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NATIONAL WATER RESOURCES ASSESSMENT AND MANAGEMENT STRATEGY

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prepared by

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PREAMBLE

To provide the necessary improvement in management of the nation's water resources, and to establish a platform for informed and balanced decision-making on water resource development and exploitation, the Government of The Gambia through the Ministry of Environment, Climate Change, Water Resources, Parks and Wildlife has made important strides towards implementation of the National Water Policy, which was formally endorsed in 2007. The policy fully embraces the 'paradigm' referred to as integrated water resources management (IWRM). Furthermore, with the aim of setting the stage for implementation of the National Water Policy, an IWRM Roadmap for The Gambia was elaborated in 2008.

Water resources many different uses – e.g. for people and their livelihoods, for agriculture and for healthy ecosystems – require coordinated actions. An IWRM approach is an open, flexible process, bringing together decision-makers across the various sectors that impact on water, and bringing all stakeholders to the table to set individual sub-sector policies and make sound, balanced decisions in response to specific water challenges faced.

Although The Gambia apparently possesses sufficient water resources, which should make the country able to meet future requirements for water, it is also a fact that growing seasonal and localized water scarcity occurs with an increasing frequency. To solve the emerging problems in relation to the water resources, the supply side as well as the demand side will have to be managed more carefully than at present. Measures must be put in place to ensure that water is used in a sustainable manner.

At the West African regional level, The Gambia maintains a 'good neighbours' water policy and promotes regional cooperation through various working groups and initiatives, prominently as member of ECOWAS and the Gambia River Basin Development Organisation (OMVG). A case in point is the newly contracted construction of the Sambangalou Hydroelectric Power Project upstream on the Gambia River. The dam-reservoir structure, when commissioned and reservoir filling starts, will forever change the natural flow pattern of the Gambia River downstream of the dam.

Since water resource systems are dynamic and highly weather/climate driven, a prerequisite for any water resources planning and management initiative is to have well founded knowledge about the water resources, quantitatively and qualitatively. It is indispensable therefore that the water resources managers have access to updated and detailed assessments of the availability of the nation's water stock to be able to make informed decisions.

A water resources management strategy should not just be limited to the assessment of water resources availability set against water demands – and how to meet these water requirements over time. It shall also be a 'foundation' for cross-sectoral collaboration to ensure that water, land and other natural resources are developed and utilized in a sustainable manner.

It is against this background that the present National Water Resources Assessment and Management Strategy has been prepared as one of the main outputs under the National Water Sector Reform Project executed by the Department of Water Resources. The overall objective is to provide the National Water Policy with the required implementation guidance and technical direction to fully establish a sustainable framework for managing the nation's water resources.

Department of Water Resources
Banjul, March 2015

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

ACRONYMS AND ABBREVATIONS

ADB	African Development Bank
ANR	Agriculture and Natural Resources
AWF	African Water Facility
BOD	Biochemical Oxygen Demand
CAADP	Comprehensive Africa Agricultural Development Programme
CRR	Central River Region
CWP	Country Water Partnership (The Gambia)
DSA	Deep Sandstone Aquifer
DSS	Decision Support System
DTM	Digital Elevation Model
DWR	Department of Water Resources
^oC	Degree Celsius
ECOWAS	Economic Community of West African States
EEZ	Exclusive Economic Zone (for fishing rights)
ESIA	Environmental and Social Impact Assessment
EUR	European Unit of Account (Euro)
GAMA	The Gambia Meteorological Authority (proposed)
GBA	Greater Banjul Area
GBoS	Gambia Bureau of Statistics
GDP	Gross Domestic Product
GIS	Geographic Information System
GMD	Gambian Dalasi
GNAIP	Gambia National Agricultural Investment Programme
GPS	Global Positioning System
GWP	Global Water Partnership
g/l	Gram per litre
ha	Hectare
HRD	Human Resource Development
HYCOS	Hydrological Cycle Observing System
IWRM	Integrated Water Resources Management
km	Kilometre
l/c/d	litre per capita (person) per day
LGA	Local Government Authority
LIFDC	Low Income Food Deficit Country
LRR	Lower River Region
MDG	Millennium Development Goals
Mm^3	Million cubic metres
m^3/d	Cubic metre per day
m^3/s	Cubic metre per second
ml	Millimetre
MoA	Ministry of Agriculture
ModFlow	Groundwater modelling tool
M&E	Monitoring and Evaluation

NAWEC	National Water and Electricity Company
NBR	North Bank Region
NEA	National Environment Agency
NGO	Non-Governmental Organization
NWP	National Water Point
NWRMA	National Water Resources Management Authority (proposed)
NWSRP	National Water Sector Reform Project
OMVG	Gambia River Basin Development Organization
PAGE	Programme for Accelerated Growth and Employment
PMU	Project Management Unit
PRSP	Poverty Reduction Strategy Paper
PSC	Project Steering Committee
PURA	Public Utilities Regulatory Authority
SLD	Side Looking Doppler (Ott flow velocity measuring equipment)
SSA	Shallow Sand Aquifer
ToR	Terms of Reference
UfW	Unaccounted-for Water
UNFCCC	United Nations Framework Convention on Climate Change
URR	Upper River Rigion
UTG	University of The Gambia
WCR	West Coast Region
WDM	Water Demand Management
WMO	World Meteorological Organization
WRM	Water Resources Management
WRMIS	Water Resources Management Information System
WSSD	World Summit on Sustainable Development (Johannesburg 2002)

SYNOPSIS

This document, the National Water Resources Assessment and Management Strategy, is structured in 3 parts as follows:

***Part I: Setting the Stage for the Strategy Document** which includes two chapters, i.e. **Chapter 1**: Introduction, and **Chapter 2**: Population and Socio-economic Profiling, providing the general context for the strategy focusing on the rationale and progress made towards introducing and mainstreaming integrated water resources management in The Gambia.*

***Part II: Water Resources Assessment and Water Requirements** which includes **Chapter 3**: Hydro-physical Setting and Features, and **Chapter 4**: Water Demand Analysis and Water Availability. Additionally, in this part of the document a **Chapter 5**: Water Demand Management and Supply Efficiency is included to emphasise the important aspect related to reducing the demand and hence the requirements for water – or at least be able to postpone investments in further water abstraction facilities for some time pending the impact (results) of the water demand management and supply efficiency initiatives.*

***Part III: Strategic Plan** which includes **Chapter 6**: Strategic Intervention Areas, **Chapter 7**: Activities by Strategic Areas, and **Chapter 8**: Strategy Implementation. The strategic intervention areas address water resources management issues encompassing the full array of IWRM, viz. enabling environment (legislation and regulative framework); institutional framework (creation of new authorities); and management instruments (assessment, information and allocation instruments).*

In <u>Part II</u> the overall water balance aspects are presented with focus on the Greater Banjul Area. Based on the latest statistics on water utilization (current abstractions) set against the availability of water, the present and the future 'exploration' rate is estimated through the application of a computer-based modelling tool using a planning horizon of 25 years, i.e. year 2040. The model is used by introducing two scenario, (i) a doubling up of the 'present day' abstraction rate to match the water demand projections towards the end of the planning horizon, and (ii) a likely climate change impact manifested in a 20% reduction in the infiltration to the groundwater aquifers. In a simplified manner, this scenario reflects the combined effects of a reduction in rainfall and a temperature rise.

The concept of 'water demand management' is also directly introduced and reflected in the projected water demand projections. This alternative approach places water demand itself – not immediately structural solutions – at the centre of concern, and only develops capital-intensive structures after opportunities have been fully analysed for lowering or mitigating the proposed demands in a more socio-economically beneficial manner. In other words, water demand management deals with a reduction of the need to expand traditional water supply sources, e.g. further groundwater abstractions. It is shown that through a targeted introduction of a realistic water demand management and water use efficiency programme savings in capital investments equivalent to about 60 abstraction boreholes can be realized in the Greater Banjul Area within the plan period.

Besides the Greater Banjul Area's future water supply situation, the other important water resources management issue concerns the use of the seasonal and perennial freshwater resources in the Gambia River system. In this part of the document, a discussion is also presented on the use of the surface water resources primarily for the purpose of rice fields irrigation set against the fresh water stock in the river with due regard to the changing flow regime to be realized when the Sambangalou Dam in Senegal will be in full operation in a few years from now.

The most prominent changes in the natural flow regime to be felt downstream of the Sambangalou Dam, hence in The Gambia, are:

- *reduced high flow conditions in the rainy season resulting in lower flood water levels and less frequent (if at all) flood occurrences; and*
- *augmentation of the dry season flows by maintaining low water flows at the outlet of the hydro-electric turbines in Senegal.*

It is emphasized that the total area to be earmarked for irrigated rice production is not only determined by the number of hectares identified as 'suitable land', but as much by the availability of the Gambia River water for irrigation. In this regard, the analysis presented in Part II indicates that The Gambia would have a potential area for irrigation of about 12,000-13,000 ha – half the ultimate target of 24,000 ha as stated in the Gambia National Agricultural Investment Plan.

In Part III the strategic plan and its implementation modalities and costs are presented. The objective of the water resources management strategic plan is to provide the National Water Policy with the required implementation guidance and technical direction to fully establish a sustainable framework for managing the nation's water resources whilst adhering to IWRM principles founded on an enabling legal and institutional framework. In all, 7 strategic intervention areas have been identified and addressed in the strategic plan each associated with a number of actions (in total 25) categorized under the following headings:

- *Strategic Area 1: Legal and institutional transformation*
- *Strategic Area 2: Water resources information and knowledge*
- *Strategic Area 3: Water resources development and monitoring*
- *Strategic Area 4: Climate change implications and ecosystems*
- *Strategic Area 5: Trans-boundary water sharing and collaboration*
- *Strategic Area 6: Stakeholder awareness and participation*
- *Strategic Area 7: Human resource development*

In congruence with the pending establishment of the National Water Resources Management Authority (NWRMA), the water resources management strategic intervention areas and their actions/activities are initially framed to be implemented within a 5-8 years period.

Cost estimates for each activity/strategic intervention area are also presented in Chapter 8. The total cost for implementation of the Strategic Plan is estimated at EUR 1,833,600 – equivalent to approx. GMD 90 million (exchange rate by end of 2014). The cost estimates are based on cost of the following elements: (i) goods, materials and equipment; (ii) consultancies; (iii) administration and management by NWRMA Strategy Unit; and (iv) contingency funds (20%).

The Strategy Plan implementation should be supported by a systematic and practical monitoring and evaluation (M&E) system. For this purpose a number of performance indicators are also presented, which in one form or another may be found relevant and then in a modified form can be applied during the course of implementing the strategy.

The strategic intervention areas and associated actions must be viewed as a set of priority actions, which need to be amended in the future whereby additional strategic areas and actions may be introduced. A strategic plan of this kind should be used as a 'dynamic' tool, which requires being re-visited periodically.

PART I

SETTING THE STAGE FOR THE STRATEGY DOCUMENT
(Chapters 1 and 2)

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1. INTRODUCTION

1.1 Integrated approach to water resources management

On the one hand, The Gambia is blessed with sufficient water resources which should make the country able to meet future demands, including requirements related to the economic development and social uplift of the population. *On the other hand*, seasonal water scarcity occurs. Population growth, highly localized water demand to serve the touristic sector, irrigation requirements, growing commercial and industrial activities and changes in land use practices (not only in The Gambia, but in the entire upstream Gambia River Basin) cause a number of problems as witnessed today in the form of degradation of the environment and depletion/pollution (salt water intrusion) of the water resources.

To solve the emerging problems in relation to the water resources, the *supply side* as well as the *demand side* will have to be managed more carefully than at present. Measures must be put in place to ensure that water is used in a sustainable manner.

Furthermore, all users must share the responsibility to use water efficiently with little or no wastage. Obviously, water must be shared out equitably, so that all levels of society can make use of it. These basic principles – proper development, protection, sustainability, efficiency and equity – should be guiding in the further utilization and management of the water resources and water supply sectors in the Gambia.

At the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, the international community took an important step towards more sustainable patterns of water management by including in the WSSD Plan of Implementation a call for all countries to develop "*integrated water resources management (IWRM) and water efficiency plans*". Hence, activities aimed at enhancing 'water efficiency' are considered important components of IWRM.

The term IWRM has been subject to various interpretations, but the following definition by the Global Water Partnership[1] is the most widely adopted:

> *"... a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems ..."*

Due to competing demands for the water resource (in the worst case resulting in limiting economic development, decreasing food production, and decline in human health and hygiene services), the process is intended to facilitate broad stakeholder input in order to build compromise and equitable access.

The Global Water Partnership (GWP) presents IWRM as building on three pillars: (i) management instruments, (ii) enabling environment, and (iii) institutional framework as depicted in Figure 1.

[1] *Global Water Partnership (GWP): Integrated Water Resources Management, Technical Advisory Committee, TAC Background Paper No. 4 (2000)*

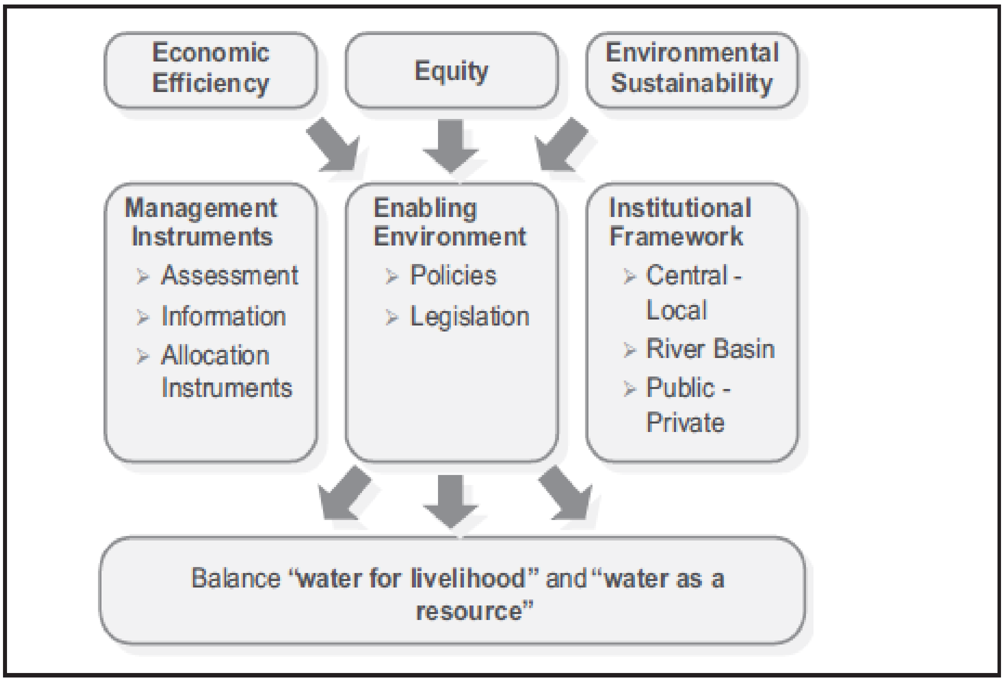


Figure 1: The pillars of IWRM

More specifically, the three complementary elements (the 'pillars') typically embrace the following:

- Management instruments: These include operational instruments for effective regulation, monitoring and enforcement, that enable the decision-makers to make informed choices between alternative actions. Such choices need to be based on available resources, environmental impacts, and the social and economic consequences.
- Enabling environment: The general framework of national 'water sector' policies, legislation and regulations.
- Institutional framework: The roles and functions of ministries and departments, statutory bodies (agencies/authorities), the interaction between the various administrative levels (national, regional and lower levels) and often a great number of diversified stakeholders.

During implementation and mainstreaming of the IWRM framework, the three complementary elements must be developed and strengthened concurrently.

Integrated water resources management means that all the different uses of water resources are considered together. Water allocations and management decisions consider the effects of each use on the others. Thus IWRM is a broad-based concept to the development of water, addressing its management both as a resource and within the framework of providing water services.

The IWRM approach moves away from single sector water planning to multi-objective and integrated planning of land and water resources, recognizing the wider social and economic implications of development goals and cross-sectoral coordination.

IWRM can be thought of as the way in which water can be managed to achieve the objectives of sustainable development. It is an approach that reflects the need to achieve a balance among (i) economic efficiency; (ii) social equity; and (iii) environmental sustainability as also reflected in Figure 1 above.

The 'water sector' represents all the means and activities dedicated to water resources allocation and use. The 'water sector' thus defined includes all at the same time, viz.

- activities related to water resources allocation, including water pricing;
- activities related to water use within the traditional socio-economic sectors, e.g. provision of potable water, water for irrigated agriculture and industrial water requirements;
- activities aimed at institutional development, organizational strengthening, and awareness raising and capacity building of a variety of stakeholders;
- activities to improve catchment planning and land use; and
- if needed, the establishment of specific river basin organizations of various types.

Water resources are the primary focus of IWRM. However, the interactions with other natural resources must also be recognized. *Water-related* resources are those resources and those aspects of their management that interact significantly with water. The management of land, forests, sand exploitation, fisheries etc. can have significant implications for water quantity and quality, and these natural resources require their own management strategies, which should be properly linked into IWRM.

1.2 Present status of IWRM in The Gambia

To provide the necessary improvement in management of the nation's water resources, and to establish a platform for informed and balanced decision-making on water resource exploitation, the Government of The Gambia through the then Department of State for Fisheries and Water Resources prepared a National Water Policy[2]. This policy document fully embraces the IWRM principles.

With the aim of accelerating implementation of the National Water Policy, an IWRM Roadmap for The Gambia[3] was elaborated in 2008 and subsequently adopted in May 2009. The Roadmap comprised a number of priority actions to facilitate the transition from the prevailing unsatisfactory water sector management practices to a fully-fledged, mainstreamed integrated water resources management paradigm. Besides outlining how to pursue the IWRM 'visions' articulated in the National Water Policy, one of the prime purposes of the Roadmap was also to provide the lead institution with the documentation/justification required to seek and mobilize funds.

This aim was achieved when the Ministry of Fisheries and Water Resources[4] obtained the support from the African Water Facility (AWF) of the African Development Bank (ADB) providing the means to embark on the National Water Sector Reform Project (NWSRP). This project started in 2011 and is scheduled to be concluded in 2015.

[2] *National Water Policy, 2006 (formally endorsed in 2007). The Government of the Republic of The Gambia, Department of State for Fisheries and Water Resources.*

[3] *IWRM Roadmap for The Gambia, 2008 (formally adopted in May 2009). Momodou Njie, Blue Gold Solutions.*

[4] *In May 2014, certain ministerial portfolios were reorganized and merged into a new Ministry of Environment, Climate Change, Water Resources, Parks and Wildlife.*

In a parallel development – and also included as one of the priority actions in the IWRM Roadmap – the need for establishing a Country Water Partnership in The Gambia was also articulated, and subsequently with support rendered by the Global Water Partnership through its regional GWP West Africa office, The Gambia Country Water Partnership (CWP) was officially launched in December 2011. By virtue of its mandate, including interaction and direct dialogue with the various relevant stakeholder groups at regional and district level, CWP has an important role to play in supporting and facilitating the further understanding and people's perception and appreciation of the need for 'good' water governance at all levels to achieve sustainable management of the nation's water resources.

As an integral part of the preparations and 'designing' the National Water Sector Reform Project, and building on the recommended actions given in the IWRM Roadmap[5], further assessments were made highlighting the strengths and weaknesses of the country's water resources governance, and in which areas and to which extent further support was needed. Based on these in depth preparatory activities, the NWSRP components addressed a broad range of equally important elements required towards mainstreaming IWRM as the paradigm of choice at all levels of society.

The NWSRP's components included:

- An institutional development component, which combined (i) an institutional analysis with recommendations for the most appropriate organizational set-up at national level; and (ii) the 'enabling environment' in form of a proposed new water sector legislation as a foundation for establishing the new institutional framework.
- An human resource development component, which looked at the present manpower situation, and the requirements in this regard as part of the proposed institutional framework, in terms of the cadre (number) of professional staff and the training and educational background needed.
- A water resource data and information component, which (i) provided a renewal of and established a 'modernized' infrastructure of data collection networks (groundwater, surface water, meteorology and water quality); and (ii) introduced a water resources management information system in form of a computerized state-of-the-art database software, including data manipulation and presentation tools.
- A groundwater assessment component, which in addition to existing boreholes included the construction of 20 new deep boreholes country-wide all equipped with data-loggers providing the means to monitor groundwater level on a continuous basis. As part of this component a groundwater modelling tool was also introduced and a Hydrogeological Map produced.
- A stakeholder mobilization component, which based on a regional stakeholder analysis provided an IWRM Communication Strategy, and on a pilot basis initiated an awareness and advocacy campaign in two regions ready to be rolled out nationally.

[5] *The IWRM Roadmap concluded with a set of 13 priority actions of which all but a few have been carried forward and addressed as part of the NWSRP activities, with the result that a broad range of 'tools' is available as further highlighted in Section 1.5. The foundation is now established in readiness to facilitate practical sector reform implementation, and move the process from policies and plans to concrete interventions for consolidating the IWRM paradigm in The Gambia.*

In order to assess the present status concerning introduction of IWRM in The Gambia, it is relevant to recall how the Global Water Partnership normally visualizes the IWRM process as a cycle shown in Figure 2.

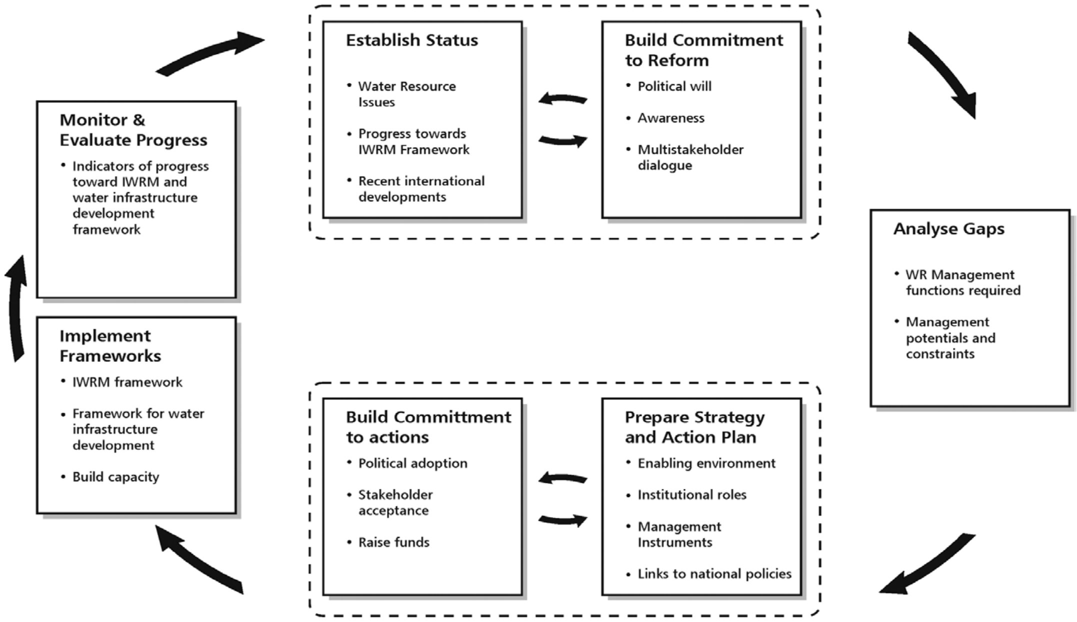


Figure 2: The IWRM implementation cycle

With reference to the IWRM implementation cycle, it can be concluded that The Gambia has progressed quite substantially in the process towards introducing and mainstreaming IWRM. The present status is that the IWRM implementation process from the top boxes has reached and is well underway towards addressing the tasks imbedded in the two lower boxes in Figure 2. The task of reaching 'political adoption' as stated in the lower left box will be achieved when the proposed new water sector legislation is enacted.

