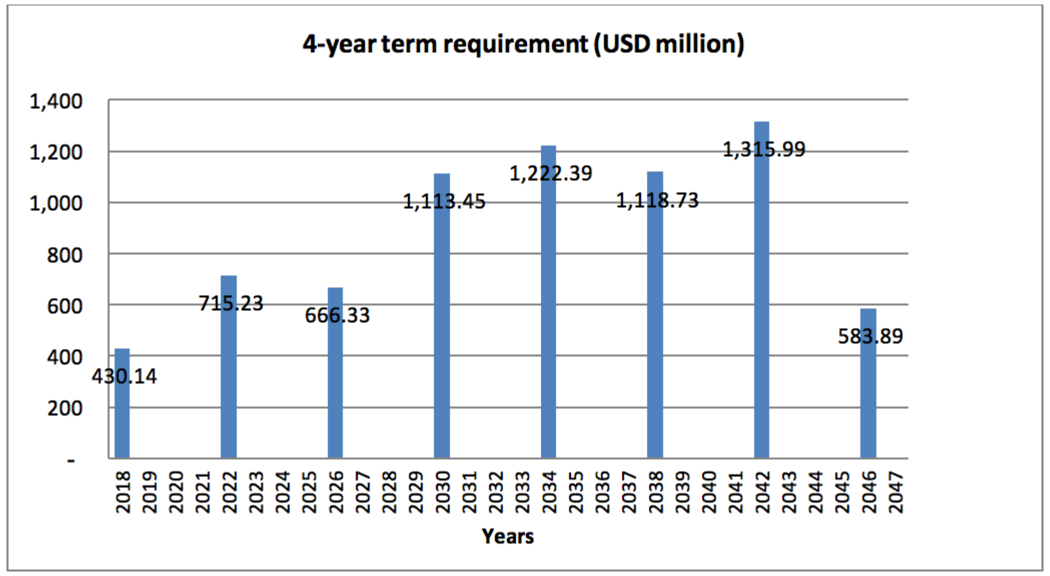
i. Establishing capital requirement for the 4-year term activities based on the current and the projected income per capita by 2047;
ii. Grouping based on priority levels of the projects;
iii. Scheduling to keep to the capital cost requirement per year and per 4-year term period.

Figure 5.13: Annual Budget Requirement (per project scheduling) for Irrigation Development – 30-year period (2018-2047)



Source: Author's construct

Figure 5.14: 4yr-Term Budget Requirement for GIP for Irrigation Development — 30-year period (2018-2047)



Source: Author's construct

Figure 5.15: Annual Project Cost per Year, Duration and Prioritisation and Implementation Schedule of Projects

Annual Project cost per year, duration and prioritisation and Implementation schedule of projects

Years and Project Schedule

No t	Projec	Area, Ha	Project Cost, US$, million	Duration, yrs	Yearly alloca.	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047
1		30,000	360	24	15																														
2	project Road diversion weirs for culvert	4000	48	30	1.6	15	15	15	15	15	15	15	15	15	15	15	15			15	15	15	15			15	15	15	15			15	15	15	15
	irrigation and livestock watering Accra Plains	150,000	1800	24	75	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
3	irrigation project	7,640	92	16	.75			75	75	75	75	75	75	75	75			75	75	75	75	75	75	75	75			75	75	75	75	75	75	75	75
	Avu-Keta irrigation project													5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75			5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75				
4 5	Small-scale/Micro-scale Irrigation and	32,000	384	30	[illegible]	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
6	Ho-Keta Plains irrigation	1,500	18	8	2.25																														
7	project Sabare irrigation project				3.8																							2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
8	Kamba irrigation scheme	3,800	45.6 2	1	4.5	3.8	3.8	3.8	3.8			3.8	3.8	3.8	3.8			3.8	3.8	3.8	3.8														
		1,500	18	4	4.5											4.5	4.5	4.5	4.5																
	scheme	1,500	18	4		4.5	4.5	4.5	4.5																										
10	Rehabilitation of Amate irrigation scheme	17	w	ct	6.6	110	13		6.6	6.6																		20							
11	Rehabilitation of Libga irrigation scheme		a t e r		0.38	32	2	1.8	0.38 2	2																									
12	Rehabilitation of Nasia irrigation scheme and		m		0.15	100	0	2	0.15	0.15	0.15	0.15			0.15	0.15	0.15	0.15																	
13	Construction of Tamne irrigation		a n a		4.8	2,000	.38	.4	4.8 1	4.8 2	4.8	4.8	4.8																						
14	scheme Mprumem irrigation		g e		0.9	150			0.9	0.9																									
15	scheme Extension of Wheta irrigation		m e n		1.2	200	1.2	133.2		1.2	1.2																								
16	project Nasia-Nabogo irrigation project Nasia-Nabogo		t p r o j e		6.66	11,100			8	20		6.66	6.66	6.66	6.66	6.66			6.66	6.66	6.66			6.66	6.66	6.66				6.66	6.66	6.66	6.66		
					20	20,000	24	240	5	12																	20			20	20	20	20	20 20	20