Having said that, it should be pointed out that the preparation of a strategic plan is not a one-time event. The introduction of integrated water resources management cannot take place as just an immediate change from one concept to another. Implementation of the IWRM concept is a cyclic process where the development of the individual components inevitably will be stepwise and inter-related to the other components, and the strategy plan has to be updated dynamically as also illustrated in Figure 2.

The present strategic plan should therefore be seen as the first 'version' of the planning tool aimed at supporting the further implementation process based on the various 'tools' now created as a result of the NWSRP activities. In other words, the IWRM implementation process is now moving into the last part of the cycle starting with the left box named 'implement frameworks', which needless to say also require funds.

IWRM PLANNING MEANS

- Moving from a view that the State alone is the one responsible for water resources management towards one that sees responsibility with society as a whole.
- Moving from a centralized and controlled decision-making paradigm towards sharing results and opportunities, negotiation, cooperation and concerted action.
- Moving from sectoral planning towards coordinated and fully integrated planning of water-related resources.

1.3 The Gambia's policy towards water resources management

It is clear from the initiatives taken as of lately, specifically implementation of the National Water Sector Reform Project, that the authorities pro-actively are seeking to improve water resource management and calling for a much more integrated approach. It is recognized that The Gambia's water resource sector still is fragmented with several institutions having overlapping responsibilities for monitoring quality and quantity and that there is a need for improved collaboration between water sector governing bodies. An earlier World Bank Policy Paper on Water Resource Management (1993)[6] is still very relevant to the restructuring process also in the case of The Gambia as it identifies three universal problems in particular which need to be addressed in a water resources management restructuring process. These are:

- Lack of public coordination and effective regulations for water quality, health, and environment issues.
- Difficulties in addressing the interdependencies among agencies, jurisdictions and sectors hampering effective public investment programming and sector management.
- Excessive reliance on understaffed and underpaid government agencies that have neglected the need for economic pricing, financial accountability, and user participation, and hence have not provided services (water resource management) effectively;

Although the concept of IWRM is widely recognized across the world as the 'paradigm' of choice, it should also be emphasised that there are no unique models of successful water resource management, and many different arrangements and forms are seen to work more or less effectively in different countries at different times. That is, the success is conditional on effectively addressing a wide array of problems for which there are no standard answers – only good practices and general guidelines as outlined below:

- the principle of fundamental right of all people without discrimination to safe and adequate water to meet basic human needs;
- the principle of meeting the social needs for water as a priority, while recognizing the economic value of water and the goods and services it provides;

[6] *World Bank, 1993. Water Resources Management - A World Bank Policy Paper. Washington DC*.

- the principle of recognizing water as a finite and vulnerable resource given its multiple uses;
- the principle of improving equity and gender sensitivity;
- the principle of integrating water resources management (participatory management involving users, planners and policy makers) and development with environmental management to ensure sustainability of water resources in both quantity and quality;
- the precautionary principle that seeks to minimize activities that have the potential to negatively affect the integrity of all water resources;
- the principle of coordinating water resources planning with land use planning;
- the principle of adopting the catchment area as a planning unit where appropriate;
- the principle of polluter pays, to serve as a disincentive to uncontrolled discharge of pollutants into the environment; and
- the principle of subsidiarity (the principle which states that matters as found relevant ought to be handled by the smallest/local competent authority) in order to ensure participatory decision-making at the lowest appropriate level in society.

The National Water Policy already provides the policy-related ‘enabling environment’ for the good practices and general guidelines listed above – and as highlighted earlier clearly reflects the principles of IWRM. But over the past many years, a revised water sector legislation has been pending mainly due to the lack of agreement on the institutional arrangements.

The key principles articulated in the National Water Policy is to move away from single sector water planning to multi-objective and integrated planning of land and water resources, recognising the wider social and economic implications of development goals and cross-sectoral coordination. Among the key issues is to move towards a distinct separation of water resources management functions (policy, coordination, monitoring and regulation) from those of water resources utilisation (provision of water for all water users). Further, the National Water Policy also calls for the effective participation of all stakeholders realising that users of water in The Gambia have an increasingly important responsibility to use water conservatively and wisely.

Under the NWSRP, the institutional development component has in an open dialogue earnestly attempted to propose the new institutional arrangement keeping in mind that the new apex institution must have the oversight, credibility, authority and respect to lead the way through some tough decisions and potential opposition. This is particularly the case where it is in the national interest to change functions and powers from existing institutions, and change old water allocation and water use ‘traditions’ in favor of new ones which are in the national and public interest.

It is important to stress that such a new arrangement in The Gambia will not be a matter of government taking power and functions away from particular departments or ministries – but more an attempt to enable efficient water resource management with clear division of powers and functions between institutions, and underscoring the need for actively seeking a collaborative approach among the various stakeholders.

1.4 International dimension in context of the strategy

The Gambia is a signatory to a number of international conventions and agreements. Those of specific importance to water resource management includes the Ramsar

Wetlands Convention (1971), the Millennium Development Goals (2000), the African Ministerial Conference on Water (2001), and the UN '97 Watercourses Convention[7].

At the regional level, The Gambia maintains a 'good neighbours' policy and promotes regional cooperation through various working groups and initiatives, prominently as member of ECOWAS and the Gambia River Basin Development Organisation (OMVG).

The framework for water resources management as established for the ECOWAS member states is set out in the West Africa Water Resources Policy[8] (ECOWAS, 2008). Its general objective is to promote efficient, equitable and sustainable development, thereby contributing to poverty reduction in member states. Its guiding principles are equitable sharing of trans-boundary water resources, complementarity and partnership between and among communities of users, decision-making based on sound science, conflict prevention, gender equality, resources conservation, and common responsibilities to implement agreed measures. Following these principles three strategic areas of intervention are articulated, viz. (a) to reform water governance; (b) to promote investments in the water sector; and (c) to promote regional cooperation and integration in the water sector.

The mandate of OMVG (established in 1981) is to '*promote and implement studies and development works on the Gambia, Kayanga/Gebe and Koliba/Corubal River Basins within the territories of its member states*[9]'. The OMVG is an essential body as the management of water resources in the signatory countries has the greatest impact on The Gambia being at the downstream end of the Gambia River. Any major infrastructure works and large abstractions, e.g. for irrigation purposes, upstream inevitably pose concerns related to the flow of the river along the lower reaches where it passes through The Gambia and discharges valuable fresh water resources in the eastern half of the estuary system. The same argument is also valid for the tributaries originating in Senegal and join the Gambia River both along the North Bank and the South Bank. In this regard the impacts and consequences are related both to flow volumes (quantity) and water quality.

A case in point is the newly contracted construction of the Sambangalou Hydroelectric Power Project on the Gambia River located at the Senegal-Guinea border some 470 km upstream of The Gambia-Senegal border. The dam-reservoir structure, when ready for commissioning and reservoir filling (scheduled for 2018/2019), will forever change the natural flow pattern (the hydrological regime) of the Gambia River downstream of the dam.

Various attenuation measures have been studied/included as part of the dam design in response to the Environmental and Social Impact Assessment carried out. Once built, it will be possible to create artificial floods (once or twice a year) for ecological purposes, e.g. to mitigate the resultant reduction of flooded wetland areas. Likewise, by virtue of being a hydropower dam, a certain flow through the turbines is required – preferably with little variation over the year – which provides the advantage of being able to maintain a steady low water flow during the dry season. Artificial maintenance of

[7] *Expected to be ratified by the National Assembly in 2015.*

[8] *The West Africa Water Resources Policy was adopted by the Authority of Heads of State and Government in December 2008 as a general framework and guidance for cooperation between ECOWAS member states in the field of water.*

[9] *The member states are Senegal, Guinea, The Gambia and Guinea-Bissau each with a share of the river basin area of 71%, 15%, 14% and <1%, respectively.*

minimum low waters is ecological justified as a mitigation measure to reduce the effects of the project on certain environmental and social components, but more important for The Gambia to provide a 'buffer' to maintain the saltwater front further downstream that at present.

Without firm operational rules in place concerning the use and possible artificial releases of the stored water in the Sambangalou dam-reservoir complex yet agreed to under the OMVG umbrella, a strategic area of concern is the means and ways of interaction through OMVG to protect Gambian interests, including how to negotiate in that forum, and which outputs would represent reasonable equitable use of the shared waters and their benefits.

1.5 Preparation of the water resources management strategy

Vision 2020 and Programme for Accelerated Growth and Employment (PAGE)

It is imperative that the water resources strategic plan is consistent with the national development plans, Gambia National Development Strategy: 'Vision 2020' and Programme for Accelerated Growth and Employment (PAGE)[10] in as much as availability of water in sufficient quantity and satisfactory quality is a prerequisite to much of the envisaged development efforts outlined in these national development plans. As it is articulated, the strategic objective of the water sector is to provide for sustainable development and management of water resources to enhance water, food and energy security, and environmental sustainability.

Basically, PAGE operationalizes Vision 2020, which seeks to map out a clear strategy for socio-economic development that aims at raising the standard of living of all Gambians by transforming The Gambia into a dynamic middle-income country – socially, economically and scientifically – through export-oriented agriculture and manufacturing ventures.

Digested from PAGE, the following paragraphs highlight the interrelationship there is between stated development goals and the availability of water resources.

In 2010, the Government approved The Gambia National Agricultural Investment Programme (GNAIP) in line with the Comprehensive Africa Agricultural Development Programme (CAADP), which it will continue to implement during the PAGE period. The Government intends to gradually increase investments in the sector from 3% of Government revenue in 2009 to at least 10% by the end of 2015. The focus of the increased expenditure in the agriculture sector relates to irrigation, quality (seed) inputs, extension services, post-harvest management and marketing.

The agriculture sector has the potential to become a pathway by which the country can reach its long-term development goals, especially by reducing poverty and achieving food security. In the last decade, the Government has embarked on a series of interventions to address food security issues and intends to continue and revitalize these efforts.

To address these issues the PAGE also advocates that the Government should strengthen the basis of land use planning to add to the necessary foundations of a functional and operational National Spatial Development Plan. This plan will guide and optimize land use in the country and ensure rational distribution of the relatively meagre

[10] *Ministry of Finance and Economic Affairs (2011). Programme for Accelerated Growth and Employment (PAGE) 2012-2015.*

land resources among competing uses, i.e. agriculture, domestic ‘space’, the hospitality sector (tourism), commercial and industrial ventures, aquatic ecosystems, and national parks and wildlife.

To sustain agricultural production throughout the year, the Government will improve and expand irrigation systems and will develop rainwater harvesting infrastructure – two measures that have been identified as climate change adaptation interventions to assist towards alleviating possible water stress and also enhance agricultural productivity under a changing climate. These aspects are also articulated in the Agriculture and Natural Resources (ANR) Policy[11], which states: *Water resource availability and accessibility on a timely basis allow for forward planning, optimization of appropriate investments as well as realistic prediction of inputs and outputs.*

According to PAGE, the tourism sector contributed about 12% of The Gambia’s real GDP in 2010. After agriculture, tourism is one of the country’s main sources of employment, providing more than 16,000 formal and informal jobs. Tourism is highly seasonal – and hence the implied water requirements – with the main tourist period from November to April, when the bulk of the more than 100,000 visitors arrive. Per capita demand from tourism is typically high relying on abundant supplies of water. With most hotels having swimming pools and water required for landscaping, maintenance of gardens and large scale laundry, the tourism industry is the highest user of water in the commercial sector.

In The Gambia, the efforts to ensure access to safe drinking water have been effective over the past years. The proportion of the population with access to safe drinking water increased to about 85% in 2010 already exceeding the MDG target. Looking at the sub-national level, in general, the water supply situation improved in all regions across the country. However, water supply depends on available electricity; therefore, this issue continues to be a major problem in rural health and education facilities as well as at households’ level.

The steps that the Government will undertake in the area of water and sanitation include provision of safe drinking water supply to all education and health facilities across the country as well as to the entire population of the country. The Government also plans to improve the operation and maintenance arrangements for water and sanitation facilities and to mobilize stakeholders in the water and sanitation sector so as to improve governance of water resources and address climate change issues.

Conditions specific to The Gambia make it particularly imperative that the Government mainstreams climate change into its development policies and programmes. Recognizing this, the Government developed and submitted to the UNFCCC Secretariat its First National Communications in 2003 and a National Adaptation Programme of Action on climate change in 2007 to stimulate a critical re-examination of the role of climate on societal and natural systems in the areas of agriculture, fisheries, wildlife, energy, water resources, and forests and woodlands.

NWSRP outputs as departure point for the strategic plan

As indicated in Section 1.2, this strategy and the ensuing actions/interventions logically take its departure point and build on the foundation now created as result of the activities carried out under the National Water Sector Reform Project. These ‘building blocks’ (or ‘tools’) can be summarized as follows:

[11] *Ministry of Agriculture (2008). Agriculture and National Resources Sector Policy (2006 -2015)*

- Reorganization of the present institutional set-up with establishment of two new authorities decided on with the proper documentation prepared, inclusive of 5-year Business (Strategic) Plans[12].
- New water sector legislation prepared including 3 Bills ready for enactment by the National Assembly[13], cabinet briefing papers and draft priority regulations.
- New 'modernized' water resource related data collection networks in place, including 38 monitoring boreholes, surface water observation/monitoring stations all equipped with data-loggers, automatic weather stations and upgrading of the DWR water quality laboratory.
- A water resources management information system (national database for water related data and information) established and existing data imported to the GeODin database.
- Groundwater modelling software application (Visual Modflow) introduced and annual water balance modelled covering the Greater Banjul Area.
- Formal diploma and M.Sc. training of a number of staff, and on-the-job (basic) training carried out in the use and maintenance of the new equipment and software.
- IWRM Communication Strategy prepared and public awareness raising activities piloted in two regions (Lower River Region and Kanifing Municipal Council), ready to be rolled out country-wide.

The above listed 'tools' are interrelated and need to be looked at and applied in conjunction, but together have created a platform on which concrete activities can now be launched.

Needless to say, this platform will be amended in the future whereby additional tools will be introduced, and the Water Resources Management Strategic Plan should be re-visited accordingly. Updating and amendment of the plan as and when needed is also a statutory requirement stipulated in The Gambia Water Bill (2014).

Structure of the strategy document

Water resources many different uses – e.g. for people and their livelihoods, for agriculture and for healthy ecosystems – require coordinated actions. An IWRM approach is an open, flexible process, bringing together decision-makers across the various sectors that impact on water, and bringing all stakeholders to the table to set individual sub-sector policies and make sound, balanced decisions in response to specific water challenges faced.

Since water resource systems are dynamic and highly weather/climate driven, a prerequisite for any water resources planning and management initiative is to have well founded knowledge about the water resources, quantitatively and qualitatively, as well as the spatial and temporal distribution. It is indispensable therefore that the water resources managers have available updated and detailed assessments of the availability of water resources to be able to make informed decisions.

To establish the necessary up-to-date foundation, a rapid water resources assessment and water demand projection analysis (25-year planning horizon) have been carried out

[12] *The authorities are: National Water Resources Management Authority (NWRMA) and The Gambia Meteorological Authority (GAMA).*

[13] *The legislative bills have been subject to' public hearing' following the normal process of being vetted at a Validation Workshop. Furthermore, members of the National Assembly have also been consulted and briefed about the intent and implications of the proposed legislation as part of drafting the bills.*

based on desk study activities, including a review of all relevant reports, papers and data related to the water sector of The Gambia. In addition, the verification and updates of this water resources assessment and water balance analysis (water availability versus requirements) have been possible by utilizing the WRMIS (GeODin software package) and the application of a groundwater modelling tool (Visual Modflow) introduced and made operational as part of the NWSRP activities.

It is implied from the foregoing discussions in this Chapter 1 that a water resources management strategy should not just be limited to the assessment of water resources availability versus water resources needs – and how to meet these water requirements over time. It shall also be a ‘foundation’ for sustainable water, land and related resources development and management with the aim to maximize economic and social welfare in an equitable manner while safeguarding the environment. As such the strategy provides the National Water Policy with the required implementation guidance, technical direction and momentum to move forward also with due cognizance given to the achievements accomplished as result of the activities outlined in the IWRM Roadmap for The Gambia – activities which to some extent have been addressed as part of the NWSRP.

The water resources assessment and management strategy document is structured in three parts as follows:

Part I: Setting the Stage for the Strategy Document including two chapters, i.e. Chapter 1: Introduction (present chapter), and Chapter 2: Population and Socio-economic Profiling, which provide the general context for the strategy focusing on the rationale and progress towards introducing and mainstreaming integrated water resources management in The Gambia.

Part II: Water Resources Assessment and Water Requirements including Chapter 3: Hydro-physical Setting and Features, and Chapter 4: Water Demand Analysis and Water Availability. Additionally, in this Part a Chapter 5: Water Demand Management and Supply Efficiency is included to put focus on the important aspect related to reducing the demand and hence the requirements for water – or at least be able to postpone investments in further water abstraction facilities for some time pending the impact (results) of the water demand management and supply efficiency initiatives.

Part III: Strategic Plan including Chapter 6: Strategic Intervention Areas, Chapter 7: Activities by Strategic Areas, and Chapter 8: Strategy Implementation.

2. POPULATION AND SOCIO-ECONOMIC PROFILING

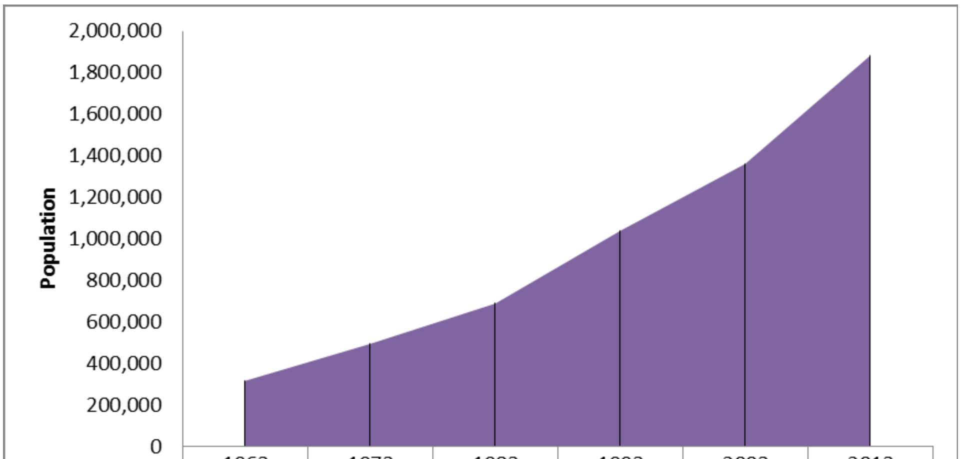
2.1 Introduction

The Gambia is a small country located in the West Coast of Africa with a total area of 10,689 square km, and a population of 1,882,450. About 51% of the population is concentrated in the urban and peri-urban areas while 49% is living in the rural areas with 60% of total population under 25 years of age.

The Gambian economy is characterized by its small size, narrow base and a large re-export[14] trade comprising about 80% of the country's merchandise exports. Re-export trade contributes between 53 and 60% of domestic tax. Between 2004 and 2009 the country has had a stable macroeconomic performance and steady economic growth averaging 5-6% per annum. Economic growth was based on services (58%), agriculture (30%) and industry (12%). During the period 2008 to 2011[15], The Gambia's Gross Domestic Product (GDP) grew by an average of 4.5% a year while the incidence of poverty among the population dwindled from 58% to 48% over the past decade.

2.2 Population and settlement trends

The 2013 Population and Housing Census[16] indicates that the population of The Gambia is 1,882,450 persons (ref. Figure 3). Overall, the population has steadily grown since the commencement of a complete census in 1963, rising from less than a third of a million persons in 1963 to 1.4 million persons in 2003 and 1.9 million persons in 2013.



	1963	1973	1983	1993	2003	2013
Year	315,486	493,499	687,817	1,038,145	1,360,681	1,882,450

Figure 3: Population size and growth (Source: ref.[16])

[14] *The Gambia re-exports imported commodities such as rice, sugar and flour to countries in the sub-region, mainly Senegal, Guinea Bissau and Mali.*

[15] *The Gambia PAGE 2012-2015, Ministry of Finance and Economic Affairs (2011).*

[16] *Gambia Bureau of Statistics (GBoS): The Gambia 2013 Population and Housing Census, Preliminary Results.*

Population growth

On average the population of The Gambia has been growing at the rate of 3.3% per annum during the inter-censal period 2003 - 2013. If this growth rate prevails, The Gambia's population can be expected to double in another 20 years' time. Comparing the current rate of population growth to the observed annual growth rate of 2.7% over the inter-censal period 1993-2003, the population growth rate has significantly increased over the past decade. As expected, the movement of the population out of Banjul City (emigration) has outweighed the contribution of births and in-migration to Banjul leading to a decline in population over the inter-censal period. In contrast, as depicted in Figure 3, the population in Brikama LGA grew at a rate of 6.1 per cent annually on average. The unprecedented rate of population growth registered for this LGA is attributable to the influx of migrants from other regions of the country and from outside the country.

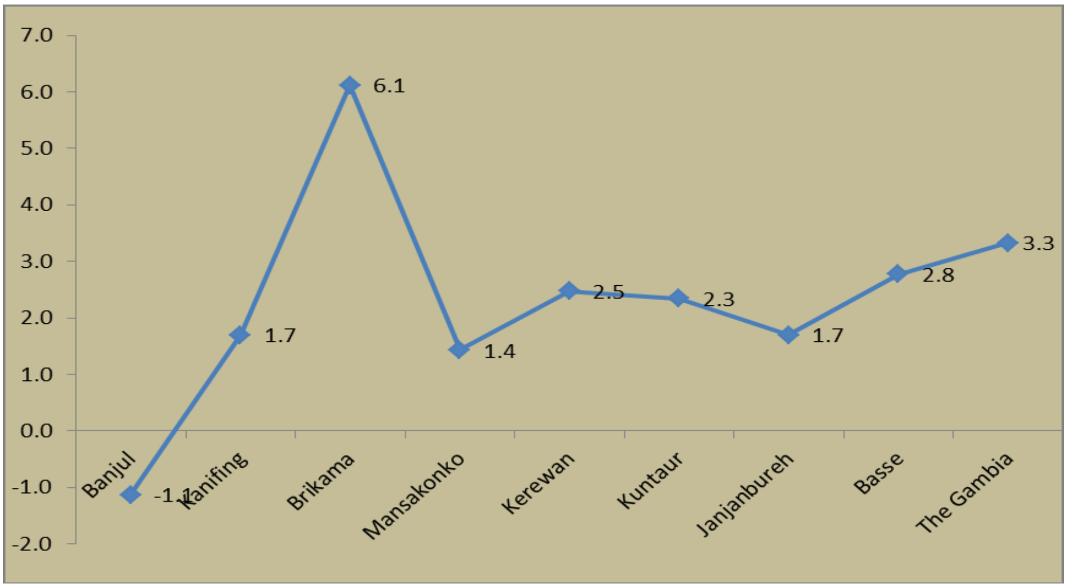


Figure 4: Average annual growth rate (%) by Local Government Area

Population density

The 2013 population census figures show a rise in population density from 127 persons per square kilometre in 2003 to 176 persons per square kilometre in 2013.

Since population density is a direct outcome of internal population redistribution as dictated by various "push and pull" factors, in the absence of changes in these factors in the foreseeable future the density is expected to continue to increase. This has policy implications for authorities both at the central and local government levels. Over the years agricultural land has been dwindling with increasing pressure on land and water resources due to an increasing population. On the other hand, land for housing is becoming increasingly scarce in urban areas which led to an unprecedented appreciation in the value of urban land and the settlement of people in areas unfit for human settlement due to the swampy nature of the terrain.

2.3 Agricultural production and development trends

The transformation of the agricultural sector from subsistence to a commercially-oriented modern sector is a national priority as stated in the PRSP II and ANR Policy and Strategy which emphasize development of the agribusiness sub-sector in support of smallholders as the main pathway to development. This will be achieved through accelerated growth in potentially fast growing sub-sectors such as horticulture, groundnuts, coarse grains and livestock, as well as increased rice production and productivity for enhanced food security and import substitution.

General overview

The natural vegetation type of The Gambia is Guinea Savanna Woodland in the coastal areas that gradually changes into Open Sudan Savanna in the east. The country has a total arable land area of 558,000 ha and about 320,000 ha or 57% is cropped annually. Agriculture is mostly rain fed, and only about 6% of the irrigation potential has been used.

The agricultural sector accounts for about 30% of GDP. It provides employment to 70% of the population and meets about 50% of the national food requirements[17]. Its share of the country's total exports is 70 percent, thus constituting a substantial part of The Gambia's foreign exchange earnings. Agriculture is also the sole means of income generation for the majority of rural households below the poverty line. In The Gambia, about 80% of the poorer segment of the population works in agriculture. The agricultural sector is regarded as the prime sector for investments to raise income, improve food security and reduce poverty.

The livestock sector contributes 33% to agricultural GDP, groundnuts 23%, other crops 43%, fisheries 3% and forestry 2%[18]. GNAIP aims to increase the agriculture sector growth rate from 4% in 2009 to 8% by 2015.

Agricultural output is generated by around 69,100 farm households (500,000 people engaged in farming) cultivating 320,000 ha. Of the total cultivated area about 30 percent is devoted to the production of groundnuts for cash income, 144,000 ha for coarse grains and about 72,000 ha for rice cultivation under rain-fed conditions. Cotton is grown on land area averaging about 3,000 hectares annually, while cassava, potato and horticultural crops occupy between 1,500 to 2,000 ha on average. An estimated 2,500 ha is annually put to irrigated rice, mainly in the Central River Region, with an additional 800 ha under horticulture. Livestock production is carried out nationwide by almost all rural households.

The GNAIP puts much emphasis on productivity of crops and livestock. It is hoped that this will not only optimize the use of the available land, but will also go a long way in protecting the environment.

Irrigated rice production

The Gambia is classified as a Low Income Food Deficit Country (LIFDC) and produces about 50% of total food consumption needs. Its national requirement for rice (major staple food) is in the range of 180,000 to 200,000 tonnes, while the quantum of national production of polished rice is estimated at only 12,000 tonnes. Despite the relative increasing trend of cereal net production, the population growth has thus rendered the

[17] *Gambia National Agricultural Investment Plan, GNAIP (2011- 2015), The Republic of The Gambia (Sept. 2010)*

[18] *2009 estimates by Gambia Bureau of Statistics*

country's cereal needs to be consistently above local production with the result that the cereal gap has been widening over the past decade. Cereal consumption deficit increased from 65,661tonnes in 1991 to 150,000 tonnes in 2007[19].

Of the estimated total arable land area of 558,000 ha, only some 3,000 ha of land is usually under irrigation. The production system is characterized by subsistence-based, rain-fed mixed-crop farming carried out mainly by small-scale farmers who use labour-intensive traditional production practices on less than one-hectare average farm size plots of usually fragmented holdings.

There have been several soil fertility maintenance interventions by the sector, which led to the development of 3,700 ha of lowlands for rice production and 3,000 ha of tidal irrigation.

In addition, one of the components of the Gambia National Agricultural Investment Plan (GNAIP) targets 24,000 ha of land under the various lowland ecologies with the aim of expanding rice production, including the use of new sorts such as NERICA (New Rice for Africa), to attain an annual production of 70,000 tonnes, and facilitate pond aquaculture production to optimize yields per year.

Groundnut production

The agricultural sector dominates the national economy by providing productive employment for 75% of the population and generating 35-40 % of GDP. It provides up to 40% of the country's export earnings. In the past, groundnut exports contributed significantly to the national economy, accounting for 60%[20], however exports collapsed in 2004 to just USD 10 million compared to USD 49 million in 1975 as a result of failures in internal marketing arrangements.

Groundnut production is highly sensitive to rainfall, seed availability, fertilizer use, pests, pricing policy etc. Yields have stagnated at approximately 1.1 tons per hectare, which compares unfavourably to international competitors, but nevertheless, favourably in the West African region. Up to 40% of the marketable groundnut crop is sold in the domestic market. Most of the trading occurs at the local "lumo" markets that are frequently situated around towns. The remaining 60% of the marketable crop is exported primarily to the Europe. The Government has undertaken several measures and started implementing strategic reforms to revitalize the groundnut sub-sector.

Horticulture production

The horticulture sector is rapidly emerging as one of the key sectors and growth areas of the Gambian economy. The sector currently contributes about 4% to GDP on average, employs over 65% of the agricultural labour force and its development is favoured for socio-economic development of the country.

Horticultural production, mainly fruits and vegetables, is an important source of rural income, employment and food, thus ensuring food security and poverty alleviation. This sub-sector is becoming a major economic activity in The Gambia due to its vast export market opportunities and conditions favoring its production in the country.

Horticulture in The Gambia is characterized by smallholder plot gardens where the major source of water for watering is groundwater through shallow hand-dug or concrete lined wells. However, there are several large farm owners with significant

[19] *Global Agriculture and Food Security Programme, Ministry of Agriculture, The Gambia (March 2010)*

[20] *Government of The Gambia / ISFP (2008)*

investments in boreholes and equipment. GNAIP[21] aims to bring 1,000 ha of land under year-round crop production to ensure reliable availability of selected vegetables thus improving nutrition and increasing household incomes.

The commercially-oriented farms have an average weekly export estimated at 120 tons of fruits and vegetables.

Livestock

Domestic livestock, including cattle, sheep, goats, horses, donkeys, pigs and poultry, constitute a significant part of the Agricultural and Natural Resources (ANR) Sector. Relative to its size and population, the country is well endowed with livestock; however, the potential of remains under-exploited and the country continues to be a net importer of livestock and livestock products. The livestock sector is estimated to contribute 5% to GDP, and possesses potential to increase this level significantly.

Current livestock population is estimated at around 300,000 cattle, 150,000 sheep and 230,000 goats. The equine population (horses and donkeys) has dramatically increased in numbers and significance in view of their role as a source of animal traction and farm transportation. Similarly, the pig population is small (about 10,000) and concentrated in the western part of the country, especially in the urban and peri-urban areas. Pig production is an important source of income and livelihood for breeders and producers, and nutrition for consumers.

Degradation and depletion of rangeland resources threatens the growth of the livestock sector and exacerbates degradation of the natural resource base. Rangeland occupies 40 percent or 400,000 ha of the country's total area of which about 60% (or 240,000 ha) is used for pasture practicing transhumance. Rangeland resources are often characterized by poor drainage, rocky topography and low soil fertility. While transhumance of livestock (particularly cattle) is practiced in order to increase access to pasture and water, especially during the dry season, it also exposes livestock to increased incidence of disease epidemics.

2.4 Tourism development

Tourism is a key driver of the economy and the country's most significant earner of foreign currency. Tourism contributed 14.7% to GDP in 2009 and dropped to 12% in 2010. After agriculture, tourism is one of the country's main sources of employment, providing more than 16,000 formal and informal jobs.

Visitors' arrivals is a vulnerable 'industry' and vary quite substantially from year to and, hence, is a difficult sector to project the outlook for. The statistics obtained from The Gambia Tourism Board show that the arrivals by air for the past five years were –

2009: 152,416
2010: 114,103
2011: 135,888
2012: 157,323
2013: 171,200

The average number of visitors' arrivals (by air) over the past five years has been 152,500. Figure 5 depicts the monthly distribution of these arrivals, and the seasonality of the arrivals is clearly detected.

[21] *Gambia National Agricultural Investment Plan (2011- 2015), The Republic of The Gambia (Sept. 2010)*

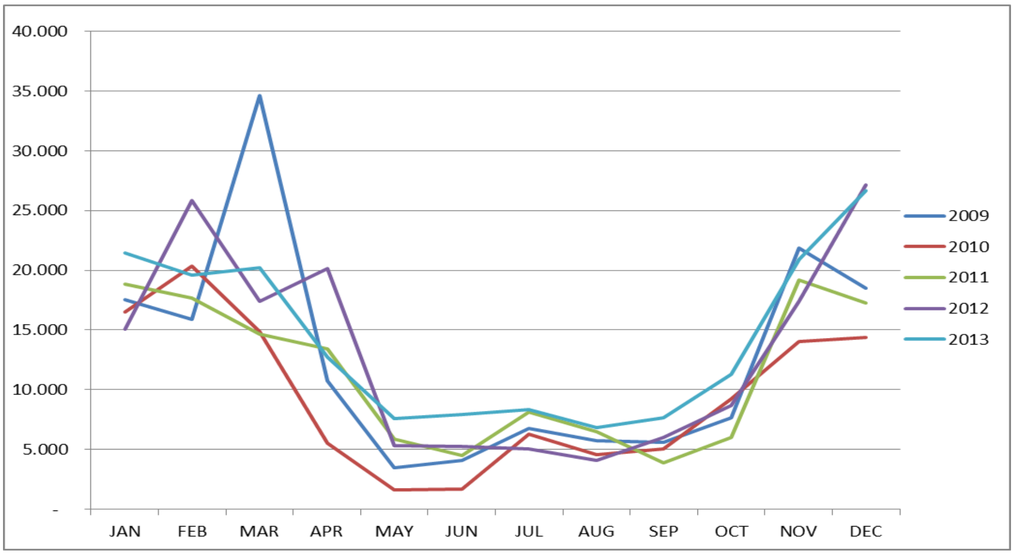


Figure 5: Monthly distribution of visitors' arrivals (by air), 2009-2013[22]

In addition to the arrivals by air, there is also a smaller segment of the 'traditional market' visitor arrivals 'by land' and 'by sea' amounting to around 7,000 visitors in 2013 according the Gambia Tourist Board.

In its drive to increase employment, the country plans to exploit the potential inherent in linking tourism to the agriculture and natural resources sector, to industry, and to the arts. Exploiting the potentials of eco and rural tourism, is hoped, will contribute to the creation of employment and improved livelihoods. According to projections in the PAGE, the sector's contribution to GDP will increase from 12% in 2010 to 18% by 2015.

2.5 Industrial and commercial activities

Demand for water in the industrial/commercial sector is driven by requirements for food processing, product packaging, cleaning, and as raw material in some industrial processes, e.g. Banjul Brewery.

Growth in the construction industry has often come at high environmental costs. Mining of beach sand and its subsequent use as construction aggregate in public projects and real estate development has caused severe coastline degradation.

The manufacturing sector in The Gambia is small and limited to small and medium-sized enterprises producing mainly for the domestic market. The sector on average contributes 5% to GDP, though with a lot of untapped potential. The informal sector and petty trading are widely practiced and provide a means of livelihood to many, especially women.

While the electricity sub-sector is fundamental to the socio-economic development of the country, the current electrification rate is still low taken as an average for the whole country. However, with the construction of the Sambangalou Hydroelectric Power Project in Senegal now started, the prospects look good for The Gambia to progress

[22] *Source: The Gambia Tourism Board*

vividly in its electrification programme in a few years' time (Sambangalou Dam and associated power transmission grid are scheduled to be commissioned by 2017/18).

2.6 Fisheries and aquaculture

The fisheries sector is characterized by marine waters, brackish waters and fresh water regimes. The Gambia has a territorial sea extending to 12 nautical miles with an Exclusive Economic Zone (EEZ) of 200 nautical miles from the geographical baseline. The continental shelf area of The Gambia is approximately 4,000 square kilo meters and an EEZ of nearly 10,500 km^2. The fishing grounds of Gambia River have a potential to produce about 70,000 metric tonnes of pelagic and demersal fish annually. At present it is estimated that fishermen operating within the continental shelf are landing between 7,000 and 10,000 tonnes annually from trawling, and between 15,000 and 20,000 tonnes through artisanal fishery.

The fisheries sector is divided into two categories: artisanal and industrial fisheries, the former producing the bulk of resources. Industrial production remains largely underdeveloped. Fish provides the cheapest form of protein and supplies about 40% of the total animal protein consumed in the country. Its current per capita consumption is estimated at 28 kg (compared to 20 kg in 1995).

The country is endowed with considerable marine and riverine fish resources located within the Eastern Central Atlantic Ocean – an area classified as one of the richest fishing zones of the world. The marine fish resources are enhanced by the freshwater flows of the River Gambia with substantial nutrients that attract marine fish species for feeding and spawning purposes.

There are over 500 marine fish species[23] which are usually classed as demersals and pelagics. The demersals include groupers, sea breams, grunts, croakers and snappers etc. The small pelagics group consists of the two sardinellas (*Saridnella aurita* and *Sardinella maderensis),* horse mackerels (*Trachurus trecae, Trachurus trachurus* and *Caranx rhoncus*) and mackerel (*Scomber japonicues*). Biomass estimates of the demersal fish resources in 1986 conducted by the Spanish Institute of Oceangraphy, was 43,645 tonnes.

The fisheries sector plans to reconsider its approach and strategy[24] in order to increase its contribution to national wealth and reduce the poverty of its beneficiaries, strengthen and support information services to facilitate distribution and movement of fish products to and from the community. The sub-sector's contribution to the ANR sector growth rate is planned to increase from 1.5% to 8% through efficient and effective management of the sector.

Industrial fisheries

There are about 20 locally registered companies in the industrial fisheries sub-sector and only 9 companies have made investments in on-shore processing factories. 8 factories have so far been certified to export their products to European market.

About 2,000 people are presently employed in the industrial sub-sector, the majority of whom are factory workers (mainly women). The total catch by industrial fishing vessels in 2005 was 4,600 metric tonnes[25]. About 35 trawlers were licensed to operate in

[23] *National Fisheries Policy (draft), The Gambia, (undated).*

[24] *According to Programme for accelerated Growth and Employment (PAGE 2012 -2015, P59, Para 156)*

[25] *An Overview of The Fisheries Sector, The Gambia, Mendy, 2006*.

Gambian waters in 2005 and most of them were granted access through the Senegalo-Gambian Agreement on Maritime Fisheries.

Artisanal Fisheries

The artisanal fishery sub-sector is primarily engaged in relatively low-input fishing practices using both motorized and un-motorized fishing canoes. It is estimated that about 40% of these canoes are motorized. The artisanal fishermen employ diverse fishing gears, such as entangling/ surround gill nets, and bottom gill nets, hand and long lines, cast nets and traps – and stow nets are used for shrimping operations in the tributaries. The results of the 2006 Frame Survey indicated that there are 1,410 head fishermen operating in all fish landing sites in The Gambia. Of these, 805 are Gambian nationals and 605 foreigners.

Inland Fisheries

The Gambia River has a surface area of approximately 2,000 km^2, which represents close to 20% of the total area of The Gambia, and constitutes an important resource, which carries a large fish stock.

There are about 500 fishermen[26] operating inland mostly fishing on part-time basis after the farming season. Some of the marine fish species caught in the river include Shad *(Ethmalosa fimbriata)*, Threadfins *(Polynemidae spp.)*, marine Catfish *(Arius spp.)* and Solefish *(Cynoglossidae spp.) etc*. These fish normally migrate up the river during the dry season. The area is also notable for shrimping, an activity that has now become increasingly important because of higher economic returns. The shrimps are caught by artisanal fishermen and sold to industrial companies for processing and export.

2.7 Land cover and use

Land in The Gambia is currently managed under three land tenure systems (customary, freehold, and leasehold), and difficult to secure for investment. 43% of the country's total land area is under forest, which can be classified into open and closed woodlands[27], and the remainder consisting of Savannah woodland.

Table 1: Land use change in The Gambia 1980 to 1993

Land use category	1980		1993		Change	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Woodland	14,400	1.3	12,000	1.1	-2,400	-1.1
Savannah woodland	121,600	10.7	88,800	7.8	-32,800	-2.9
Tree & shrub savannah	280,400	24.8	360,800	31.9	80,400	7.1
Agriculture with trees	84,000	7.4	85,200	7.5	1,200	0.1
Agriculture no trees	226,400	20.0	241,200	21.3	14,800	1.3
Fallow area	138,800	12.3	89,200	7.9	-49,600	-4.4
Mangroves	68,000	6.0	59,600	5.3	-8,400	-0.7
Others	198,800	17.6	195,600	17.3	-3,200	-0.3
Total	1,132,400	100	1,132,400	100	0	0.0

Source: FAO, 1999

[26] *Frame survey results, 2006*

[27] *FAO/ Sillah, The Gambia, 1999*

The patterns of land use as depicted in Table 1 to a large extent correspond to the vegetation zones across the country. The vegetation zones in turn are largely determined by the rainfall patterns of the different parts of the country. In general, the wetter western half of the country covering all of the Greater Banjul Area (GBA), the entire Western Region and the western parts of the Lower River Region, have thicker land forest covers of bigger tree species. These areas attract greater human settlements with the residents mainly engaged in both crop farming and logging. On the other hand, the drier hinterlands, especially the North Bank, are covered mainly with shrubs and savannah grasses. These lands are used for crop production and extensive livestock rearing in the grass-covered areas.

Recent studies clearly indicate trends of deforestation. In one such study, it was established that the annual rate of deforestation currently stands at 7%[28]. This constitutes a significant deterioration compared to the figure of about 5.3% deforestation rate as reported in the State of the Environment Report[29]. Areas with dense tree cover tend to get less dense, and the cultivated area is expanding at the expense of forests and savannah. These trends are attributable to population growth, causing a higher demand for firewood, extensive agricultural production and overgrazing. In addition, bushfires, change rainfall pattern and high demand for settlement areas are also contributing to this situation.

Land is fast becoming a highly sensitive or ‘critical’ issue in The Gambia in recent years. Not only is large scale degradation decreasing the availability of economically useful land, the value of land is ever-increasing, particularly in the rapidly expanding populations of the growth centres and in the GBA.

By far the most significant pressure on Gambian lands is the rapid growth rate of human and livestock population. The country is one of the most densely populated countries in Africa. For this reason, the requirements of land for agricultural production, animal grazing, the production of fuel wood and building materials and human settlements take their toll on the finite natural resource. The enormous pressures exerted on the natural resources such as land cover have significant impacts. These include deforestation, overgrazing by the increased livestock population, destruction of biodiversity through burnings and energy and water scarcities due to their depletions.

2.8 Forestry and forest resources

Forest resources including mangroves cover some 423,000 ha of the country[30]. State forest is the largest proportion (78%) of this coverage, with community and private forests covering about 17,487 ha only, though increasing. Forest products include timber, palm oil, wild fruits, honey, woodcarvings and fuel wood, the latter providing nearly 90% of all household energy needs. Forests also provide important potential revenue sources through eco-tourism, forest-based enterprise development, including wood and non-wood products, and habitats for wildlife and fish.

The increasing demand for forest products, particularly fuel wood for household energy, stands at about 650,000 m^3 annually. It is estimated that 97% of all household energy in the country depends on wood energy for boiling, heating or fish smoking. Furthermore,

[28] *Forest Resources and Plantations of The Gambia, Sillah, Jato, S, EC-FAO, Banjul, The Gambia, 2007*

[29] *State of the Environment Report, National Environment Agency, The Gambia, 2010, p.40*

[30] *Source: National Forest Assessment Report 2008-2010, Department of Forestry*

73% of the fuel wood consumers use the traditional 'three-stone' cooking stove which loses over 50% of the wood energy and is regarded as highly inefficient.

Forestry is an integrated live-support system to many Gambians and the resources contribute significantly to their living standards. Trees and shrubs are commonly used in traditional medical treatments and for other uses. Many women, especially in the Western Region, rely on the natural forests for their subsistence.

2.9 Key environmental stresses

Climate and non-climate stressors have a significant influence on the status and evolution of The Gambia's natural endowments. Climate change and variability in particular has placed tremendous pressure on natural resources and ecosystems.

Partly as a result of population pressure, the natural environment in The Gambia has taken the full brunt of unsustainable use of natural resources, as seen in the negative effects on the forest cover, rangelands, aquatic and marine organisms. Rapid urbanization from 25% to nearly 50% in the last three decades is paralleled by clearing of forests and woodlands, expansion of cultivated area, over-fishing of particular species and severe coastal erosion. For instances, fish landings increased from 15,000 to 40,000 tonnes between 1980 and 2000, and closed woodland forest area decreased by 86% between 1968 and 1993 in response to agricultural expansion and commercial logging for timber and fuel wood[31]. Disappearance of species from affected areas is further exacerbated by human wildlife conflicts and/or hunting pressure.

The major cause of forest degradation in The Gambia is human-induced bushfires. Some estimates suggest that on average up to 70% of forests are burnt annually, killing the regenerations, retarding the growth of most tree species and transforming the tree composition from mixed species to fire tolerant species. These factors have contributed collectively to poor soil fertility and declining crop yields over the years.

Sand extraction for construction is also another key environmental stress especially in the coastal areas of the country. The estimated volume of sand extracted annually for construction and other purposes is 100,000 to 160,000 m^3. Coastal erosion in The Gambia has been estimated at a rate of 2 meters annually[32].

Apart from bushfires, by far the greatest pressure on the vegetation cover is human population engaged in activities such as agriculture (which covers about one-third of all Gambian lands), illegal logging, charcoal burning, or hunting. These activities have intensified in recent years, particularly in major urban centers in the Greater Banjul Area where the populations have witnessed very rapid growth rates. The need for fuel wood and building materials has sharply increased forest harvests, often employing destructive technologies such as the chainsaw.

Depletion of natural resources has reached serious proportions resulting in adverse effects to the ANR sector. The upland watershed ecosystem has been disturbed and degraded largely due to deforestation and extended periods of shifting cultivation. Reduced water infiltration, high water runoff rates, drying of inland valleys and river tributaries and less water availability for crops and livestock have been observed. The destruction of riverine wetlands has resulted in erosion and siltation of the Gambia River, reducing water flow and causing increased saltwater intrusion from the Atlantic

[31] *Bojang et al, The Gambia, 2005*

[32] *According to the State of the Environment Report, The Gambia, February 2010*

Ocean. The lowlands - where most of the investments in agricultural production take place - have undergone pronounced siltation and sedimentation which threatens their sustainability. These effects combined with increasing periods of drought, increasing desertification largely caused by climate change, periodic floods and epidemics place the country at risk to disasters.

PART II

WATER RESOURCES ASSESSMENT AND REQUIREMENTS
(Chapters 3, 4 and 5)

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3. HYDRO-PHYSICAL SETTING AND FEATURES

3.1 Gambia River Basin

The Gambia River Basin lies between 11° and 15° North latitude, and 11° and 17° West longitude in the semi-arid Sudano-Sahelian zone of West Africa. The Gambia River and its tributaries drain approximately 77,850 km^2 of territory in four countries: 10,356 km^2 in Gambia, 54,665 km^2 in Senegal, 12,815 km^2 in Guinea and a mere 14 km^2 in Guinea-Bissau. The Gambia River has a total length of 1,150 km. It has its head in the Fouta Djallon plateau in north Guinea at a level of 1,125 m above sea level, from where it flows in a north-westerly direction through the southern part of Senegal after which the flow turns towards west and continuous through the entire Gambia for about 480 km to end up in the Atlantic Ocean. The Gambia River Basin is shown in Figure 6.