6.66 20

6.66	6.66	6.66	6.66
20	20		

No	Project	Area, Ha	Project Cost, US$, million	Duration, yrs	Yearly alloca.	Years and Project Schedule 2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	
18	Angaw-Basin irrigation project	14,000	168	8	21																							211	2	211	2	211	2	21	21	
19	Pwalugu Multipurpose Dam	20,000	240	6	40					400	4	400	4	40	40																					
20	Daboya irrigation project	3,000	36	6	6																									6	6	6	6	6	6	
21	Fumbisi valley water management	50,000	300	22	13.64									13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	
22	Sisilli Kulpawn irrigation project	50,000	600	16	37.5														37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5		
23	Passam irrigation project	1,200	14	4	3.5																											3.5	3.5	3.5	3.5	
24	Mpaha irrigation project	5,500	66	5	13.2																										13.2	13.2	13.2	13.2	13.2	
25	Lamassa irrigation project	3,200	38.4	5	7.68												7.68	7.68	7.68	7.68	7.68															
26	Extension of Mankessim irrigation scheme	330	3.96	2	1.98		1.98	1.98																												
27	Katanga valley water management	50,000	600	18	33.33													33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	
28	Karaga irrigation scheme	22,500	270	14	19.29																	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	19.29	
29	Daka Valley Irrigation Project	35,000	210	12	17.5											17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5									
30	Fumbi Valley Water Conservation project	242,400	700	20	35											35	35	35	35	35	35	35	35	35	35	35	35	35 35		35 5	3	35 5	3	35	35	
31	Diversion weir on River Tano and irrigable area	20,000	240	28	8.57143			8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	8.571	
32	Komenda Sugar Irrigation Project	40,000	480	30	16	16 6	1	16	16 16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16		
	Totals	**822,762**	**7,166**																																	
	Yearly budget project cost (Implementation)					66.53	69.33	145.40	148.88	180.43	175.63	179.58	179.58	192.31	192.31	137.02	144.70	241.83	279.33	289.83	302.46	305.23	311.89	302.64	302.64	242.64	242.64	316.73	316.73	307.73	327.59	340.34	340.34	320.34	263.55	**7,166.14**
	Yearly budget proposal								108.80	120.74	132.69	144.63	156.58	168.52	180.47	192.41	204.35	216.30	228.24	240.19	252.13	264.08	276.02	287.96	299.91	311.85	323.80	335.74	347.69	359.63	371.57	383.52	395.46	407.41	206.69	**7,166.14**
	Difference in cost scheduling								-40.08	-59.69	-42.94	-34.95	-23.00	-23.79	-11.84	55.39	59.66	-25.53	-51.09	-49.64	-50.33	-41.15	-35.87	-14.67											-56.86	**0.00**

Cost per Ha (US$)