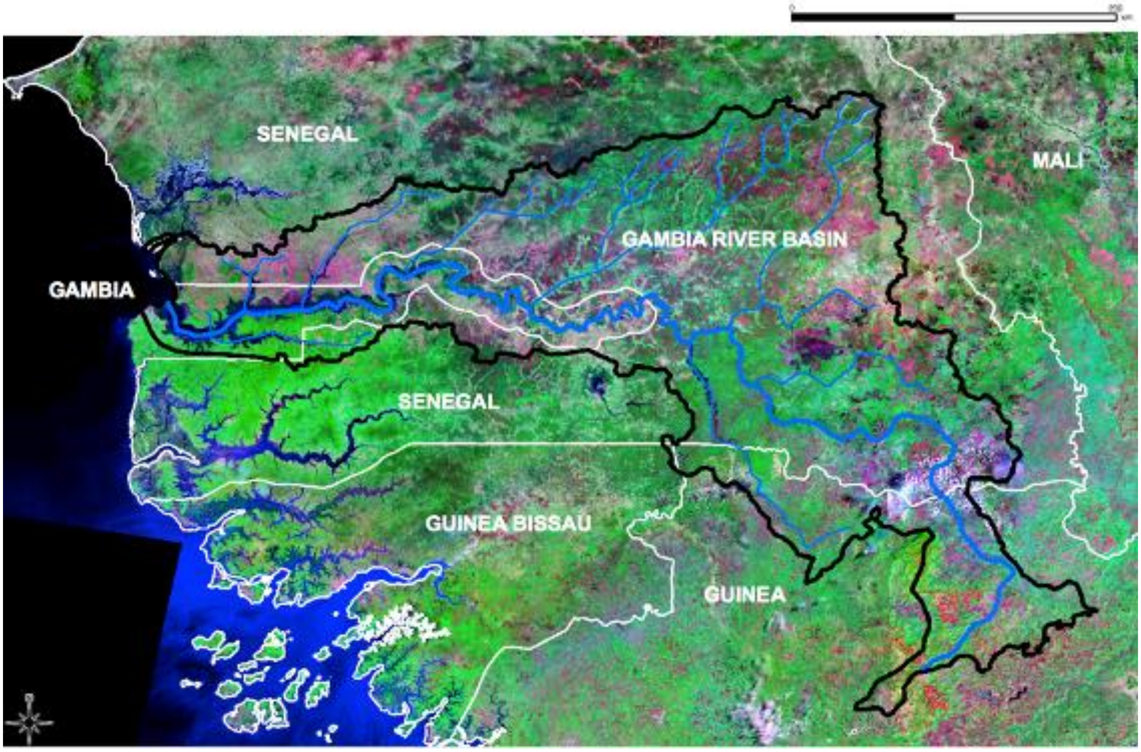

Figure 6: Gambia River Basin

Like the other rivers in the region, the flows in the upper reaches of the Gambia River are highly seasonal, while in the lower courses the appearances are greatly influenced by tidal movement. The Gambia River can be divided into two quite distinct parts of about the same length, namely a continental and a maritime section, the latter being influenced by tidal movements throughout the year. In the dry season, the 1.0 g/l salt front in average intrudes beyond 250 km upstream of Banjul.

The Guinea portion of the basin provides a large proportion of the waters in the Gambia River system as the rainfall is relatively plentiful, 1,300 - 1,750 mm/year. Furthermore, the mountainous terrain with steep slopes and relatively impermeable soils results in comparatively high surface runoff.

Except for a small portion along the Atlantic coast line, The Gambia is situated within the Gambia River Basin. The Gambia, which the river traverses entirely from east to west, is directly situated within the flood plains of the river. The Gambia has pronounced flat topographical features with the highest plateau surfaces in the east of the country reaching 40 to 50 m above seas level. Nearly 50% of the total land area is below 20 m above sea level, 30% is below 10 m above sea level, and 10-20% is seasonally or diurnally flooded.

Most of the land surface in The Gambia is formed from sandstone and highly-weathered and eroded sediment that has been subjected to countless phases of transport and deposition by fluvial forces, giving rise to a rather complex pattern of alluvial deposits and fluvial marine deposits in the floodplains of the lower Gambia River system.

3.2 Climate regime and climate change indications

The Gambia has a subtropical climate with two distinct seasons, a long dry season (November to May) and a shorter wet season (June to October). In the dry period dusty winds from the Sahara are often experienced (Harmattan). This section provides an overview of the hydro-meteorological parameters as they prevail in The Gambia, including the latest statistics (through 2013), and on that basis attempt to detect trends in the meteorological conditions, which in turn can be interpreted as observed climate change indications.

Data for these parameters are well documented with a good coverage country-wide through long-term records, which are ready available from the Meteorology Division of the Department of Water Resources.

3.2.1 Monthly climate statistics

Temperature

The temperature regime is steady year-round and with the same feature across the country as depicted in Figure 7 and Figure 8, which presents the monthly max/min temperatures at Yundum Met. Station and Basse Met. Station, respectively, calculated over a 40-year period (1973-2013). It can be noted that the mean monthly minimum temperatures show a bigger variation within the year in comparison with the mean maximum temperatures.

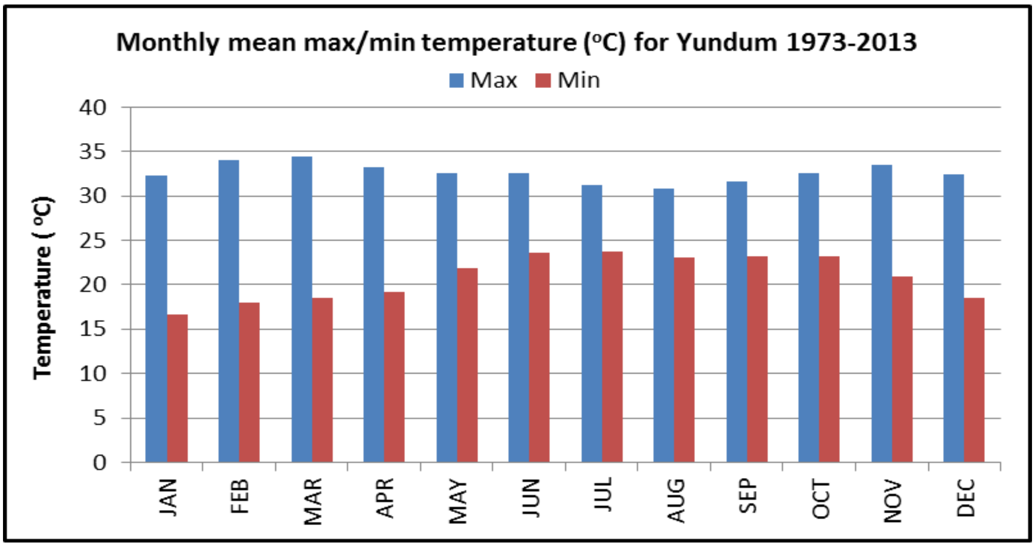

Figure 7: Monthly mean max/min temperature, Yundum (1973-2013)

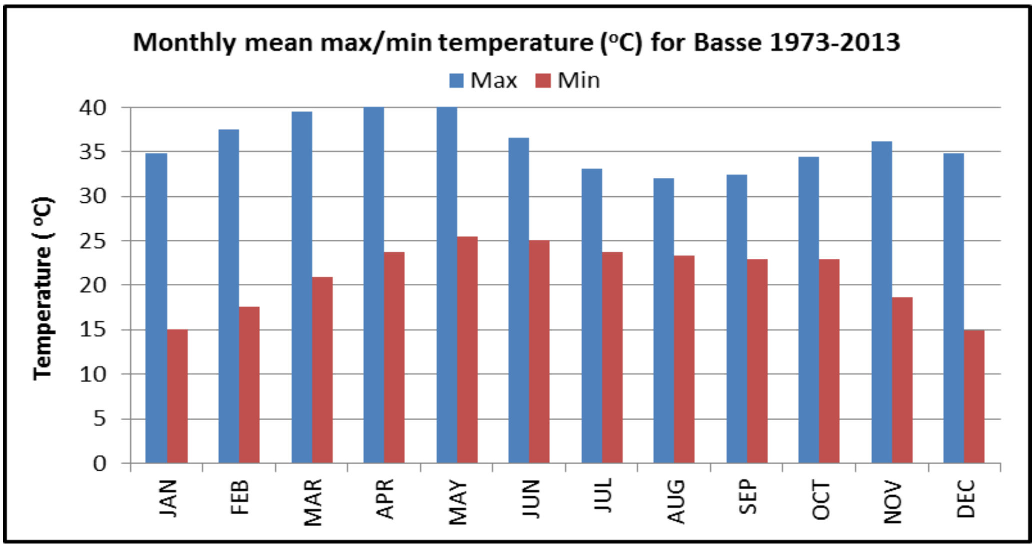

Figure 8: Monthly mean max/min temperature, Basse (1973-2013)

Rainfall

The major climatological feature of the region is the marked seasonality and undependability of rainfall, which poses an important challenge in water resources management, specifically concerning the rainfall's role in replenishing the groundwater reserves. Close to 90% of the annual precipitation falls in the five-month period from June to October. This feature is clearly visible in Figure 9, which presents the monthly mean rainfall at Yundum, Jenoi and Basse, covering the 40-year (1973-2013) period.

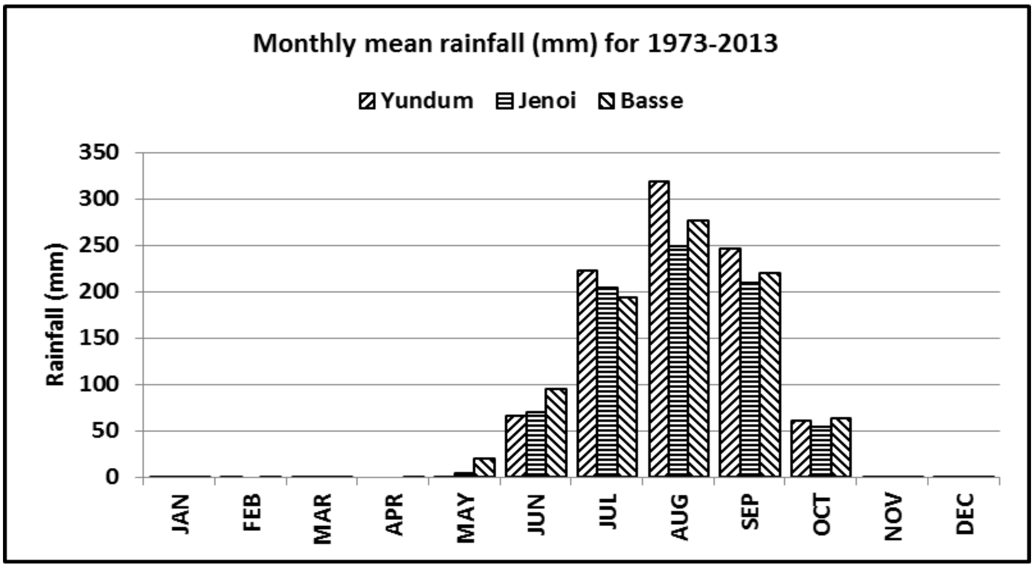

Figure 9: Monthly mean rainfall, Yundum, Jenoi and Basse (1973-2013)

In Figure 9 it is also noted that the rainfall variation is rather limited across the country from east to west and follow the same pattern. In other words the rainfall distribution when looking at a scale of a month (not daily variations) is rather steady.

Evaporation

The (open pan) evaporation has its peak in the months (March-April-May) preceding the rainy season. Figure 10 presents the monthly mean evaporation at Yundum, Jenoi and Basse covering a 29-year period (1984-2013). It can also be deduced that the evaporation across the country possesses the same pattern in as much as the three stations show similar distribution over the year.

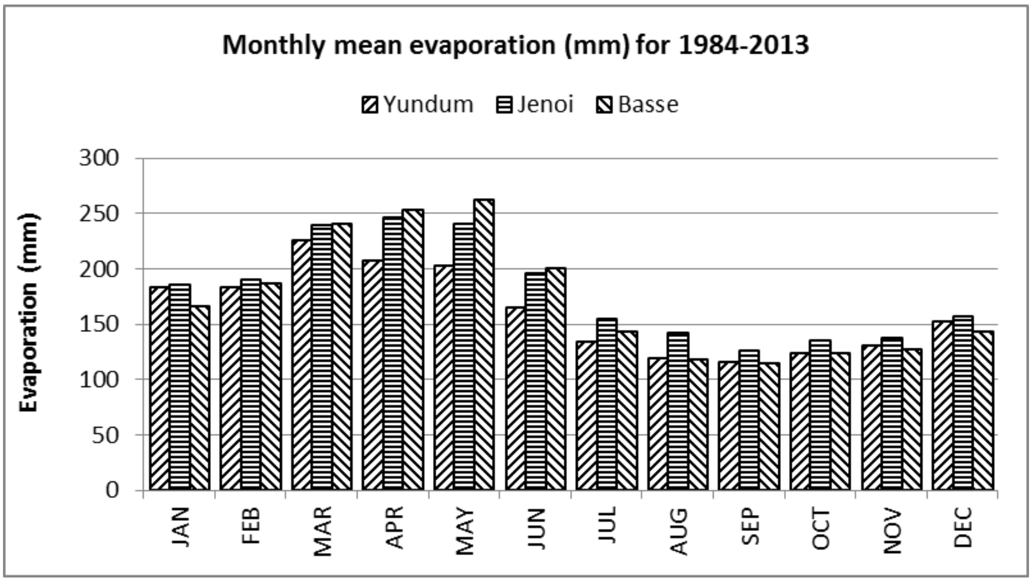

Figure 10: Monthly mean evaporation, Yundum, Jenoi and Basse (1984-2013)

3.2.2 Climate change indications

In relation to water resources assessment and water balance calculations, the most important climatic parameters to study are –

- trends in temperature increase, which would have a bearing on crop water requirements in irrigated agriculture, and
- change in annual rainfall amounts and distribution pattern, which obviously have an impact on water availability, that be surface water flow and – crucial for The Gambia – aquifer recharge and groundwater occurrences.

Mean annual temperature

Climate warming observed over the past several decades, as depicted in Figure 11 on a global scale, is associated with changes in a number of components of the hydrological cycle and hydrological system such as: changing precipitation patterns, intensity and extremes, increasing evaporation and changes in soil moisture and run-off. There is significant natural variability, on inter-annual to decade time scales, in all components of the hydrological cycle, often masking long-term trends, and there is still substantial uncertainty in trends of hydrological variables because of large regional differences and limitations in the coverage of monitoring networks.

From the mean annual temperature records represented by data for Yundum Met. Station, the latest 40-year trend is depicted in Figure 12. Table 2 provides a numerical account of the same annual figures broken into 4 'decade' periods. Similar data for the Basse Met. Station is also included in Table 2. On this basis, the table presents results from an analysis of the anomaly in the long-term temperature pattern (data source: Meteorology Division/Climate Unit of the Department of Water Resources).

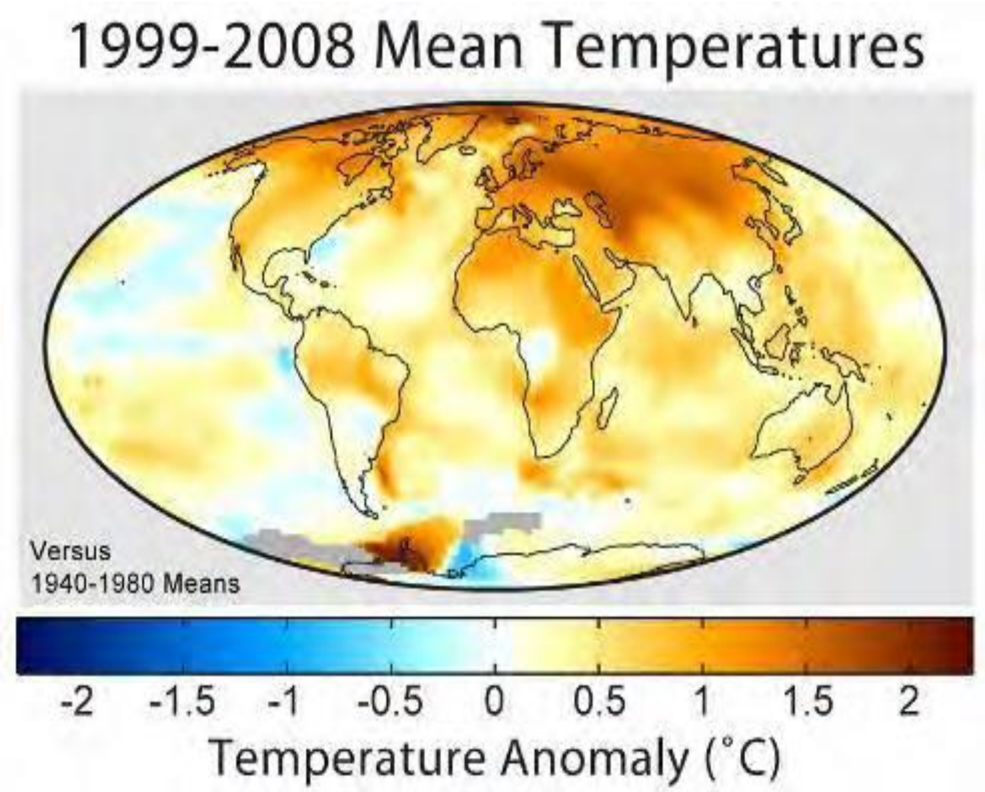

Figure 11 Global warming[33]

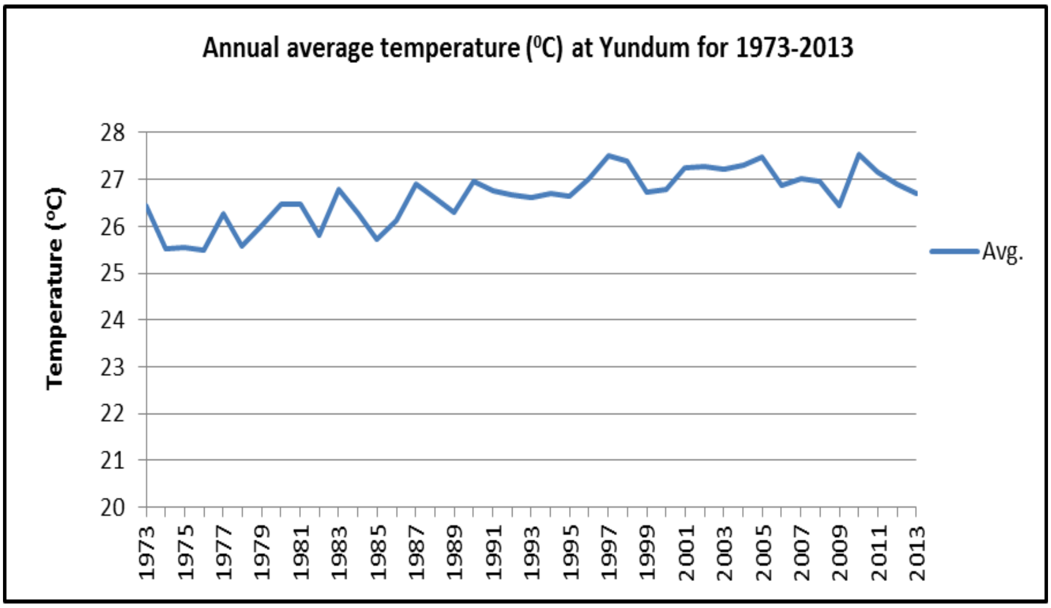

Figure 12: Annual average temperature (° C), Yundum (1973-2013)

[33] *NASA, Goddard Institute for Space Studies*

From Figure 12 and Table 2 it is observed that the annual mean temperature in The Gambia has increased by about 1^0C over the past 40 years in harmony with what can be detected from the global observation depicted in the map in Figure 11.

Table 2: Anomaly in annual mean temperature, Yundum and Basse (1974-2013)

YUNDUM			BASSE		
10-year period	**Mean (^{o} C)**	**Variance from long-term mean**	**10-year period**	**Mean (^{o} C)**	**Variance from long-term mean**
1974-1983	26.0	- 2.6%	1974-1983	28.1	- 1.7%
1984-1993	26.5	- 0.7%	1984-1993	28.5	- 0.3%
1994- 2003	27.0	+1.1%	1994- 2003	29.0	+1.4%
2004-2013	27.1	+1.5%	2004-2013	28.9	+1.0%
Long-term mean	26.7		Long-term mean	28.6	

Annual rainfall

From the annual total rainfall records represented by data for Yundum and Basse stations, the long-term trend is depicted in Figure 13 and Figure 14, respectively. The variation in annual rainfall over the years differs markedly, e.g. at Yundum with a 70-year average (1943-2013) of 1,050 mm, the rainfall amounts have varied from 1,850 mm in 1958 to 420 mm in 1983.

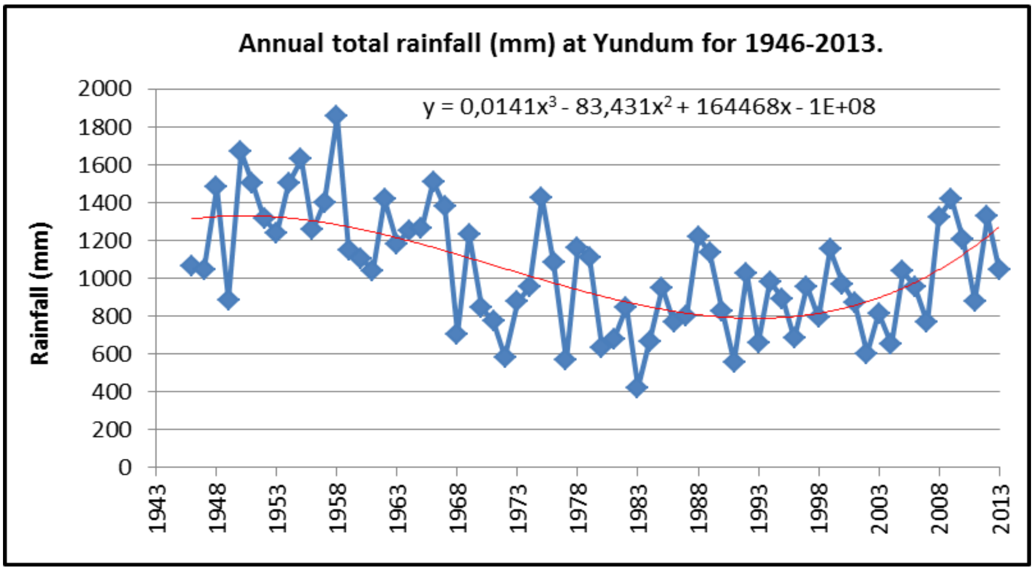

Figure 13: Annual total rainfall (mm), Yundum (1946-2013)

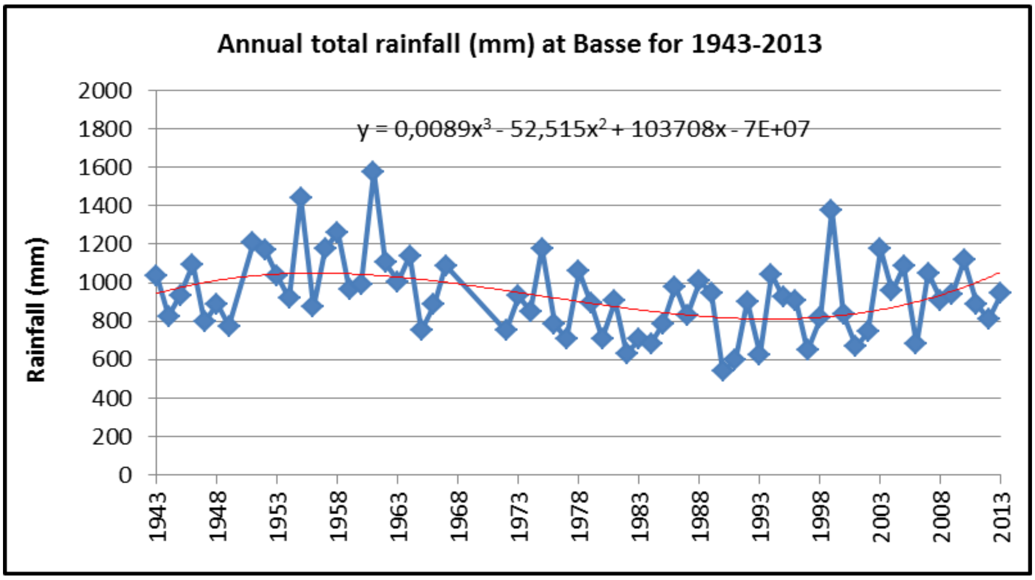

Figure 14: Annual total rainfall (mm), Basse (1943-2013)

Table 3 provides a numerical account of the same annual figures broken into 7 'decade' periods for both stations.