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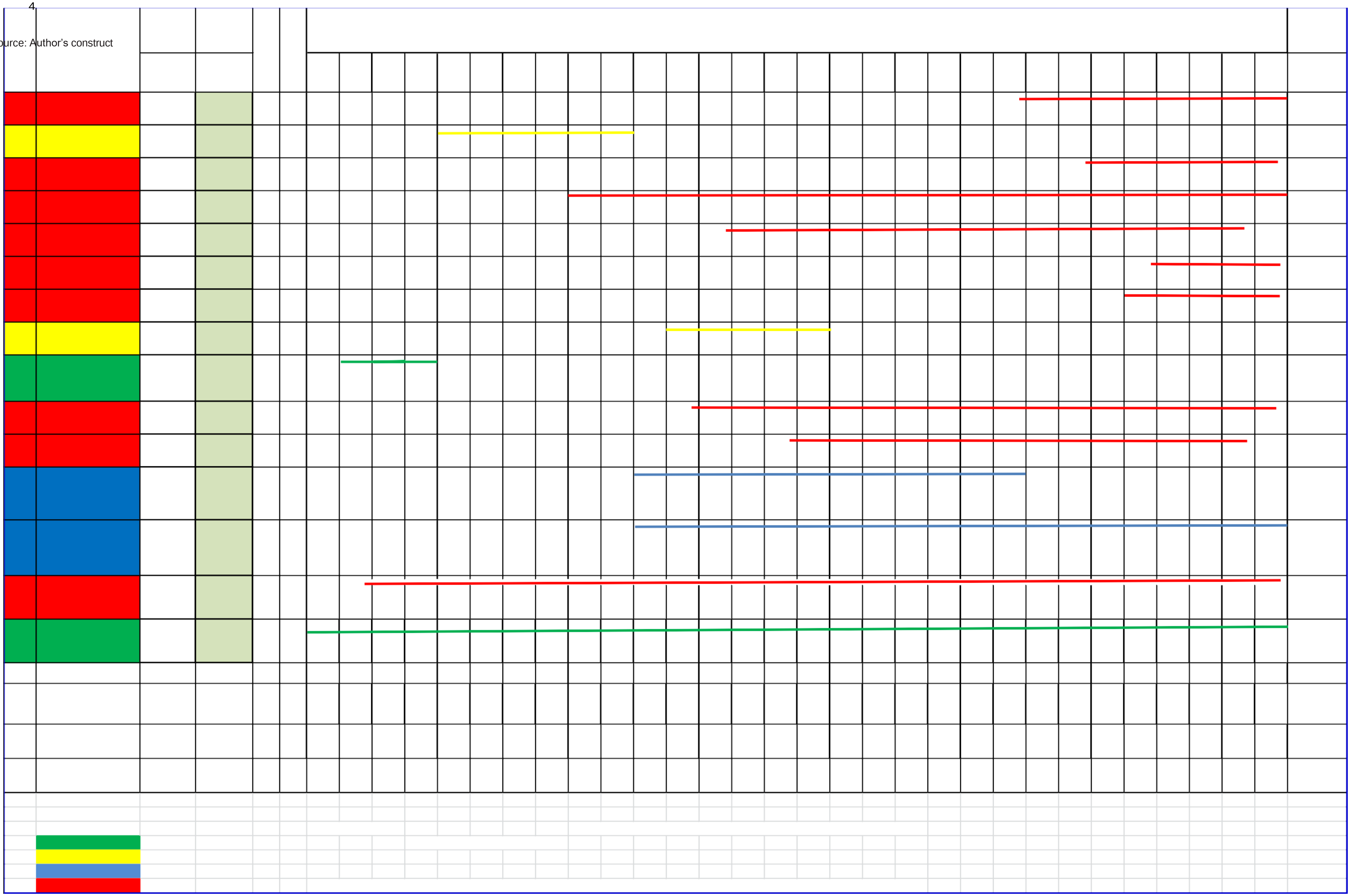
1 -

2

3

4



Source: Author's construct

Figure 5.16: Annual Acreage Delivery and Implementation Schedule of Projects

Annual acreage projection and Implementation schedule of projects

Years, Annual acreages and Project Schedule

No t	Projec	Area, Ha	Project Cost, US$, million	Duration, yrs	Annual acreage	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	
1	Bui irrigation project	30,000	360.00	24	1,250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250	1250			1250	1250	1250	1250			1250	1250	1250	1250			1250	1250	1250	1250	
2	Road culvert diversion weirs for irrigation and livestock watering	4,000	48.00	30	133	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	133.3	
3	Accra Plains irrigation project	150,000	1800.00	24	6,250			6250	6250	6250	6250	6250	6250	6250	6250			6250	6250	6250	6250	6250	6250	6250	6250			6250	6250	6250	6250	6250	6250	6250	6250	
4	Avu-Keta irrigation project	7,640	92.00	16	478									477.5	477.5	477.5	477.5	477.5	477.5	477.5	477.5			477.5	477.5	477.5	477.5	477.5	477.5	477.5	477.5					
5	Small-scale/Micro-scale Irrigation and Drainage Project	32,000	384.00	30	1,067	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	1066.7	
6	Ho-Keta Plains irrigation project	1,500	18.00	8	188																							187.5	187.5	187.5	187.5	187.5	187.5	187.5	187.5	
7	Sabare irrigation project	3,800	45.60	12	317	316.7	316.7	316.7	316.7			316.7	316.7	316.7	316.7			316.7	316.7	316.7	316.7															
8	Kamba irrigation scheme	1,500	18.00	4	375											375	375	375	375																	
9	Kpli irrigation scheme	1,500	18.00	4	375	375	375	375	375																											
10	Rehabilitation of Amate irrigation	110	13.20	2	55	55	55																													
11	Rehabilitation of Libga irrigation scheme	32	0.38	1	32	32																														
12	Rehabilitation of Nasia irrigation	100	1.20	8	13	12.5	12.5	12.5	12.5			12.5	12.5	12.5	12.5																					
13	Construction of Tamne irrigation scheme	2,000	24.00	5	400	400	400	400	400	400																										
14	Mprumem irrigation scheme	150	1.80	2	75	75	75																													
15	Extension of Wheta irrigation project	200	2.40	2	100		100	100																												
16	Nasia-Nabogo irrigation project	11,100	133.20	20	555				555	555	555	555	555			555	555	555	555	555			555	555	555	555	555				555	555	555	555	555	
17	Nasia-Nabogo water management project	20,000	240.00	12	1,667																	1666.7	1666.7	1666.7	1666.7	1666.7	1666.7	1666.7	1666.7	1666.7	1666.7	1666.7	1666.7			
18	Angaw-Basin irrigation project	14,000	168.00	8	1,750																							1750	1750	1750	1750	1750			1	750

1750

1750

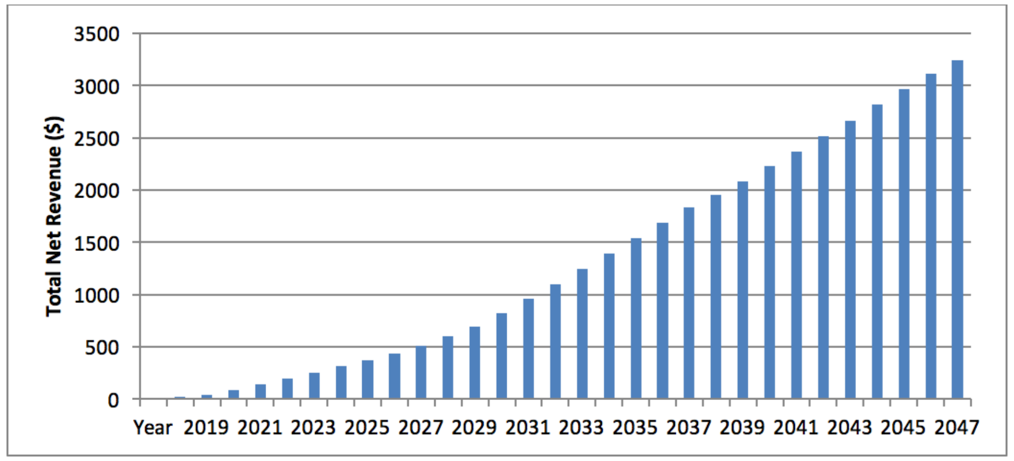
No	Project	Area, Ha	Project Cost, US$, million	Duration, yrs	Annual acreage	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	
19	Pwalugu Multipurpose Dam	20,000	240.00	6	3,333					3333	3333	3333	3333	3333	3333																					
20	Daboya irrigation project	3,000	36.00	6	500																									500	500	500	500	500	500	
21	Fumbisi valley water management project	50,000	300.00	22	2,273									2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	2272.7	
22	Sisilli Kulpawn irrigation project	50,000	600.00	16	3,12														3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125		
23	Passam irrigation project	1,200	14.00	4	300																											300	300	300	300	
24	Mpaha irrigation project	5,500	66.00	5	1,100																										1100	1100	1100	1100	1100	
25	Lamassa irrigation project	3,200	38.40	5	640												640	640	640	640	640															
26	Extension of Mankessim irrigation scheme	330	3.96	2	165		165	165																												
27	Katanga valley water management	50,000	600.00	18	2,778													2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	2777.8	
28	Karaga irrigation scheme	22,500	270.00	14	1,607																1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1	1607.1		
29	Daka Valley Irrigation Project	35,000	210.00	12	2,917											2916.7	2916.7	2916.7	2916.7	2916.7	2916.7	2916.7	2916.7	2916.7	2916.7	2916.7	2916.7									
30	Fumbi Valley Water Conservation project	242,400	700.00	20	12,120											12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	12120	
31	Diversion weir on River Tano and irrigable area	20,000	240.00	28	714			714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	714.29	
32	Komenda Sugar Irrigation Project	40,000	480.00	30	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	
	Total Hectarage	**822,762**	**7,166.14**																																	
	Annual acreage delivery, Ha			`		5,049.5	5,282.5	12,116.7	12,406.7	15,035.9	14,635.9	14,965.1	14,965.1	17,160.3	17,160.3	23,214.5	23,854.5	31,948.9	35,073.9	35,948.9	37,001.1	37,233.6	37,788.6	37,016.1	37,016.1	32,016.1	32,016.1	36,731.9	36,731.9	35,981.9	37,636.9	38,709.4	38,709.4	37,042.7	32,310.6	**822,762**
	Cost per Ha (US$)	**8709.86**																																		
1																																				
2																																				
3																																				
4																																				