Table 3: Anomaly in annual total rainfall, Yundum and Basse (1944-2013)

YUNDUM			BASSE		
10-year period	**Mean (mm)**	**Variance from long-term mean**	**10-year period**	**Mean (mm)**	**Variance from long-term mean**
1944-1953	1,275	+21.4%	1944-1953	969	+4.0%
1954-1963	1,353	+28.9%	1954-1963	1,137	+22.0%
1964- 1973	1,042	- 0.8%	1964- 1973	936	+0.4%
1974-1983	889	- 15.3%	1974-1983	842	-9.7%
1984-1993	860	- 18.1%	1984-1993	790	-15.2%
1994-2003	872	-17.0%	1994-2003	913	-2.0%
2004-2013	1,061	+1.0%	2004-2013	938	+0.6%
Long-term mean	1,050		Long-term mean	932	

It is clear from the graphs and the variance values presented above that a rather marked decrease in the annual rainfall amounts has occurred during the past 70-year period. At the same time it is also detected that the last 10-15 years have realized an increase in the annual rainfall to a level which now balances the long-term (70 years) mean value. This trend is the same when scrutinizing the rainfall data from Yundum and Basse, though the feature is mostly prominent in the Greater Banjul Area (Yundum Met. Station).

It can be concluded from the above analysis that over a span of 70 years, a decrease in the annual rainfall amounting to 20-25% has been experienced in The Gambia, but also worth noting, with a tendency for the annual rainfall totals to show a 'cyclic' pattern with two 'highs' and one 'low' detected during this period. In other words, although a decreasing trend in annual rainfall amounts is a fact, it is also seen that this general feature is not constant and indeed has been reversed to some extent over the past decade.

Projected change in climate parameters

A rise in global temperature will change the climate in several ways. Firstly, it will lead to a rise in the mean sea level. This results from expansion of ocean water, and from the melting of ice around the poles. Secondly, it will change the hydrological process of evapo-transpiration and precipitation.

The Gambian Focal Point, established under the direction of the UNFCCC[34], is in charge of the studies and ensuing communications as per requirement of the UNFCCC, and in other ways is active in researching and publishing results as part of the international collaboration under the Inter-governmental Panel on Climate Change (IPCC). From the latest publication[35] of the Gambian UNFCCC Focal Point, the following projections have been made based on the application of a selected number of General Circulation Models[36] (the ranges given below reflect the results obtained from selected model applications, and the value in [..] is the mean value as deduced from the three GCMs):

- an increase in mean temperature in the range of 1.7 to 2.1°C [1.9°C] by 2050 (this change should be added to the current long-term mean temperatures indicated in Table 1 above);
- a decreasing trend in annual rainfall in the range of 1% to 23% [9.6%] by 2050. This wide range in the projection results underscores the fact that rainfall is the most difficult climate parameter to predict as also pointed out above based on the analysis of historical long-term and recent rainfall statistics; and
- an increase in the rate of evapotranspiration in the range of 9% to 29% [16.3%] by 2050 (this change in evapotranspiration rate may necessitate a reassessment concerning water use caused by an increase in crop water demand for irrigation).

Additionally, other impacts which may be related to climate change have already been observed and can be expected to intensify, such as:

- increase in heavy precipitation events (downpours) with increased risk of local flash floods; and
- a tendency towards prolonged duration of dry seasons with more severe drought occurrences as a result, and hence shorter rainy seasons.

The direct consequences of these scenarios will in general lead to a reduction in freshwater availability, including base-flow, in the surface water systems.

Considering that the aquifer system from which the bulk of The Gambia’s groundwater requirements are abstracted is replenished by local infiltration, and since significant deviations in annual rainfall totals from current levels are not predicted, the climate change trend is judged to have rather limited impact on groundwater recharge. The aquifer system is semi-confined, which also ‘shields’ the groundwater occurrences from evaporation, and hence makes it less susceptible to an increase in evaporation due to higher temperatures.

[34] *United Nations Framework Convention on Climate Change (UNFCCC)*

[35] *The Gambia’s Second National Communication under the UNFCCC (November 2012). Figures quoted are extracted from Section 5.2 of this publication.*

[36] *A total of 14 General Circulation Models (GCM) were applied and the three which recorded the highest correlation coefficients with historical climate data of The Gambia were adopted, i.e. the Canadian Climate Centre Model (CCC199), the Global Fluid Dynamic Laboratory Model (GFDL90) and the Australian GCM (BMRC98).*

It is prudent to emphasize that many uncertainties still surround the science of the future climate. Hence, climate change scenarios used do not consist of definite predictions, but rather present plausible future climates. What matters is the ability to manage the uncertainty. This includes reducing current vulnerability to climate variability and extreme events as well as keeping management options open enough to deal with the 'worst-case' scenarios and to take advantage of opportunities that may arise.

Sea level rise

The Gambia has about 80 km of open coastline bordering the Atlantic Ocean and more than 200 km of sheltered shoreline along the Gambia River. The open coast is characterized by low-gradient sandy beaches, whereas the sheltered shoreline is dominated by extensive mangrove systems and mud flats.

In the long term perspective, perhaps for The Gambia the most pronounced impact of global warming is the sea level rise, which cautiously is predicted to amount to 1.0 meter by the end of this century. Besides having the potential to inundate considerable land areas, which particularly will affect the heavy populated zones along the Atlantic Coast and the Gambia River shoreline, it will also have consequences on the saltwater intrusion and the boundary between freshwater and sea water in the Gambia River system.

However, under the projected sea level rise (1.0 meter), the saline front (defined as where salt concentrations equal 1 g/l) is expected to migrate less than 10 km further landward of its present upper limit at about 250 km upstream of the Gambia River outlet[37].

Where hydraulic connectivity exists between the aquifers near the coast and saline surface water bodies, the likelihood saline intrusion into the aquifers depends on the location of well fields, abstraction rates and sea level rise. Analysing data from previous studies[38] it has been possible to delineate areas where groundwater is at risk of saline intrusion. These areas are represented by a 3-km strip of land adjacent to the Atlantic Ocean and 1-km wide track of land along tidal streams and Gambia River estuary.

3.3 Groundwater characteristics

Comprehensive studies and detailed description of the country's groundwater systems can be found in a number of older reports[39]. Furthermore, as part of the groundwater assessment component under the NWSRP activities (2013-14) additional detailed information has been obtained about the aquifer/groundwater situation, including data from 20 new observation boreholes and rehabilitation of existing observation boreholes in the Greater Banjul Area. These reports and studies are referred to for further details and in-depth description of the aquifer/groundwater occurrences not provided in this strategy document.

[37] *Saline intrusion in the Gambia River after dam construction – Solutions to control saline intrusion while accounting for irrigation development and climate change. M.P. Verkerk and C.P.M. van Rens. University of Twente – The Netherlands, 2005.*

[38] *Groundwater Survey of The Gambia – Phase 2. Scott W. Kirkpatrick (1993).*

[39] *GITEC Consult: Feasibility Study for a Rural Water Supply Programme (1981). S. Ceesay & Sons and Howard Humphreys Ltd: Groundwater Survey Studies, Phase I. Emergency Aid Programmes to Sahelian Member Countries (1987). SNC Lavalin: Water Supply and Sanitation Study, The Gambia – Master Plan, Volume 1 and 2 (2005).*

The overall characteristics of the groundwater occurrences throughout The Gambia feature two main aquifer systems, i.e. the Shallow Sand Aquifer and the Deep Sandstone Aquifer.

3.3.1 Shallow Sand Aquifer (SSA)

The SSA is found and tapped throughout the Gambia. The SSA is subdivided into two distinct units, the phreatic aquifer and the semi-confined aquifer. The two are separated by a clay-silt layer – at places nearly impermeable (aquitard) – typically 15 m to 30 m thick that allows limited hydraulic connection between the two.

All groundwater utilized in The Gambia is abstracted from the shallow sand aquifer partly through numerous dug wells tapping water from the upper phreatic part of the SSA and from boreholes sunk in the lower semi-confined part of the SSA, which constitute the backbone of the water resources exploited for potable use in The Gambia.

Phreatic aquifer

This upper aquifer system is found on both banks of the Gambia River and comprises mainly fine to medium grained quartz sands with occurrences of silt and clay. The aquifer occurs at depths between 10 m and 30 m, and in most places has an overlying lateritic layer.

All the hand-dug wells in the Gambia exploit this aquifer. Some shallow boreholes also tap water from the phreatic aquifer. Generally, the aquifer thickness increases towards the east of the country, and similarly there is also an increase in a north-south direction.

Over the past few years, however, the reliability of this upper aquifer as a water source has to some extent diminished with an increasing number of the shallow wells seasonally running dry and also in some cases with an increase in salinity of the well water (particularly the wells located in the vicinity of the coastal zone in the Greater Banjul Area). This phenomenon is attributed to the increasing abstractions with sinking of new boreholes into the semi-confined aquifer due to the rapid population growth experienced in this part of the country.

Semi-confined aquifer

This aquifer is mainly composed of fine to medium-grained sands and coarse sands with calcite. The depth of the aquifer varies between 30 m to 100 m below ground level, and the static water level is generally between 10 m and 20 m below ground level, but in a few cases at depths below 30 m.

Across the country, the groundwater table (piezometric surface) is characterized by ‘mounds’ and ‘sinks’. Generally, the ‘mounds’ are found in areas where – relatively speaking – higher recharge rates prevail and feature radial outward flows. The best examples are the Kombo Peninsula mound (in the GBA) and Niumi (Kerewan). ‘Sinks’ on the other hand indicates zones of groundwater flow convergence, which are found in Mansakonko, Kuntaur and the Basse-Fatoto area.

Groundwater level dynamics and fluctuations in the SSA depend to a large extent on rainfall. The phreatic aquifer is recharged by direct (instant) infiltration and therefore exhibits seasonal fluctuations of groundwater levels directly correlated to rainfall events. Recharge to the semi-confined aquifer of the SSA is also through rainfall infiltration and delayed leakage of the phreatic aquifer through the separating aquitard. A secondary source of recharge of the semi-confined aquifer in certain areas is attributed to lateral flow from neighboring areas (Senegal), although this recharge is estimated to be a small portion compared to what is contributed from infiltration.

The properties of the semi-confined aquifer is conducive to dependable groundwater abstractions generally based on high-yielding boreholes. With the current rate of abstractions realized in the Gambia, the seasonal fluctuations of the groundwater level in general does not exceed 1.5-2.0 m. Also a general (long-term) lowering trend of the semi-confined groundwater level has not yet been detected. But in goes without saying, that in the Greater Banjul Area a 'delicate' balance exists between the requirements for additional groundwater exploitation and the ability of the aquifer system to sustain further abstractions (this aspect is studied further in the subsequent Chapter 4).

3.3.2 Deep Sandstone Aquifer (DSA)

Paleocene sandstones occur at average depths of typically 250 to 400 meter below ground level. The aquifer is recharged through lateral flow over long distances from the southern part of Senegal. The general direction of the groundwater flow lines is depicted in Figure 15.

Water found in the DSA is of fossil origin, several thousands of years old, and is stored under confined (artesian) conditions of considerable volume. Three older exploratory boreholes at Banjul, Sankwia and Garowal penetrating down to the DSA have proven that there is an increasing mineralization of the deep groundwater in an east to west direction. This implies that good quality water (for potable use) in the DSA is expected only in the eastern part of the country, where the reservoir (aquifer storage volume) is estimated to hold 80,000 Mm^3 of a total of about 650,000 Mm^3. Figure 16 shows the location of the three exploratory deep boreholes and the deduced piezometric map of the DSA. Water sampling has been carried out over some 20 years, and the results suggest that the groundwater chemistry in the DSA has remained fairly constant.

Figure 15: Conceptual regional flow model of the Deep Sandstone Aquifer system[40]

[40] *COWI / Polyconsult / SGPRE, 2001. Hydrogeological characteristics in the Maastrichtian aquifer system, presented at the International Symposium on Aquifer Systems Management, May 2006, Dijon, France*.

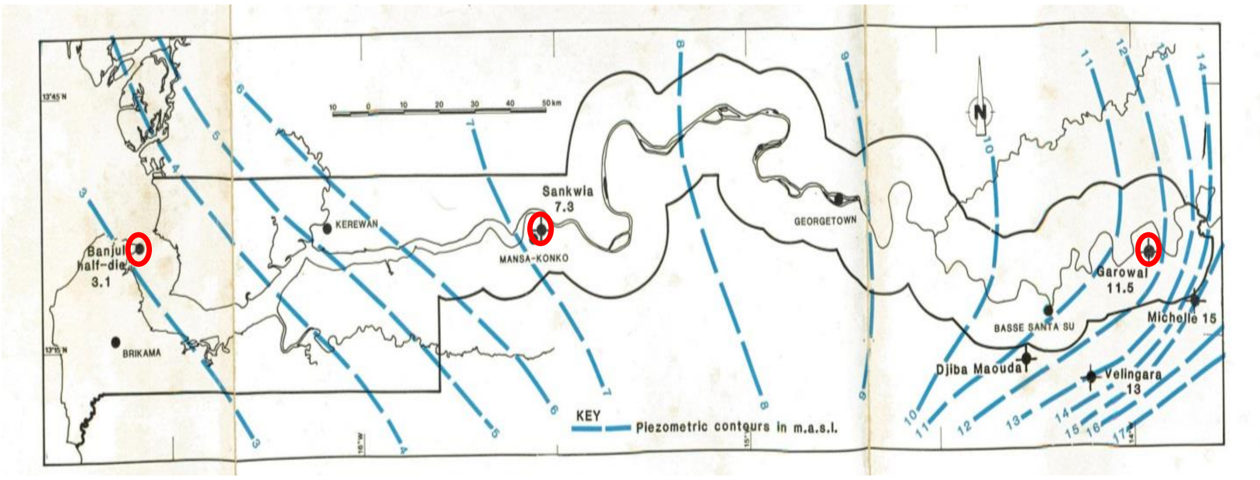

Figure 16: Piezometric map of the deep sandstone aquifer (DSA)

Notwithstanding the mineralized water found in the middle and western parts of the country, the groundwater of the DSA can be considered a huge untapped resource for The Gambia[41]. It has been argued that the deep DSA groundwater can be abstracted and 'diluted' with groundwater from the SSA to obtain a 'raw' water quality, which with conventional treatment processes can be used for potable water supply[42].

3.4 Surface water characteristics

3.4.1 River flows

Gambia River

The Gambia River bisects the country into two narrow strips of lands with varying width from about 48 km at the Atlantic Coast to in average 24 km in the eastern section of the country. The river has a surface area of approximately 2,000 km^2, which represents close to 20% of the total area of The Gambia. The total length of the river within The Gambia is about 480 km. The river course can be divided into four reaches with different morphological characteristics:

- The estuary mouth (0-20 km upstream). The river coarse narrows at the mouth defined by Banjul and Dog Island where it is approximately 5 km wide.
- Lover estuary (20-150 km upstream). This reach is 8-10 km wide. Tidal flats covered with shallow water are present at both side of the river channel which can have a depth of up to 10 m. Mangroves are found over a distance up to 10 km from the tidal flats.
- Upper estuary (150-300 km upstream). This reach is 5-6 km wide. It is characterized by many meanders and the presence of islands. Average depths are 8-16 m. Mangrove zones approximately 3 km wide are present and behind these swampy flood zones exist approximately 1 km wide.

[41] *The DSA is not exploited in The Gambia, but in neighbouring Senegal it is an important source of water at various locations.*

[42] *S. Ceesay & Sons and Howard Humphreys Ltd: Groundwater Survey Studies, Phase I. (1987)*

- Upper reach (300-480 km upstream). The reach is 200-400 m wide and the depth 3-7 m. There is little difference between the high and low flow channels. The banks are high and steep and the river flow is in general entirely within the flow channel during high flow.

The major tributaries to the Gambia River have all their origin in Senegal. To a large extent they are also typical tidal rivers, with meandering courses over swampy mangrove areas and responding to the ebb and the flood of the tide. They are highly seasonal streams, which at occasions can carry abundant flow in the rainy season, but vanish to zero flow during the dry season. The main tributaries are the Sofanyama, Bintang and Sudual on the South Bank, and the Mimiminiang and Sandugu on the North Bank. The Sandugu is the largest of the tributaries and drains a catchment area of some 12,000 km^2.

During the wet season and flood occurrences, the Gambia River can rise up into the valleys of its tributaries causing huge movements of water that stir up considerable amounts of sediment. After the end of the rains, the river system continues to receive inflows from saturated sub-surface and groundwater sources (base-flow) for another 2 to 3 months – after which the flow declines relatively fast. During the latter part of the dry season, i.e. March-April-May, the flow of the Gambia River is virtually nil and the estuary water levels depend entirely on the tide.

Except for episodic flow measurements carried out at Bansang during the late 1970’s and early 1980’s, river flow data are generally not available in the Gambian stretch of the river. However, long-term flow measurements are available from the Gouloumbou bridge river gauging site some 30 km upstream of the border between The Gambia and Senegal. It is worth noting that this discharge record indicates a reduction of about 35% in the mean annual discharge when comparing the 1953-1970 period with the 1970-2001 period.

Table 4 depicts the mean monthly flows as measured at Gouloumbou for the 1970-2001 period[43].

Table 4: Mean monthly flow (m^3/s), Gambia River at Gouloumbou (1970-2001)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean (m^3/s)
15.3	6.8	2.8	1.2	1.0	7.0	93.0	435.6	694.0	406.2	105.5	33.3	150.1

It is seen that the mean annual flow of the Gambia River at Gouloumbou over the 1970-2001 period was 150 m^3/sec with mean monthly discharges varying between a little less than 700 m^3/sec and less than 1 m^3/sec. The highest instantaneous discharge recorded at Gouloumbou was recorded in September 1961 to be 1,870 m^3/sec.

Along the Gambia River, stations equipped with mechanical ‘drum’ type water level recorders have been in operation in various periods on an intermittent basis since 1974 for the purpose of monitoring the tidal regime.

[43] *Source: Additional Economic Study of Sambangalou Hydroelectric Power Project on the Gambia River – Main Report. BRL Ingénieres & Nodalis Conseil (2012).*

A full year (1980) which combined recorded data and, in periods when data gaps occurred, estimated/simulated data for Fatoto and Balingho monitoring sites are reproduced in Figure 17 and Figure 18. The two curves in each graph represent the recorded daily high level and low level (tidal effects), respectively.

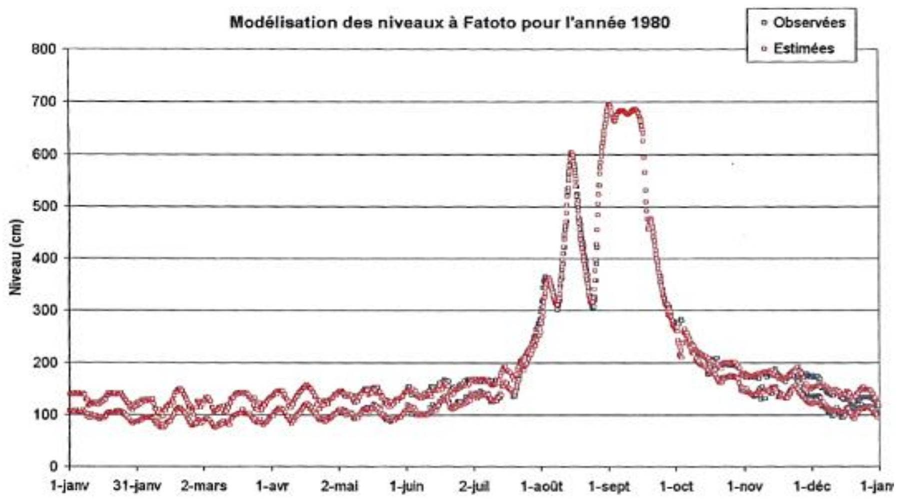

Figure 17: Yearly water level fluctuations at Fatoto station[44]

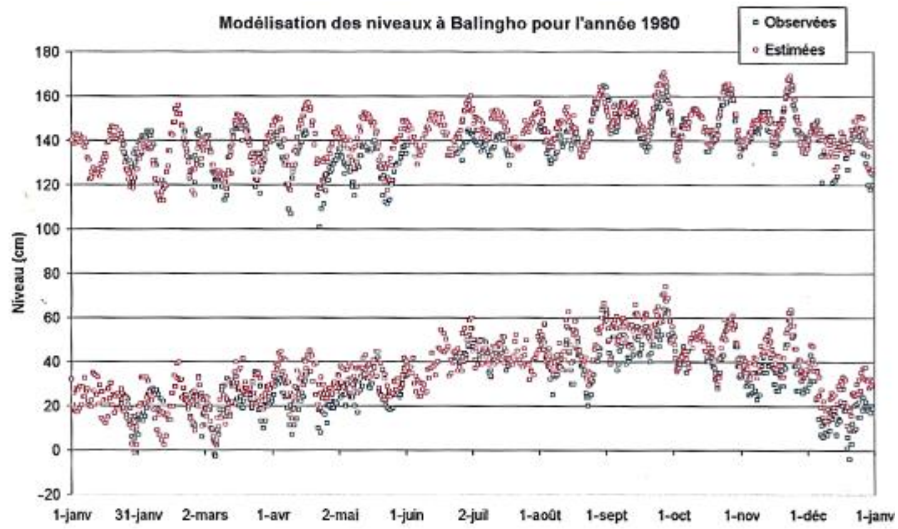

Figure 18: Yearly water level fluctuations at Balingho station[44]

Coastal streams and tributaries

The coastal streams drain relatively small catchments with no or insignificant flow in the dry season. The congestion and expansion of the urbanization of the Greater Banjul Area are gradually chocking the original flow pattern of these streams to the extent that they do not possess their 'natural' characteristics anymore. Monitoring of the flows has been carried out for some of the coastal streams draining to the Atlantic Ocean and a few tributaries to the Gambia River. The location of the flow gauging sites is shown in Figure 19.

[44] *Gambia River Basin Hydraulic Master Plan – 2nd Phase. Draft Report, Volume 2, Appendices 1 to 5. OMVG (1998).*

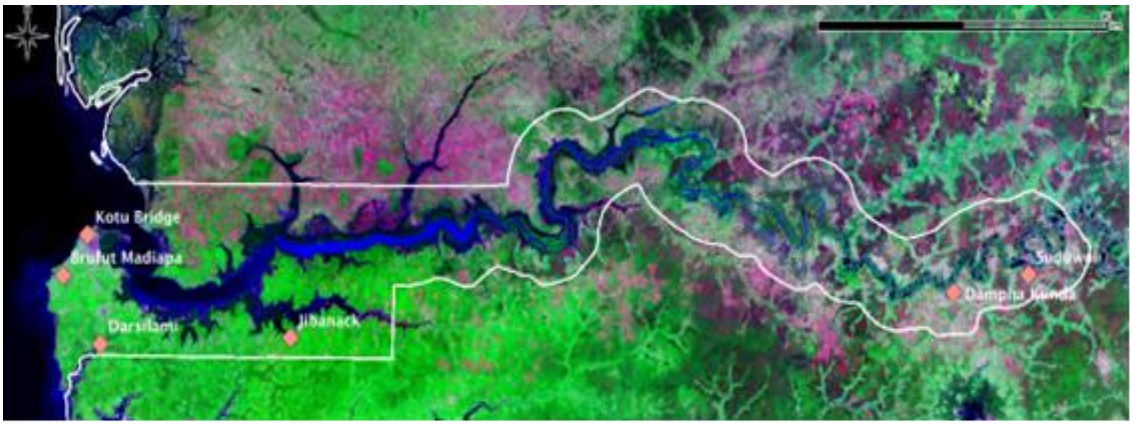

Figure 19: Previous flow monitoring stations on coastal streams and tributaries

It should be noted, though, that the flow monitoring has been carried out in a rather intermittent manner during the period 1974-1980. A single station on Prufu Bolon at Dampha Kunda was monitored from 1974 to 1995.