Source: Author's construct

5.7.3 Annual Revenue Projections for Selected Crops

The agricultural sector directly and indirectly employs about 45 percent 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 by the end of the plan period. The details of the annual total net revenue are shown in Figure 5.17.

Figure 5.17: Total net revenue projections for selected irrigated crops per annum

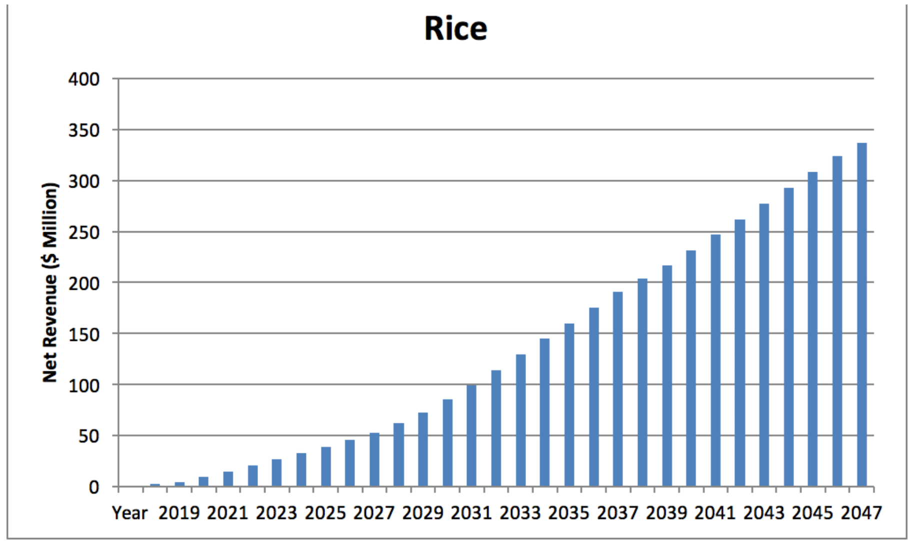


Source: Author's construct

In 2013, Ghana's unemployment rate was 5.2 percent according to the CIA World Fact Book. This suggests that over 1.4 million 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 percent. 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 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 role in progressively increasing rice production towards self-sufficiency level and eventually curtailing the import trend. Figure 5.18 shows the net revenue projections for rice during the plan period.

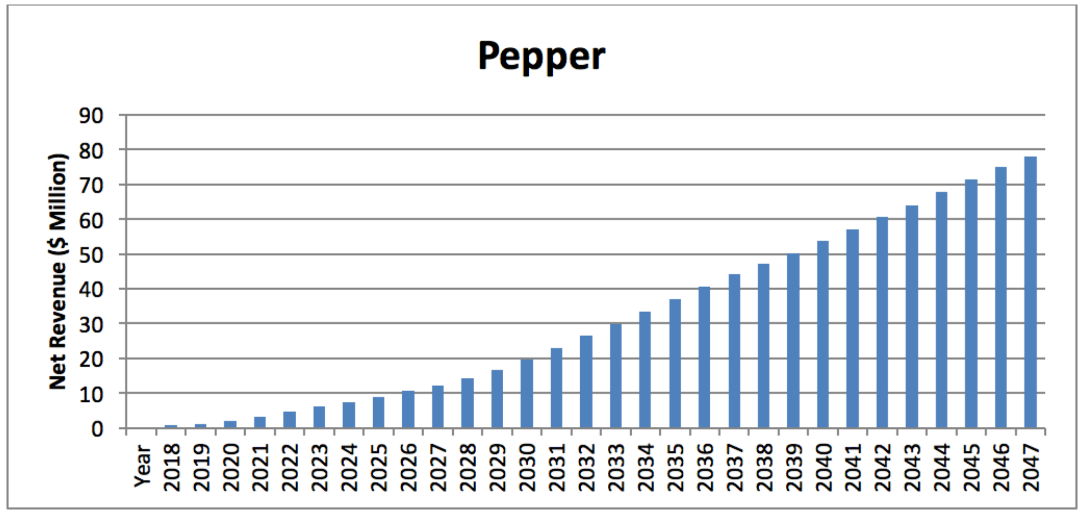
Figure 5.18: Net Revenue Projections of Rice ($ Million)



Source: Author's construct

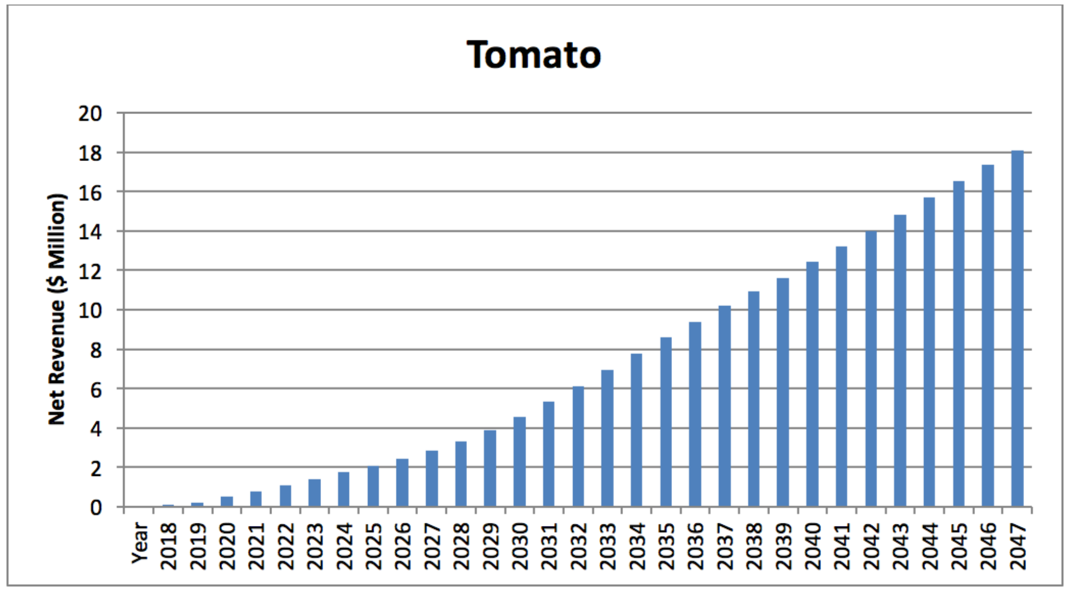
Import substitution could be replicated for sugar and canned tomato if steps are taken in the right direction of food processing and industrialisation. Figures 5.19 and 5.20 show the net revenue projections for pepper and tomato respectively during the plan period.