The gauging stations were equipped with staff gauges for manual water level readings, and the relation between water levels and flow was established by rating curves based on current meter measurements. However, due to inadequate flow control of the river sections at the gauging sites, the rating curves were only valid at the lower ranges, and hence the flow records during high water levels must be rated highly uncertain.

One of the larger of the coastal streams, the Allahein, forms the south-western border between The Gambia and Senegal. The peak flow (at the Darsilami measuring site) was estimated to be below 10 m^3/sec. Other coastal rivers are estimated to have a specific (mean) discharge in the order of 0.5 l/sec/km^2.

3.4.2 Tidal regime and saltwater intrusion

Gambia River is nearly at sea level (less than 1.0 m above sea level) throughout its course in The Gambia stretching beyond the border into Senegal to a little upstream of Gouloumbou some 500 km upstream, and hence has a very small hydraulic gradient. For this reason, the river is subject to sea water intrusion, and the effect of the tides migrate beyond the crossing point at the border to Senegal.

The highest tide, i.e. at the spring equinox, is about 2.0 m measured in the estuary at the Atlantic Ocean. In the center of the estuary zone the tidal movement is in the range of 1.0 - 1.5 m. It is in this zone that the confrontation of fresh and salt water takes place. Some 300 km upstream, near Bansang, the tidal range is about 1 m. Further upstream it gradually dwindles. Even so, during low flow periods, tidal action causes water level fluctuations of up to 0.3 m at Fatoto.

Tidal action from the sea results in backwater along the estuarine reach of The Gambia River and its tributaries. However, the saline intrusion is as much dependent on the freshwater inflow from upstream as on sea induced tidal water levels. These two ‘forces’ in combination results in an ever changing situation with regard to the location of the saline front, which basically shifts it upstream during the dry season (low freshwater inflow from Senegal) and downstream during the high flow occurrences[45].

[45] *The Gambia National Adaptation Programme of Action (NAPA) on Climate Change, Banjul (2007)*

Figure 20 illustrates the main ‘tidal’ sections, which the Gambia River conceptually can be divided into (i) a perennially fresh water section stretching some 200 km downstream from the border upstream of Fatoto to the Kuntaur area; (ii) a seasonally saline/fresh water middle section from around 100 km close to Kemoto to around 250 km (Kuntaur) from the Atlantic Ocean; and (iii) a perennially saline water section from the sea to some 100 km upstream (Kemoto). These demarcations represent an ‘average’ situation based on salinity measurements carried out over a span of many years.

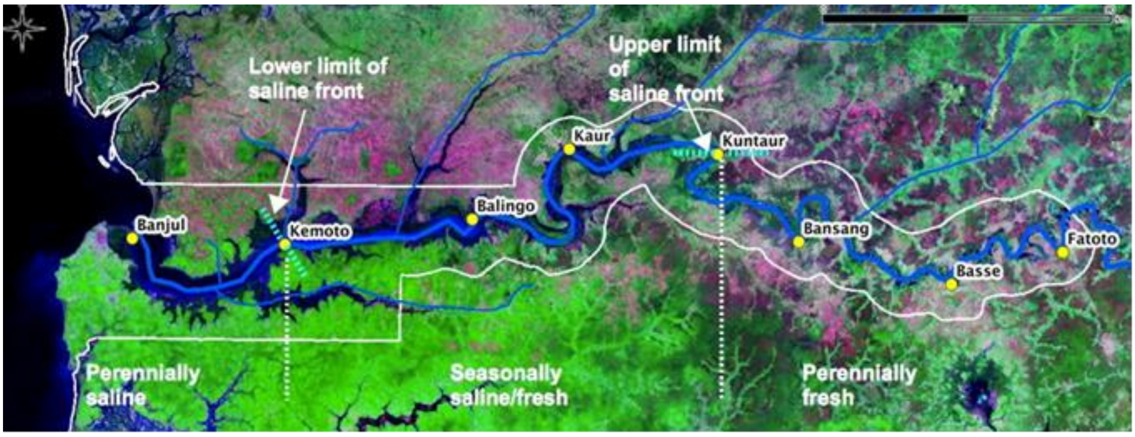

Figure 20: Variation of saline intrusion in the Gambia River

The year-to-year variation in the saline front’s movement is pronounced depending much on the individual years’ rainfall amount and pattern, and hence, the inflow of fresh water to the river system from upstream parts of the basin in Guinea and Senegal.

In a similar manner, Figure 21 depicts the average annual shift of the 1.0 g/l fresh-saltwater interface in the Gambia River coupled with an annual flow hydrograph generated from Gouloumbou discharge data. The fresh-saltwater interface curve represents measurements carried out during the period 1972 to 1997. The two curves clearly depict the relationship between the mean position of the interface and the mean river flow.

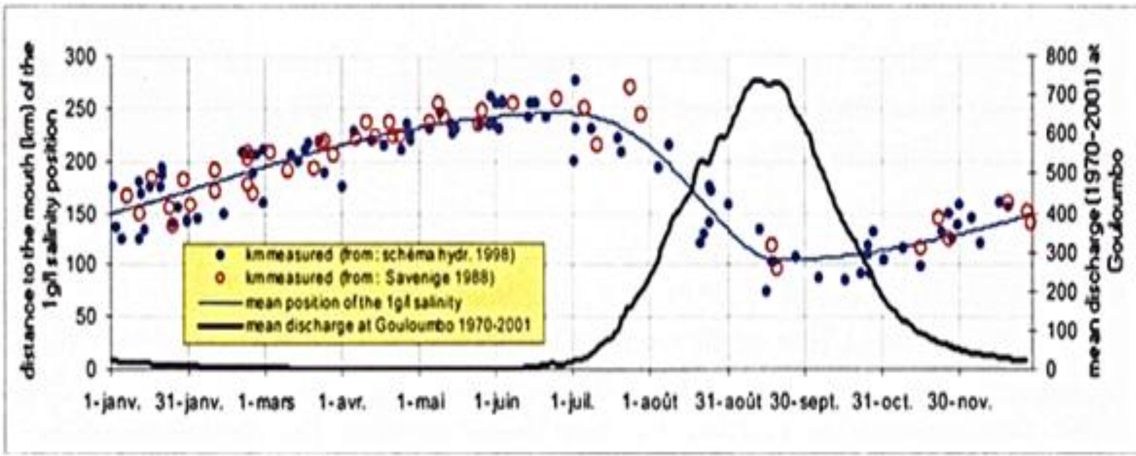

Figure 21: Average annual shift of the 1.0 g/l fresh-saltwater interface[46]

[46] *Source: Additional Economic Study of Sambangalou Hydroelectric Power Project on the Gambia River – Main Report. BRL Ingénieres & Nodalis Conseil (2012).[as adapted from COTECO Design Report, 2006].*

Studies on the saline intrusion in the Gambia River system have primarily focussed on saline intrusion in the river channel itself. Saline intrusion in the adjacent aquifer system have not attracted much attention. The notion is that the river system receives a rather steady amount of base-flow, even in the dry season, suggesting net flow from the aquifer to the river. As mentioned earlier, however, there is a limit as to the 'sustainable' abstraction rate of groundwater and the amount of base-flow to the surface water system beyond which an irreversible process may start whereby the flow will be from the surface water system to the aquifer system (this aspect is described further in the following Chapter 4).

3.5 Water quality and pollution

3.5.1 Causes of water quality degradation

The information presented in this sub-section is to a large extent extracted from NEA[47].

Urbanization

The urban areas of The Gambia account for 20% of the land area, on which more than 60% of population lives. In these highly populated areas – notably the Greater Banjul Area (GBA) – the threats to groundwater quality are greatest with potential sources of pollution including: (a) leaky sanitary facilities and pit latrines; (b) on-site sanitation systems in vicinity of groundwater abstraction points; (c) solid waste dumpsites and landfills; (d) unlined drainage ditches; (e) quarries/sand mining; and (f) underground storage tanks.

The industrial sector is still quite modest in The Gambia and is mostly limited to plastic materials production, agro-based soap production, production of candles, brewery, bottlers, confectionery production, sand and gravel mining among other small scale industries. However, the sector is clearly growing in step with the increasing population.

These industries can be a cause for concern in terms of water quality, as chemicals and other discharges can pollute surface water and groundwater if not handled appropriately. Specifically should be mentioned that oil spills and leaks from petrol stations also pose serious pollution risks of the groundwater. It is important to take into account the further development of the industrial sector when future water quality monitoring activities and abatement measures are planned and implemented.

Waste management

There are two official solid waste dumpsites in the GBA, Bakoteh dumpsite and Mile II dumpsite. The Bakoteh dumpsite receives solid waste from Kanifing Municipal Council (KMC) and parts of Kombo North, and is situated in an old quarry that is surrounded by residential areas, a school and an orphanage. The Mile II dumpsite receives solid waste from Banjul City and is situated in a wetland and very close to the RVTH Sanatorium.

The municipalities do not have the capacity to collect all domestic waste for disposal, and the majority of residents resort to open burning, dumping in old wells, burying or merely dumping on grounds around their households. The dumpsites are the only disposal facilities available, apart from the Medical Research Council's incinerator, and therefore a wide range of waste is deposited including domestic waste, commercial waste, industrial waste, construction waste and the majority of clinical waste. The waste in the dumpsites is occasionally burnt to reduce the quantity. Neither of the dumpsites

[47] *The Gambia, State of the Environment Report. National Environment Agency, NEA (2010)*

are constructed as sanitary landfills and therefore pose high risk of groundwater and nearby surface water contamination.

Wastewater in The Gambia is also a critical source of pollution. Some parts of the urban area are connected to a municipal sewerage system, run by the National Water and Electricity Company Ltd. (NAWEC), through which sewage is either discharged untreated through a pipeline into the Atlantic Ocean (Banjul City) or is directed into wastewater stabilisation ponds (Kotu). The stabilisation ponds have a capacity of around 20,000 m^3/d, and receive not only wastewater from the sewerage system, but also from approximately 14 sludge tankers daily. There is no preliminary treatment of the wastewater before being discharged to the ponds. The ponds are not functioning as intended as the old pumps are constantly breaking down leading to the back up and overflow of sewerage. The sludge received from the sludge tankers often also contain plastics and other solids.

Not all flush toilets in the urban areas are connected to the municipal sewerage system and many resort to private septic tanks. The risk of leakage to the groundwater from septic tanks is high as not all septic tanks are properly constructed. In low income areas and rural areas, outdoor pit latrines are commonly used. These pit latrines are often poorly constructed and are also a source of groundwater contamination. This is of particular concern during the rainy season when the groundwater table rises and the pits become hydraulically connected to the shallow aquifer.

Agricultural practices

Agricultural activities in The Gambia account for approximately a third of the land use. The usage of fertilizers and pesticides is widespread. Pesticides are not manufactured in The Gambia but are imported and sold. The National Environment Agency (NEA) registers all the pesticides that enter the country legally, but it has been reported that some pesticides are smuggled into the country illegally.

The majority of farmers are also untrained in the proper use of pesticides and this has in many cases resulted in the overuse and/or inappropriate use of pesticides. The storage of pesticides and disposal of containers or applicators contaminated with pesticides is another cause for concern as both some farmers and unlicensed pesticide distributors are unaware of the hazardous impacts of these chemicals.

3.5.2 Water quality status

One of the tasks as part of the water resources monitoring network re-design component under the NWSRP activities (2013-14) was also to propose a framework for a water quality monitoring programme. Some of the information presented in this sub-section is extracted from the findings emanating from this study[48].

Groundwater

In The Gambia numerous boreholes countrywide have been tested for the water quality parameters over a span of years and compared with the World Health Organisation (WHO) water quality guidelines. The conclusion is that on average the water of the boreholes and rural wells tested are of fairly good quality. Table 5 depicts a selection of physical-chemical parameters analysed from samples from both the SSA and the DSA, and it is evident from the table values that the quality of the water of the SSA is well suited for potable use.

[48] *Framework for a Water Quality Monitoring Programme. NWSRP/NIRAS (April 2014)*

Table 5: Water quality of the deep sandstone and shallow sand aquifers

Parameter	WHO drinking water standards		Deep Sandstone Aquifer			Shallow Sand Aquifer (mg/l)
	Highest desirable (mg/l)	Max. permissible (mg/l)	Garowal (mg/l)	Sankiwa (mg/l)	Banjul (mg/l)	
TDS	500	1,500	322	955	1,766	20 – 90
Calcium	75	200	34	6	6	4 – 15
Magnesium	30	150	20	3	5	0.2 – 4
Chloride	200	600	17	355	616	2 – 25
Sulphate	200	400	28	42	101	1.6 – 15
Nitrate	45	50	0.1	0.2	0.1	0 – 50
Fluoride	0.6	0.8	0.4	1.8	5.3	0 – 0.1

Additionally, the following can be said about the SSA groundwater quality.

The pH values in the SSA is recorded to be on the low side in certain areas, ranging from 4.0 to 6.7 in some cases. In existing treatment works in the Greater Banjul Area this is raised by aeration to remove the free CO_2 gas – or by lime dosing.

Furthermore, relatively high iron content – typically ranging from 2.5 mg/l to 4 mg/l – is encountered in almost all regions of the country with the exception of Upper River Region. Iron removal as part of conventional treatment works is a common procedure used – the problem is more associated with individual and smaller rural supply schemes, which for now do not have treatment facilities included. For this category of supplies it is imperative to look into viable methods for alleviating the iron problem usually encountered in deeper boreholes sunk into the SSA.

The nitrate (NO_3) concentrations in groundwater are for the most part within the WHO guidelines of 50 mg/l. High concentrations of nitrate, however, do occur, which are likely related to direct pollution from activities on the ground. It can also be mentioned that fluoride content is generally well within WHO guidelines in the SSA groundwater.

The electrical conductivity, and hence the total dissolved solids, have on average been measured to be well within the WHO guidelines in the range of 50 to 400 µS/cm at 25°C. High electrical conductivities are normally observed in boreholes and wells close to the coast line and the saline section of the Gambia River. The groundwater in the well-fields in the northern part of Greater Banjul Area shows electrical conductivity values below 100 µS/cm.

Some boreholes and rural wells showed high biological contamination with high levels of total and faecal coliforms. This is likely related to contamination by septic tanks or pit latrines in the vicinity or in the case of open wells, contamination can come from humans and animals at the well opening.

Concerning the three exploratory DSA boreholes located in Banjul, Sankwia and Garowal, as already mentioned, and substantiated by the values given in Table 4, there is a tendency for the DSA groundwater quality to decrease when moving from east to west in the country. The DSA groundwater shows an increasing mineralization from east to west, and the eastern waters show higher concentrations of calcium and magnesium, while moving westwards across the country, concentrations of bicarbonate, sodium, chloride, boron, fluoride and iron increase. Further, the DSA groundwater in Sankwia and Banjul show EC, chloride, fluoride and boron concentrations above the WHO drinking water guidelines.

Surface water

As amply described in the previous sections, the Gambia River water being saline on long stretches of the river system has no consumptive value. In the perennially freshwater upper reaches of the river system, its use as drinking water has practically been confined to history as newer and safer water supplies are developed in rural communities.

By and large the only water quality measurements carried out regularly on the river system concerns salinity in light of its use for irrigated agriculture. The main aim is to monitor the point at which the salt concentration of 1 g/l of the river water (saline front) is located and observe its movements within the year in relation to the inflow of fresh water from the upstream reaches.

Surface water samples taken from Kombo East and Greater Banjul Area in Western Region, the areas closest to the Atlantic Ocean, show salinities of approximately 25-35‰ indicating saline water. Samples taken in North Bank Region, Lower River Region and Central River Region are for the most part brackish with salinities ranging from 0.8-25‰. Samples taken in the eastern part of the Central River Region vary from freshwater to brackish water depending on the season, as during the dry season the saline front extends further up the river than during the rainy season. The high salinities are also supported by the high chloride content and electrical conductivity measured in the samples.

The Biochemical Oxygen Demand (BOD) is a good measure of pollution in surface waters. The average BOD value, 2.0 mg/l, from the samples show waters of good quality as per the guideline of 5 mg/l for surface waters intended for abstraction of drinking water. Based on the samples taken, the coliform content of the river is fairly low, with averages under 40/100 ml for both total and faecal coliforms. Good quality surface waters should maintain numbers of 5000/100 ml and 1000/100 ml for total and faecal coliforms respectively. Based on the major cations and anions measured water quality must be rated to be fairly good.

It can also be noted, that the intrusion of saline water into the river system and tidal flooding of the floodplains results in a gradually increasing salinity of the soils and the potential formation of acid sulphate conditions. During the rainy season, salts are leached down and thus may affect the groundwater quality, and soils remain saline during dry months.

3.5.3 Water pollution versus increased abstraction

It also important to point out that the continued increased exploitation of the aquifer system, particularly in the Greater Banjul Area, inevitably will have certain repercussions on the water quality due to pollution given the existing water supply structure relying on a number of rather densely drilled well-fields.

The more abstractions are increased in the lower semi-confined aquifer, a lowering of the groundwater table and, hence, a ‘quicker’ infiltration from the upper phreatic aquifer system will be realized. This in turn will not only result in an increased tendency for hand-dug wells to run dry and draw in brackish water, but – due to the growing amount of effluents being deposited in the upper layers and existence of unprotected dump sites – also pose a serious risk of pollution spreading downwards.

This trend is bound to be exacerbated in coming years, and eventually will also impact on the otherwise good yielding boreholes drawing water from the semi-confined aquifer.

It will be necessary to establish groundwater protection zones around future boreholes and well-fields meant for potable water supply against polluting activities and saltwater intrusion. In this regard it may also be required to decommission existing production boreholes in certain of the Kombos' heavily built-up areas if pollution has started. Groundwater protection zones are also important as a measure towards safeguarding the 'natural' recharge rate of the aquifer system, otherwise impacted by built-up (hard surfaced) areas as well as expanding surface water drainage facilities.

The same considerations are also required in the future shaping of the water supply facilities in the many of the growth centres around the country.

3.6 Sambangalou hydropower project impacts[49]

3.6.1 Hydrological regime changes inflicted by the project

The site of the Sambangalou Dam – the first ever to constructed across the main stem of the Gambia River – is located at the border between Senegal and Guinea some 420 km upstream from the Gambia River's crossing into The Gambia. After many years of planning, design processes, advocacy for finances, environmental and social impact assessment studies and actual commissioning of the Sambangalou dam/reservoir civil works, the construction started in the middle of 2014, and is scheduled to be completed within 3 years.

The surface area of the reservoir at normal storage level will have a size of about 185 km^2. Its main purpose is hydropower generation for the benefit of all four OMVG member countries, but also with irrigation and flood control prospects. In addition, by virtue of being a hydropower plant, a certain flow through the turbines will also be maintained in the dry (low flow) season downstream of the dam.

It is also worthwhile noting that the evaporation losses alone from the new reservoir will be in the order of 11 m^3/sec, some 7% of the mean total flow of the Gambia River at the entry to The Gambia.

It goes without saying that after completion of the dam/reservoir structure, the Gambia River will change its flow regime – it can be argued that there is only a few years remaining now to witness the Gambia River as it has meandered through Senegal and The Gambia in its natural stage and environment for ages back in time. The most prominent changes in the natural flow regime to be felt downstream of the dam, hence in The Gambia, are:

- Reduced high flow conditions in the rainy season resulting in lower flood water levels and less frequent (if at all) flood occurrences; and
- Augmentation of the dry season flows by maintaining low water flows at the outlet of the turbines at an average of 60 m^3/sec during the dry season[50].

It should be stressed that the 60 m^3/sec is the flow through the turbines at the dam site some 420 km upstream from The Gambia. The portion of this flow which eventually may still be available in the river when it reaches The Gambia is not known – an aspect which needs to be analysed and decided on in collaboration with OMVG in setting the

[49] *Information in this section has been digested from: Additional Economic Study of Sambangalou Hydroelectric Power Project on the Gambia River - Main Report. BRL Ingénierie & Nodalis Conseil (2012).*

[50] *The proposed 60 m^3/s is the 'design' average flow through the turbines to maintain a guaranteed continuous electricity production all year round.*

operating rules to govern the dam/reservoir running, i.e. water release strategy, seasonal adjustment to the flow through the turbines, artificial flood releases etc.

Furthermore, it is worth noting that the mean annual flow of the Gambia River at the entry to The Gambia is a little more than double the amount recorded at the Sambangalou site. The average annual flow during the period 1970-2001 was 72 m^3/s at Sambangalou and 150 m^3/s at Gouloumbou. This implies that the effect of the operating rules and releases from the Sambangalou Dam to some extent is ‘dampened’ and not felt fully in The Gambia. In other words, about half of the ‘natural’ river flow regime can be expected to be maintained, namely the portion which emanates from the catchments in the Senegalese part of the Gambia River Basin.

The dam project has also been subject to a detailed Environmental and Social Impact Assessment (ESIA) aimed at meeting regulations applicable within the OMVG countries. A key observation from the ESIA is that environmental and social risks will necessitate diligent management, notably regarding relocation of populations residing in the dam/reservoir zone, and – importantly for The Gambia – mitigation of likely negative environmental impacts in the downstream reaches of the river system.

The impacts are linked to modification of the hydrologic balance in the wet zones. A recession of the saline front during the dry season will be experienced, and modifications of the morpho-sedimentary balance of the estuary will be felt, including progressive decline of wetlands and mangrove swamps in the central estuary zone. Their habitats host a wealth of biodiversity and maintain fish stock, which artisanal fisher folks depend on and earn their living from.

It should be mentioned that The Gambia has not conducted its own (independent) additional studies to determine the likely environmental impacts considering the country’s specific needs in this respect.

The hydrological impacts identified in the OMVG commissioned ESIA with a bearing on The Gambia can be summarized as follows:

- reducing flood water levels during the annual dam filling operations;
- maintaining low water flows during the dry season;
- submersion of sites that normally dry up during the dry season;
- accelerated flood drainage in tributaries due to reduced flood (high) water level in the Gambia River;
- insufficient water to fill the flood retreat depressions and riverine wetlands; and
- recession of the fresh/salt water interface downstream during the dry season.

The nature of these impacts can either be positive or negative, depending on how they are looked upon. For instance, reducing the amount of flood waters can be positive as regards the effect of flooding human settlements, fields etc, but negative regarding the sustenance of aquatic ecosystems and riverine plant formations.

3.6.2 Mitigation and enhancement measures

The measures planned to mitigate or enhance hydrological impacts have several goals, and consist of producing:

- artificial floods; and
- artificial minimum dry season river flows.

Artificial floods

Artificial floods serve ecological purposes. This is a common mitigation measure, and in the case of the downstream portion of the Gambia River the aims of this measure are:

- attenuate the reduction of flooded wetland areas in order to reduce the impact of the dam project on associated fauna and flora;
- maintain spawning and fishing grounds as much as possible;
- slow flood drainage in tributaries; and
- maintain the flushing effect in the estuary.

The dam structure is designed to be equipped with large bottom outlet gates able in an instantaneous manner to discharge 700 m^3/s to produce the artificial floods if required. This means that there are two options, namely (i) to produce a flood to maximize the depth of inundation, or (ii) to produce a flood to maximize the duration of inundation.

Option (i) implies a flood lasting for a short time, but with powerful flow to maximize the spread of the waters on the banks and in the flood plain. Option (ii) implies a flood lasting as long as possible (up to one month), but of limited intensity to replenish the hydraulically connected aquifer systems and offset drainage from the tributaries, flood pools and wetlands.

Artificial maintenance of minimum low water discharge

The same as for artificial floods, the artificial maintenance of minimum low waters is ecologically justified as a mitigation measure to reduce the effects of the dam project on certain environmental and social components. The aims of the artificial maintenance of minimum low water flows are the following:

- ensure that fresh/saltwater interface rises temporarily far enough to allow replenishment of brackish water to the mangroves located in the saline front withdrawal area;
- attenuate the effect of reducing the normal river bed surface area on some of the ecological functions; and
- prevent over-production of electricity during the dry season, which would lower the reservoir water level beyond the useful storage level, and lead to water release problems the following year.