Figure 5.19: Net Revenue Projections of Pepper ($ Million)



Source: Author's construct

Figure 5.20: Net Revenue Projections of Tomato ($ Million)



Source: Author's construct

5.7.4 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.

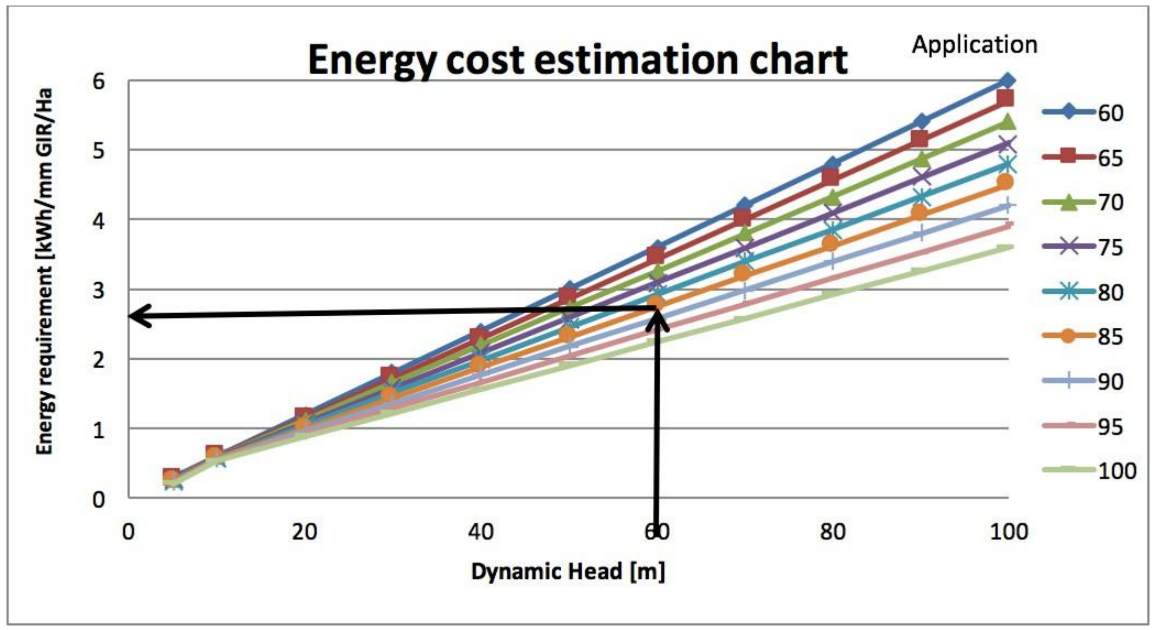
iv. Adoption of a policy that mandates District Assemblies to allocate part of their funds for the development of irrigation projects in their areas of jurisdiction.

v. Use of land as equity in project development. This eliminates social tension and allows the descendants of the land owner to benefit from the project so long as the project exits.

5.8 Energy Requirement

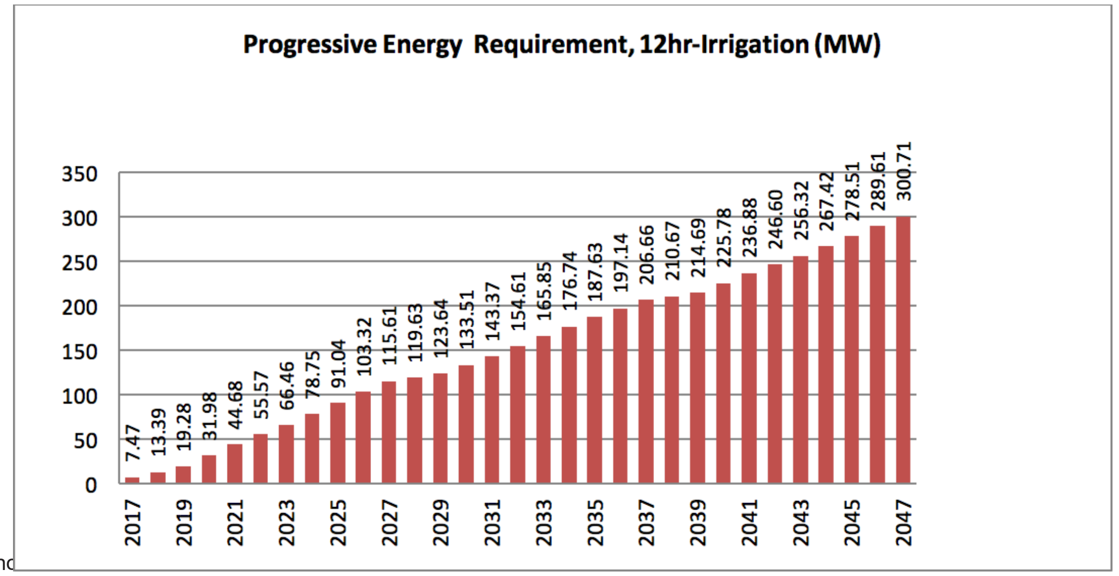
The projected energy requirement was assessed based on the consumption of existing pressurised systems and the annual new pressurised development envisaged for the 30-year period. About 300 megawatts of power would be required by the end of 2047 to operate the systems on 12-hour irrigation cycles per day. The power requirement will be halved if irrigation water delivery is increased to 24 hours per day. Average system efficiency of 85 percent and 60m head combination and 6mm Gross Irrigation Requirement (GIR) have been used for the computation of progressive energy required as shown in Figure 5.21. The progressive annual power requirements for 12-hour and 24-hour irrigation are shown in Figures 5.22 and 5.23 respectively.

Figure 5.21: Energy Cost Estimation Chart



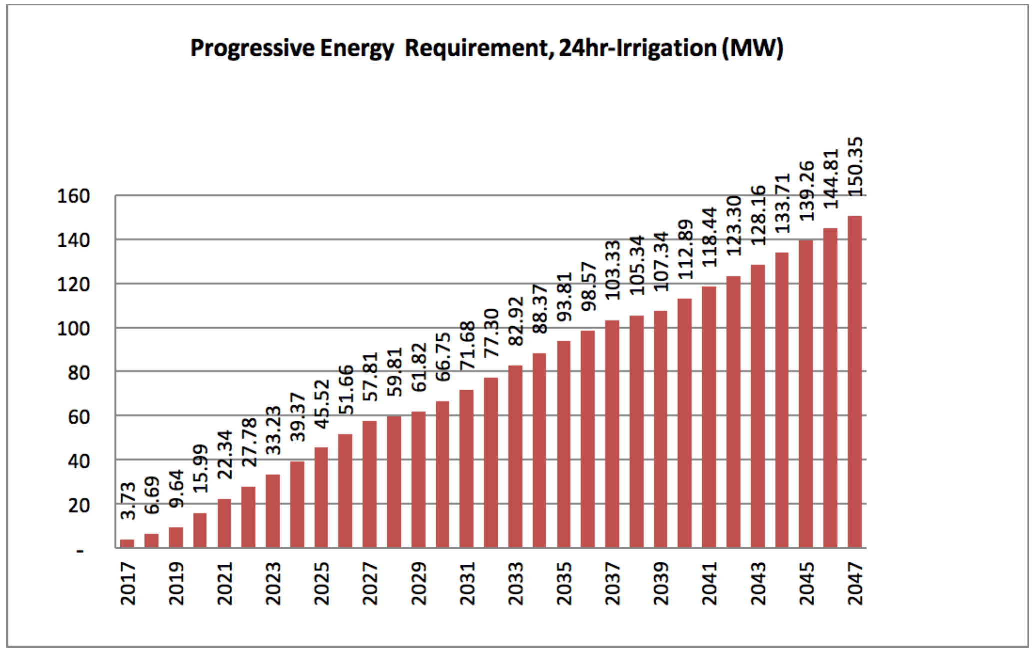
Source: Author's construct

Figure 5.22: Progressive Energy Requirement for Irrigation (12hr)



Source: Autho

Figure 5.23: Progressive Energy Requirement for Irrigation (24hr)



Source: Author's construct

5.9 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 5.11.

Table 5.11: 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.
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 projects without the full consultation with GIDA	Moderate	The restructuring requires GIDA to operate as 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. Source: Author's construct	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.