According to the planned operating rules the intention is to reduce the discharge by half (from the average value of 60 m^3/s) for three months towards the end of the dry season, whereas a certain surplus production can be maintained during the other low water months. The shift in the fresh/saltwater interface from its ‘normal’ locations is not fully known and needs to be studied further.

Finally, it should be reiterated that the operating rules for the dam/reservoir with specific reference to the two mitigating measures, i.e. artificial floods and artificial low water flows, need to be modelled and decided on bearing in mind the vast riverine stretch of 420 km between the dam site and the crossing of the river into The Gambia.

4. WATER DEMAND ANALYSIS AND WATER AVAILABILITY

4.1 Overview

The overall 'stock' of renewable fresh water resources in The Gambia includes:

- surface water contributed by the Gambia River at an annual average of 4,700 Mm^3/year at the river's entry point to The Gambia;
- an estimated additional 10%-15% of surface water contributed by tributaries to the Gambia River and local coastal streams;
- groundwater recharge of the shallow sand aquifer of about 600 Mm^3/year nation-wide, and holding an aquifer storage volume of some 36,000 Mm^3;
- groundwater recharge of the deep sandstone aquifer 2 Mm^3/year[51], and holding an aquifer storage volume of 80,000 Mm^3 (in the eastern freshwater DSA portion).

Due to the continuously saline conditions of the Gambia River system in the entire western half of the country and the flashy and diminishing flow pattern and poor water quality in the coastal streams, surface water in this part of the country is not used as a source of potable water and is not contemplated to be in the future either. On the other hand, groundwater is widely available, easily accessible and of relatively good quality. Additionally, the demographic set-up with some 60% of the population as well as most industries and tourism activities concentrated in the Greater Banjul Area (GBA) restricts the use of the Gambia River's eastern freshwater section to supply GBA due to high transportation costs over long distances coupled with the need for full treatment to make the water acceptable for potable use.

Hence, water use follows rather clear-cut lines: (i) seasonal or perennial freshwater resources in the Gambia River system are exclusively used for irrigation, and (ii) groundwater is used for all other purposes, primarily domestic and institutional water supply, industrial and commercial supply, but also for some commercial horticulture irrigation.

As a general rule, most dug wells take water from the phreatic part of the shallow sand aquifer and all boreholes from the semi-confined portion of the aquifer.

Due to the exclusive role of groundwater in The Gambia, the present chapter examines the nation's groundwater usage and future reliance (vulnerability) of groundwater as a continued sole source for the potable water supplies in much more details than the surface water situation. This analysis also includes a groundwater model application aimed at visualizing the impact of future abstractions on the groundwater level and the overall water balance created in the GBA. These deliberations are presented in sub-chapters 4.2 to 4.4

Sub-chapter 4.5 presents a discussion on the use of the Gambia River for the purpose of rice fields irrigation set against the fresh water stock in the river with due regard to the changing hydrological regime to be realized when the Sambangalou dam project will be commissioned in a few years.

[51] *S. Ceesay & Sons and Howard Humphreys Ltd: Groundwater Survey Studies, Phase I. (1987)*

4.2 Present groundwater exploitation in a national perspective

4.2.1 Current groundwater abstractions

As part of the groundwater assessment component under the NWSRP activities (2013-2014) previous groundwater studies have been consulted and additional detailed information has been obtained about the aquifer/groundwater conditions, including data from 20 newly established observation boreholes as well as rehabilitation of existing observation boreholes in the Greater Banjul Area. Furthermore, the most recent (2013-2014) statistics about the present groundwater abstractions as recorded have been gathered from a wealth of sources, including the largest abstractor, NAWEC, abstraction figures from solar-powered supply systems, and hand-pump equipped boreholes and dug wells. Also a number of boreholes at commercial agricultural (horticulture) farms constitute a sizeable abstraction rate in the Greater Banjul Area.

Table 6 provides an overview of the abstraction points as gathered from recent statistics. On this basis the actual abstraction rates are presented in Table 7. In this presentation, the country has been broken into the administration regions.

Table 6: Number of groundwater abstraction points per region (status as of 2013/14)

Region	NAWEC boreholes	Solar systems	Boreholes with hand pumps	Dug wells with hand pumps	Commercial farms boreholes
West Coast	63	68	50	413	29
North Bank	7	55	36	346	-
Lower River	2	22	42	161	-
Central River	5	46	48	476	-
Upper River	3	44	31	238	-

Table 7: Groundwater abstractions per region and nation-wide, m^3/day (status as of 2013/14)[52]

Region	NAWEC boreholes (m^3/day)[53]	Solar systems (m^3/day)[53]	Boreholes with hand pumps[54] (m^3/day)	Dug wells with hand pumps[54] (m^3/day)	Commer-cial farms boreholes (m^3/day)[53]	'Others' (m^3/day)[55]	Total (m^3/day)
West Coast	90,870	3,573	600	4,956	18,579	9,087	127,665
North Bank	2,880	4,110	432	4,152	-	288	11,862
Lower River	2,240	1,602	504	1,932	-	224	6,502
Central River	3,580	3,260	576	5,712	-	358	13,486
Upper River	2,480	2,636	372	2,856	-	248	8,592
Total The Gambia	102,050	15,181	2,484	19,608	18,579	10,205	168,107

[52] *In addition to the abstraction points listed in Table 6, a number of un-known ('unaccounted for') boreholes exists, mainly privately drilled to serve various individual housing estates, and as supplementary supplies for certain tourist hotels/resorts and industrial establishments. These abstractions are included under the category 'Others'.*

[53] *Abstractions based on actual metered volumes.*

[54] *Abstraction estimated using a rate of 12 m^3/day for a hand pump either in a borehole or in a well.*

[55] *Estimated to amount to 10% of NAWEC abstractions.*

It can be seen in Table 7 that the present total groundwater abstraction for the whole country amounts to 168,107 m^3/day or 61.4 Mm^3/year of which 127,665 m^3/day or 46.6 Mm^3/year is abstracted in the West Coast Region. That means, three-quarters of The Gambia's total groundwater abstractions takes place in this part of the country. NAWEC, which provides water supplies to homes, businesses, hotels and institutions in all major population areas in the country, is responsible for the abstraction of 102,050 m^3/day or 37.2 Mm^3/year from its 80 boreholes in different parts of the country, equivalent to about 60% of the total groundwater usage of which close to 90% of NAWEC's abstractions occur in the West Coast Region.

It is also of interest to note that the total abstraction for domestic use from hand-pump equipped wells and boreholes spread across the country is the second largest category amounting to 22,092 m^3/day or 8.1 Mm^3/year, and for commercial agricultural farms located in the West Coast Region the abstractions amount to 18,579 m^3/day or 6.8 Mm^3/year. Total abstraction from 235 solar-powered reticulation systems in the country amounts to 15,181 m^3/day or 5.5 Mm^3/year.

4.2.2 Groundwater potential

Recharge estimation

As discussed earlier, groundwater level dynamics of the Shallow Sand Aquifer is very much dependent on rainfall. The phreatic part of the aquifer is recharged by infiltration and therefore exhibits seasonal and inter-annual fluctuations of groundwater levels. Recharge to the semi-confined part of the Shallow Sand Aquifer is also by infiltration from rainfall, mainly through leakage from the upper phreatic aquifer through the separating aquitard.

A number of previous studies have attempted to calculate the amount of recharge to the Shallow Sand Aquifer. The earlier studies[56] used the simple 'Water Balance Formula' method, and in the later NAWEC Master Plan[57] the 'Rise and Fall' method was applied. However, it should be noted that there are marked disparities between recharge values obtained by applying these methods due to a number of inherent assumptions which need to be made in the absence of salient hydrogeological data, such as estimation of runoff coefficient, spatial resolution of potential evapotranspiration, inflow/outflow dynamics between the aquifer and surface water bodies (along the Atlantic Ocean coastline and the Gambia River shoreline) and the interrelationship between the phreatic and semi-confined parts of the Shallow Sand Aquifer. Thus, results obtained from these methods are associated with high uncertainties when certain basic data are lacking.

Nevertheless, the 'Rise and Fall' method, which is based on the dynamic response of water levels due to recharge, is in general judged to be the more accurate of the two methods. As part of the groundwater assessment component under the present NWSRP activities this method, therefore, was re-applied based on data series on groundwater level fluctuations captured from the recently established network of monitoring boreholes equipped with continuously recording data-loggers.

The intention of the presentation in this sub-section is to make a 'national' groundwater potential assessment and compare the various regions of the country vis-à-vis the current abstraction rates. As such any systematic 'error' (uncertainty) in the recharge estimation

[56] *(i) GITEC Consult: Feasibility Study for a Rural Water Supply Programme (1981).(ii) S. Ceesay & Sons and Howard Humphreys Ltd: Groundwater Survey Studies, Phase I (1987).*

[57] *SNC Lavalin: Water Supply and Sanitation Study, The Gambia – Master Plan, Volume 2 (2005).*

is included as a common 'parameter', which does not alter the relative picture of the situation in the individual regions for comparison purpose.

Groundwater storage

The total long-term (effective) groundwater inflow of the area under analysis is by convention normally equalled to the maximum groundwater storage. It is further assumed that the natural inflow component does not change when abstractions are brought into the picture.

A simple groundwater storage equation can be used to calculate the amount of water which can be stored in the aquifer system. The prime parameters in this equation are (i) land surface area (recharge zone); (ii) the aquifer characteristics expressed as specific yield; and (iii) the upper and lower limits of the groundwater table fluctuation. On an national basis, the calculated groundwater stored in the Shallow Sand Aquifer amounts to about 36,000 Mm^3.

4.2.3 Water balance at regional level and nationally

Table 8 summarizes the current abstraction rates as extracted from Table 7 contrasted to the recharge rates of the Shallow Sand Aquifer as discussed above. For comparison, Table 8 also includes the result of the calculation of the maximum groundwater storage available in the aquifer systems – presented region by region and nationally.

Table 8: Groundwater abstraction, recharge and storage, Shallow Sand Aquifer

Region	Abstraction		Recharge Mm^3/year	Abstraction vs. recharge in %	Groundwater storage Mm^3/year
	m^3/day	Mm^3/year			
West Coast	127,665	46.6	152	30.7	5,396
North Bank	11,862	4.3	118	3.6	9,103
Lower River	6,502	2.5	74	3.4	5,070
Central River	13,486	4.9	135	3.6	9,729
Upper River	8,592	3.1	129	2.4	6,702
Total The Gambia	168,107	61.4	608	10.1	36,000

With due consideration given to the assumptions, and hence uncertainties in the calculations and estimation of recharge rates, in arriving at the values in Table 8, the picture is clear that nationally the groundwater abstraction rates can easily be sustained in the long term even with a doubling, quadrupling or more in the expansion of the groundwater abstractions. With regard to the regions the conclusion is the same for the four 'rural' regions, which show a 'utilization rate' as low as 3.2% in average, whereas the picture governing the West Coast Region is strikingly different.

Concerning the estimated recharge rate for the West Coast Region and groundwater utilization, the following points should be borne in mind:

- the 2012-13 rainy seasons, which the 'Rise and Fall' method used data from to calculate the recharge rate, recorded a nearly 15% higher rainfall compared to the long-term mean at Yundum Met. Station;
- in the calculation formula the recharge rate is directly proportionate to the rainfall amount;

- the recharge is assumed uniform over the whole area which obviously is not the case in reality, and at the same time sizeable abstractions are taking place in concentrated 'clusters' (well-fields) with some abstractions located in high risk areas of saltwater intrusion if overexploited; and
- a general rule concerning exploitation of groundwater in hydro-physical and climatic environments similar to The Gambia is to maintain overall abstraction rates not exceeding 70% of annual average recharge.

Against this background, the 'usable' (realistically exploitable) groundwater potential in the West Coast Region is more likely to be about 70% of 0.85 x 152 Mm^3/year, equivalent to 90 Mm^3/year.

In conclusion it can be stated that the country is distinctively divided in two parts when it comes to groundwater abstraction and groundwater potential, viz.-

- given the above adjustment to arrive at realistically exploitable recharge amounts, the four 'rural' regions (NBR, LRR, CRR and URR) at present only abstract less than 6% of the 'usable' groundwater potential; whereas
- the West Coast Region at present abstracts a little more than half (52%) of the exploitable recharge amount available within the region. In other words, with an inevitable expansion of the NAWEC water supply system to meet both suppressed (unmet) requirements for water and keeping up with the ever increasing population, the region undoubtedly is beginning to experience 'water stress' when it comes to resource availability and considering the present water supply infrastructure configuration. This is further elaborated on in Section 4.4.

4.3 Projected water demands, Greater Banjul Area

Seen in light of the conclusions reached in the previous sub-chapter, Greater Banjul Area (the Kombo Peninsula) is singled out for the further in-depth analysis due to the evident acuteness in meeting the future water demand from the perspective of matching available resources.

The planning horizon in this analysis has been set at 25 years, i.e. a period ending by year 2040, and it goes without saying that the various projections made in this sub-chapter and the ensuing water demand figures by 2040 should be considered as rough estimates only.

4.3.1 Population growth

In the GBA, the domestic water demand accounts for the largest share of the current water use and deemed to increase and continue to be the single most important user category. Hence, the projected population growth of the GBA is an essential factor in projecting the future water requirements.

Up-to-date population figures are available from the 2013 Population and Housing Census[58]. This census enumeration coupled with GBoS own population projections[59] provide the background for the projected population growth in the GBA[60] used here.

[58] *Gambia Bureau of Statistics (GBoS): The Gambia 2013 Population and Housing Census, Preliminary Results.*

[59] *Gambia Bureau of Statistics (GBoS): Population Estimates and Projections (2003-2020) at National, LGA and District Levels (December 2011).*

[60] *The Greater Banjul Area (GBA) as defined in this analysis comprises of the following GBoS LGA demarcations: Banjul (South, Central and North districts), Kanifing (all districts), and Brikama (Kombo North,*

As presented in Sub-chapter 2.2, the 2013 Census indicates that the population of The Gambia has steadily grown over the past half century from less than 0.5 million people 1.9 million now. In the GBA, the 2013 census figure was 1.1 million equivalent to 58% of the entire population of the nation.

Overall, the population of The Gambia has increased by 38.3% during the 2003-2013 inter-censal period, which is equivalent to an average growth rate of 3.3% per year. The only LGA with a negative growth rate is Banjul, whereas in contrast the population in the Brikama LGA grew at a rate of 6.1% annually on average. This exceptional growth rate is attributable to the influx of migrants from other regions of the country and from outside the country.

The ‘rural’ regions have in average had a growth rate of 2.1% annually during the 2003-2013 period.

By scrutinizing GBoS 2003-2020 population projections (ref.[59]) for the GBA as a whole, it is noted that the projected figures for 2013 match well (within a margin of a couple of percent) with the actual census figures. Hence, for the purpose of this analysis, the GBoS projected figures for 2020 is adopted and used in the present study, and for the remaining of the planning horizon a set of annual growth rates have been worked out and applied as presented in Table 9.

Table 9: Projected population growth, Greater Banjul Area(*)

LGA / district	2013 population (Census result)	2020 (GBoS projection)		2030		2040	
		p.a. %	Population	p.a. %	Population	p.a. %	Population
Banjul - South - Central - North	31,301	-2.7	22,687	-0.5	21,527	0	21,527
Kanifing - all districts	382,096	3.0	537,206	1.5	613,795	1.0	678,011
Brikama - Kombo North - Kombo South - Kombo Central - Kombo East	639,315	4.5	758,380	4.0	1,122,587	3.0	1,508,663
Greater Banjul Area (GBA)	1,052,712	3.3	1,318,273	2.9	1,757,909	2.3	2,208,201

(*) *Growth rates are given in per annum (p.a.) percentages for each 10-year period.*

Although the GBoS 2003-2020 projection for year 2013 is very similar to reality, i.e. the 2013 census, when looking at the GBA as a unit, it should be noted that population growth rates for Kanifing and Brikama show other realities than applied in the GBoS projection. Instead of a 3.0% annual growth rate given for Kanifing, the 2003-2013 inter-censal period shows a lower 1.7% annual growth, and for Brikama the projected 4.5% in reality has been quite higher at a rate of 6.1% annually. In other words, it can be argued that the Kanifing municipality has reached a certain urbanized ‘saturation’ point as far as being able to accommodate much higher population and the influx to the GBA

Kombo South, Kombo Central and Kombo East).

has shifted to the Brikama LGA – a case in point is also the zero to negative growth of Banjul city. Eventually, Brikama will experience the same tendency when people then have to settle further east or south of Brikama. These aspects have been guiding in settling the growth rate figures given in Table 9 from 2020 and onward.

It can be concluded from Table 9 that the GBA as a whole can be expected to increase its population from the 2013 level of 1.05 million to 2.21 million at the end of the planning horizon (2040), i.e. a little more than a doubling.

4.3.2 Assumptions for projection of potable water demand

Proportion of population served and means of supply

Judged from the ECOWAS document[61], The Gambia has a commendable track record towards improving access to drinking water – as a matter of fact, among the fifteen ECOWAS member states, the country is shown to have achieved the highest water supply coverage rate, to a level where even the Millennium Development Goal have been surpassed. However, the coverage rate of more than 80% given in the ECOWAS (2008) publication is most likely estimated based on a combination of 'safe' (NAWEC) water supply and to some extent 'unsafe' supplies, primarily from shallow wells. Against this background, it is argued that in GBA the percentage of people with access to 'safe' drinking water is lower and in this analysis is assumed to be 70%.

In the GBA, the prominent supplier of potable water is NAWEC with its 63 good yielding production boreholes. With reference to Table 6, it is seen that the other supply sources includes the community owned/managed solar-powered boreholes systems as well as numerous hand-pump equipped tub wells and dug wells.

Guided by the metered and estimated abstraction rates given in Table 7, it is assumed that the means of supply of domestic use across GBA proportionately (as percentage of population served) presently is divided as given in Table 10. During the planning horizon it is further assumed that the access to 'safe' drinking water and the means of supply evolve in the direction as also indicated in Table 10. The changes from the present situation to 2040 will happen gradually.

Table 10: Access to 'safe' water and means of supply, Greater Banjul Area

	2014	2040
Access to 'safe' drinking water (population served)	70%	90%
Means of supply (percent of population served)		
NAWEC supply systems (boreholes)	80%	85%
Community solar-powered boreholes	4%	5%
Privately drilled/owned boreholes	10%	5%
Wells and boreholes with hand-pumps	6%	5%

The NAWEC borehole supply for domestic use is divided into two categories, viz. people served with house connections and through the use of public standpipes. It is estimated that at present the split is 80% domestic use is through house connections and

[61] *ECOWAS (2008): West Africa - Water Resources Policy (Appendix 1).*

20% using public standpipes. It is assumed that as the total population increases, this percentage feature in service delivery will likely remain unchanged.

Unit water demand

In addition to the population growth, the other important parameter to decide on is the unit water demand or per capita water demand at present and in the future.

With departure point in the analyses presented in the NAWEC Master Plan[62], Table 11 provides the per capita water demand used in this strategy document. The demand calculations are carried out using two projections for the unit water demand figures valid for the NAWEC piped supply system as seen in the table.

Table 11: Unit water demand (l/c/d)

Category	2014	2040	
		'do nothing'	'with WDM'(*)
House connections (NAWEC)	100	120	100
Public standpipes (NAWEC)	50	50	40
Solar-powered systems	50	50	50
Hand-pumps	30	30	30

(*) *WDM = Water Demand Management*

The "do nothing" situation indicates that only very modest – if any – initiatives are taken towards introducing and implementing a broad-based water demand management programme. Whereas the "with WDM" reflects that demand management measures and other water use efficiency initiatives will (and must) be introduced to tackle the issue of water wastage at consumer level.

The effect of such long-term water demand management campaigns has been realized in other parts of the world with the consumption now typically hovering around 100 l/c/d when fully reticulated multi-tap supply is provided to households. Details of how to structure and the main elements to be part of a water demand management and water supply efficiency programme is described in Chapter 5 of the present strategy document.

Industry and commercial water consumption

In the NAWEC Master Plan, which is based on actual sales figures, the demand of this user category is expressed in terms of l/c/d. This may not be the most common way of expressing it, but in lack of more accurate statistics related to actual industrial and commercial water uses and (perhaps) suppressed demands, it seems prudent to approach it that way. However, in this analysis it is opted to let the industrial and commercial water requirements be pegged on a percentage of the domestic demand with departure point in the NAWEC Master Plan findings.

At that time, NAWEC sales figures were translated into an industrial and commercial demand being equivalent to 20 l/c/d, which is equivalent to 20% of the domestic demand (NAWEC served) presently. In countries comparable with The Gambia, for planning purposes it is not uncommon to estimate the industrial and commercial water

[62] *SNC Lavalin: Water Supply and Sanitation Study, The Gambia – Master Plan, Volume 2 (2005).*

demand to be equivalent to 25% of domestic demand. This figure is set to be valid for 2040.

Institutional demand

As a general rule, institutional water usage is in the order of 5% to 10% of domestic demand. In setting the projected institutional demand it should be acknowledged that particularly in this user category there is a suppressed demand, but it should also be realized that an increase in the number of public institutions and other governmental service facilities to a large extent is proportional with a general growth in population. In conclusion, in this study the growth of institutional water consumption will be based on the lower 5% presently and then very modestly increasing to 7% of the domestic demand (NAWEC served) towards the end of the planning horizon.

Touristic/hospitality sector water demand

Based on the figures given in Sub-chapter 2.4, it is in this analysis assumed that The Gambia in average (based on the past five years records) has 160,000 visitor arrivals.

Using this number, and under the assumption that an average length of a visitor's stay in The Gambia is 10 nights, this equates to an average of around 4,380 visitors staying in the country at any day (10 x 160,000 / 365). With reference to Figure 5, the tourist season from mid-October to mid-April witnesses a much higher hotel/lodge occupancy rate at the expense of the low season.

Studies elsewhere featuring the same 'tourist environment' as in The Gambia have used the rule of thumb of consumption varying between 180 l/bed/d to 1,000 l/bed/d depending on the quality of the hotels and service offered. This could be erroneous as the number of persons staying in the room and the hotel occupancy rate are not considered in this estimate. As an example[63], based on the number of tourists at any time and the total water sales the average consumption in a similar setting amounted to close to 500 l/person/day. The unit water usage within the hotel and hospitality business is not deemed to increase much, and a figure of 600 l/person/day is assumed, representing an increase of 20% during the planning horizon.

As mentioned, tourist arrivals have experienced a varying degree of increase over the past years – and also witnessed downturns. In this analysis it is assumed that the visitors' arrivals in the longer term will show a modest annual increase which gradually could bring the number up to 50 % more than at present, i.e. 240,000 visitors by 2040, equivalent to an average of around 6,575 visitors staying in the country at any day (10 x 240,000 / 365).

It should also be noted that due to the distinct seasonality of the tourist arrivals, the water use attributed to this sector is highly skewed towards the dry months of the year.

4.3.3 Commercial horticultural groundwater based demand

The transformation of the Agricultural and Natural Resources (ANR) sector from subsistence to a commercially-oriented modern sector is a national priority as stated in the PRSP II and the ANR Policy and Strategy, which emphasize development of the agribusiness sub-sector in support of smallholders as the main pathway to development. This will be achieved through accelerated growth in potentially fast growing produce such as horticulture, groundnuts and coarse grains as well as increased rice production.

[63] *Example taken from NIRAS – Mega Design (2012): Master Plan for Development of the Water Resources in Mauritius, Volume I.*

In the country, commercial and even export-oriented horticultural cultivation is mainly practised in the West Coast Region, whereas small family gardens on which vegetables are grown in the dry season are present throughout the rural areas.

The above stated objective for the ANR sector depends on availability of water and is also influenced by the effects of climate change in two ways, namely reduction in rainfall and increase in evapotranspiration, given that it will involve pump irrigation for rice farming (drawing water from the Gambia River) and abstraction of water from boreholes in the horticulture sector, particularly in the western part of the country.

The present abstractions from 29 boreholes for the purpose of horticulture irrigation in the GBA belong to a number of commercial farms of which the most prominent are KM Alkharafi Farm, which consists of two farms, i.e. Kufata and Kuloro, Radville Farm, Galdep Garden and Banjulinding Garden. From the documentation consulted[64] it is assumed that the commercial horticulture farming within the GBA will expand to be double the size in 20 years compared to the present situation. of. This implies that the water requirements for this sub-sector will increase from around 18,500 m^3/day to 40,000 m^3/day during the plan period.

4.3.4 Other privately drilled boreholes

As pointed out in connection with Table 7, a number of 'unaccounted for' boreholes exists within GBA, mainly privately drilled to serve as supplementary ('stand-by') supplies for a number of individual housing estates, tourist hotels/resorts and industrial establishments. Given the lack of information and even knowledge about how many and location of these boreholes, it is assumed that they will continue to be used and new ones constructed, but likely their relative role in the overall water abstraction budget will diminish somewhat in step with expansion and improved service delivery by NAWEC. At present the abstraction from these boreholes is estimated to amount to 10% of NAWEC abstractions, and in the future assumed to constitute an abstraction equivalent to 5% of NAWEC's water production.

4.3.5 Water supply system losses

For any water utility the amount of 'unaccounted-for water' (UfW) often also referred to as non-revenue water is an important parameter to factor in when water requirements – whether present or future – are to be calculated. UfW comprises of two main categories, viz. (i) administrative/management (institutional) losses, e.g. unregistered consumption and unbilled consumption; and (ii) physical losses, e.g. pipe and tank leakages and meter errors at consumer level and at bulk meter points.

Disregarding the revenue losses and the utility's financial standing and sustainability, from the perspective of water resources (in this case groundwater) usage, it is in particular the second category, namely the physical losses which attract attention. In the previously cited document, i.e. the NAWEC Master Plan, a detailed analysis is presented concerning the components and relative sizes of the UfW in the GBA. It was estimated that the physical losses are surprisingly small – in 2005 at around 11% of water production (total abstraction).

To some extent this feature can be attributed to the general configuration of the GBA water supply system, which is characterized of being concentrated, meaning with relatively short water transmission and distribution pipe networks (small pipe lengths per capita) coupled with the closeness of the source of the water pumped from nearby

[64] *Republic of The Gambia (2010): Gambia National Agricultural Investment Plan 2011-2015.*

located clusters of boreholes (well fields) with no need of long pumping mains, which otherwise always pose a risk of pipe leakages.

For financially viable water supply schemes, where the utility's assets (transmission and distribution pipe networks, overhead reservoirs, pumps etc.) are maintained properly and replaced as required regularly, the physical losses can be kept below 10%. Nevertheless, as noted above, the estimated physical losses of 11% seem remarkable low in comparison with other larger schemes elsewhere of similar configuration and operating under comparable conditions.

In the present analysis, another approach has been followed in the estimation of the overall system losses compared to NAWEC Master Plan, and for the present (2013/14) situation is calculated as the residual part of the actual water production (ref. Table 7) after deduction of the estimated water consumption (demand) as per the procedure further highlighted in sub-section 4.3.6 below.

As shown in the tables below, using this method results in estimated physical losses in the NAWEC water supply system amounting to 22,360 m^3/day or 24.6% of total production (present situation, 2013/14).

4.3.6 Summary of projected water requirements for GBA

By applying the various assumptions and figures explained in the preceding sub-sections 4.3.1 to 4.3.5, the future water demand and water requirements for the Greater Banjul Area covering a 25-year planning period has been calculated. Two possible scenarios (i) 'do nothing' and (ii) introducing a programme targeting water demand management and water supply system's efficiency, are presented in this section.

With reference to Table 11, the first scenario builds on the assumption that a 'do nothing' ('business as usual') scenario is realized as reflected in Table 12, in which the unit consumption rate (l/c/d) is set at the 120 l/c/d (as per the NAWEC Master Plan) valid for 2040, and only a modest improvement is being achieved in the water supply efficiency (lowering of system losses) from the present physical losses of 24.6% to 20% in 2040.

The second scenario, which is presented in Table 13, reflects a stricter approach towards these water saving initiatives with the aim of maintaining a unit consumption figure at 100 l/c/d throughout the planning horizon and lowering of the supply system losses to 10% of water production by 2040.

From the last row line in the two tables it is seen that the total water requirements of Greater Banjul Area, including system (physical) losses, are set to increase from the present 127,665 m^3/day (= 46.6 Mm^3/year) to 363,353 m^3/day (= 132.6 Mm^3/year) at the end of the 25-year projection period (2040) under the 'do nothing' situation. Whereas, if a well-structured water demand management and water supply efficiency programme is implemented, the water requirements can be curtailed to 281,482 m^3/day (= 102.7 Mm^3/year) in 2040, equivalent to a good doubling up of the present abstractions (NAWEC plus 'other supplies').

Table 12: Water demand projections for GBA. Scenario: "do nothing" (m^3/day)

Item	Category	2013/14	2020	2030	2040
1	House connections (NAWEC)	47,161	65,742	107,200	162,170
2	Public standpipes (NAWEC)	5,895	7,902	11,964	16,893
3	Industrial and commercial (NAWEC)	10,611	15,465	27,408	44,766
4	Institutional (NAWEC)	2,653	3,977	7,388	12,534
5	Tourism (NAWEC)	2,190	2,540	3,243	3,945
6	NAWEC supply, sub-total (1+2+3+4+5)	68,510	95,626	157,203	240,308
7	Physical losses in supply system	22,360	30,198	44,339	60,077
8	**NAWEC water requirement, total (6+7)**	**90,870**	**125,824**	**201,542**	**300,385**
9	Solar-powered (community) systems	3,573	3,852	4,411	4,968
10	Private boreholes	9,087	11,324	14,107	15,019
11	Hand-pump supplies	5,556	5,035	4,014	2,981
12	Commercial horticulture	18,579	24,000	32,000	40,000
13	Other supplies, sub-total (9+10+11+12)	36,795	44,211	54,532	62,968
14	**Water requirement, GBA total (8+13)**	**127,665**	**170,035**	**256,074**	**363,353**

Table 13: Water demand projections for GBA Scenario: "with WDM" (m^3/day)

Item	Category	2013/14	2020	2030	2040
1	House connections (NAWEC)	47,161	63,214	95,715	135,142
2	Public standpipes (NAWEC)	5,895	6,321	9,571	13,514
3	Industrial and commercial (NAWEC)	10,611	14,602	24,216	37,164
4	Institutional (NAWEC)	2,653	3,755	6,528	10,406
5	Tourism (NAWEC)	2,190	2,540	3,243	3,945
6	NAWEC supply, sub-total (1+2+3+4+5)	68,510	90,432	139,273	200,171
7	Physical losses in supply system	22,360	25,506	26,528	22,241
8	**NAWEC water requirement, total (6+7)**	**90,870**	**115,938**	**165,801**	**222,412**
9	Solar-powered (community) systems	3,573	3,852	4,411	4,968
10	Private boreholes	9,087	10,434	11,606	11,121
11	Hand-pump supplies	5,556	5,035	4,014	2,981
12	Commercial horticulture	18,579	24,000	32,000	40,000
13	Other supplies, sub-total (9+10+11+12)	36,795	43,321	52,031	59,070
14	**Water requirement, GBA total (8+13)**	**127,665**	**159,259**	**217,832**	**281,482**

Figure 22 gives a graphical representation of the results of the projected water requirements given the two development paths (‘do nothing’/worst case and with a WDM programme introduced). It can be deduced from the graph that a water demand/water use efficiency programme aimed at maintaining an average unit consumption at 100 l/c/day and at the same time reducing the general water supply system (physical) losses to 10% of water production (abstractions) in the longer term could result in sizeable savings when it comes to the future expanded water supply infrastructure to meet demand.

At the end of the plan horizon the reduction in the required abstraction would be around 82,000 m^3/day (363,353 – 281,482 m^3/day). Under the assumption that future boreholes can yield the same volume as the existing NAWEC production boreholes, i.e. 1,400 m^3/day, this then translates into a saving in investment equivalent to close to 60 additional boreholes during the plan period. In other words, as also indicated in Figure 22, by introducing a water demand/water use efficiency programme it would be possible to postpone the construction of the 60 boreholes for another 7-8 years beyond 2040.

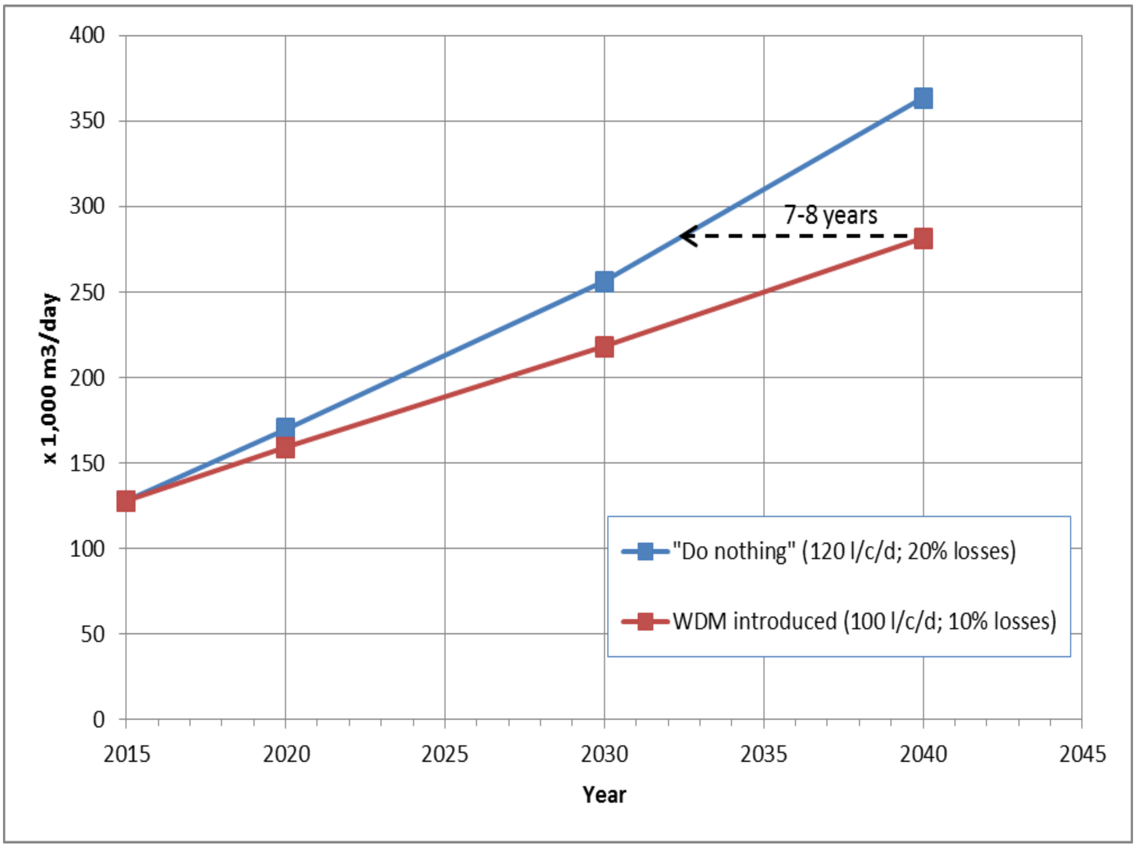

Figure 22: Water requirement projections, Greater Banjul Area

4.4 Water requirements set against groundwater potential

In Sub-section 4.2.3 (water balance at regional/national level) it is argued (i) that the four ‘rural’ regions (NBR, LRR, CRR and URR) at present abstract less than 10% of the available groundwater potential in their respective area, and (ii) that the West Coast Region at present abstracts more than half of the exploitable recharge amount available within the region. With reference to the groundwater requirement projections presented in section 4.3.6 above it is clear that the upper limit for further exploitation of the groundwater potential within the Greater Banjul Area (GBA) will be reached within the projection period, most likely in 10 to 15 years from now. This argument is valid under the hypothesis that the water supply configuration continues to develop along the same lines as has been the case in the past and that the expansion of NAWEC's abstractions will follow the pattern as presumed in the water requirement projections above.

To study this 'hydraulic dynamics' in more details, a computer-based modelling tool was introduced covering the Greater Banjul Area as described in the following sections.

4.4.1 Application of groundwater model in GBA

As a part of the NWSRP activities, a groundwater model has been setup and calibrated for the Greater Banjul Area. The purpose of the modelling is to assess the groundwater condition and to calculate an annual water balance for the area, and on that basis analyse the situation by modelling the groundwater level response when imposing future increased abstractions and also considering likely effect of climate change (scenario analysis). The software application used for the groundwater modelling is Visual Modflow Cl 2011.1, version 4.6.0.164.[65]

Input data, assumptions and calibration of the model

The model is based on available data. These data being borehole reports, water table measurements, including the NWSRP 2013 monitoring records, water abstractions, pumping tests, climate data and other relevant hydrogeological data. The model boundary, i.e. the 'cut-off' point to the east, has been determined by the hydrological feature of the prevailing swamps and water-locked areas being in hydraulic connection with the Gambia River system.

A Digital Elevation Model (DTM) was applied with a resolution of 40 m x 40 m. In the study (model) area there were no data available from the Senegal side of the border. Hence, elevation points for Senegal as required have been extracted from Google Earth and interpolated to a 200 m grid in Visual Modflow. The overall grid size for the model area is 1000 m x 1000 m, and the vertical discretization follows a 5-layer configuration identified in the established geological model.

Daily values of precipitation and evaporation as measured at the Yundum Meteorological Station were averaged covering the 1984-2012 period as presented in Figure 23. As depicted, the evaporation ranges from about 110 mm/month in September to 225 mm/month in March. Obviously, the lowest evaporation rate is realized during the rainy season.

The water (rainfall) surplus – calculated as rainfall minus evaporation – is also shown in Figure 23. Not surprisingly, the surplus only occurs in the rainy season starting by the end of June and ending in mid-October.

[65] *Groundwater Modelling for Greater Banjul Area – Model Setup, Calibration and Results. NWSRP/NIRAS (December 2014)*

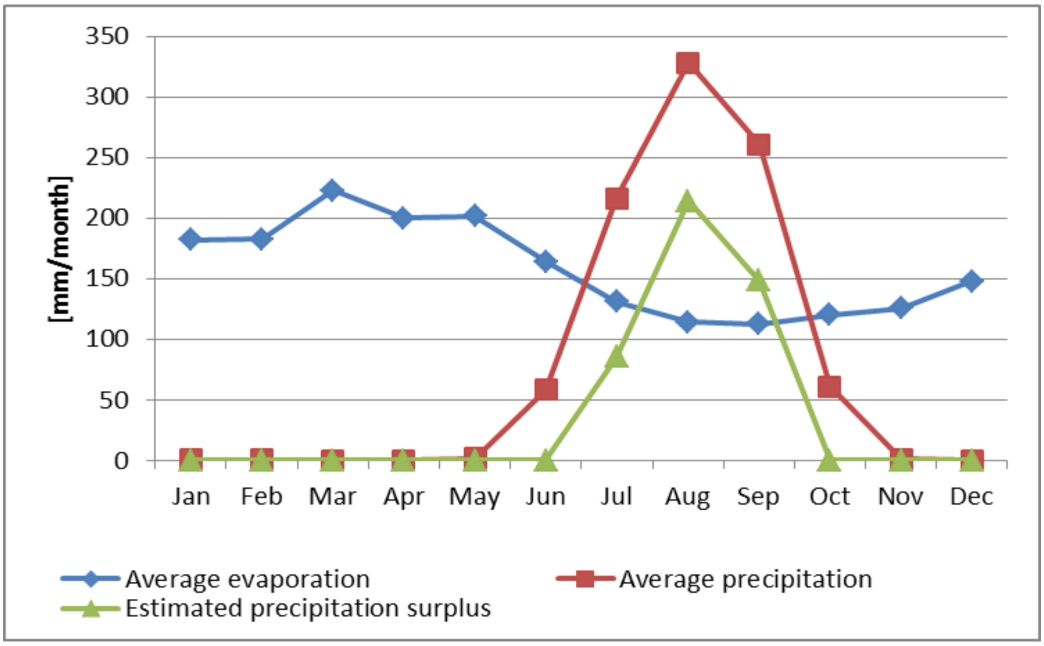

Figure 23: Monthly mean evaporation, rainfall and rainfall surplus, 1984-2012 (Yundum Met. Station)

Since the model in its present set-up is a 'static' configuration, a yearly average value for rainfall and evaporation is applied to the model. For the period 1984-2012, the average yearly rainfall surplus is about 460 mm. The value is calculated as an average of the water surplus per month for each year. For those months where the monthly evaporation exceeds the monthly rainfall, the water surplus is set to zero.

After estimation of the average water surplus, surface runoff and transpiration are subtracted to calculate the aquifer (groundwater) recharge. Surface runoff is estimated to be about 20% of the water surplus each month, and water moved from the system by transpiration is estimated to be 1 mm per day for months with precipitation surplus.

Abstraction data for NAWEC abstraction boreholes, solar pumping boreholes, hand-dug wells, commercial farms boreholes and 'fictive' abstraction boreholes to represent the unknown privately drilled boreholes are all incorporated in the model representing year 2013.

The static water level in the semi-confined aquifer has been measured on a monthly basis in 18 observation boreholes from early 2013 and is now recorded continuously by means of recently installed data-loggers in all the observation boreholes. Location and the average of the recorded water levels covering 2013 in each borehole are shown in Figure 24.

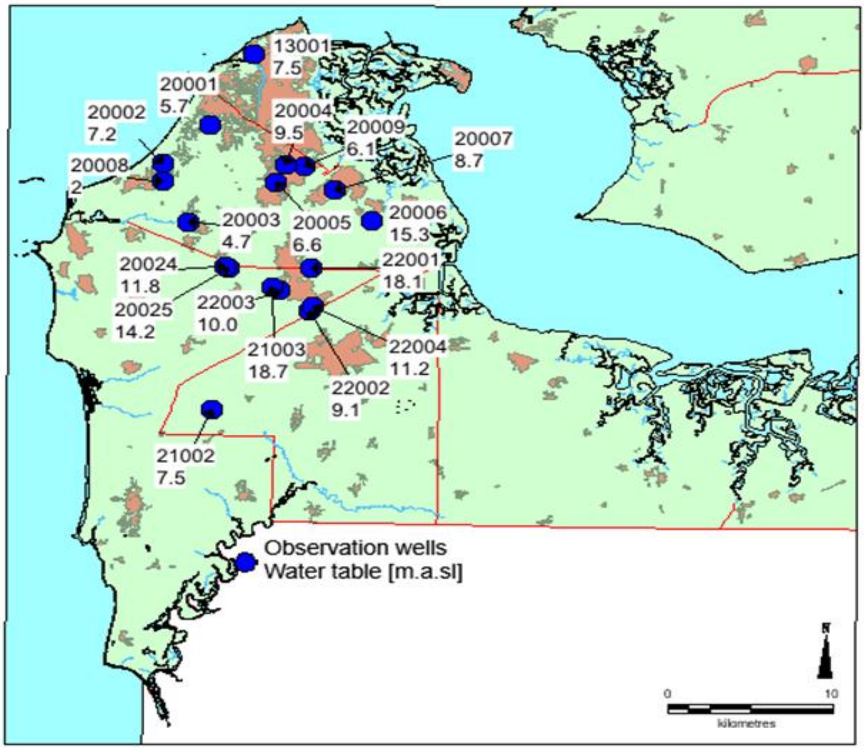

Figure 24: Location of observation boreholes in GBA

Model application representing present situation (base line)

Based on the calibration and validation of the model, the conclusion was drawn that the model is valid to simulate groundwater levels and estimate the water balance in the area of study on a larger scale. However, due to sparse data and high uncertainty related especially the measured water table and elevation of boreholes used for the geological model, it is not recommended to use the model to simulate changes on a smaller scale within GBA.

The result of the model application (ref.[65]), utilizing input data representing the 2013 situation within GBA, is given in Figure 25, which depicts the simulated groundwater table, and Table 14, which presents the water balance for the two aquifers (upper phreatic and semi-confined aquifers).

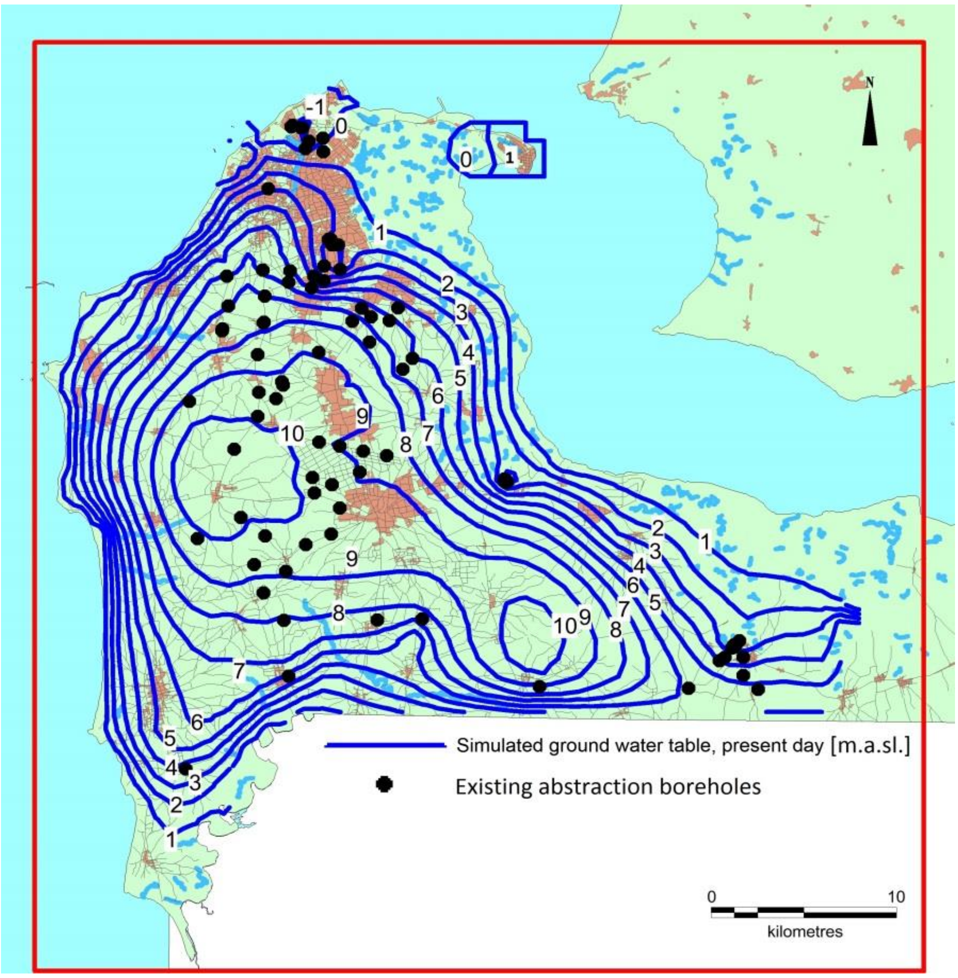

Figure 25: Simulated groundwater table contour lines for GBA (2013)

Table 14: Water balance for GBA, 2013 (m^3/day)

Water balance component	In (m^3/day)	Out (m^3/day)
Recharge:		
- upper phreatic aquifer	512,000	-
- semi-confined aquifer	214,000	-
Abstraction:		
- upper phreatic aquifer	-	3,600
- semi-confined aquifer	-	108,700
Atlantic Ocean:		
- upper phreatic aquifer	0	63,600
- semi-confined aquifer	1,700	53,600
Gambia River:		
- upper phreatic aquifer	200	63,600
- semi-confined aquifer	4,200	26,200

The largest input to the GBA is recharge, which in this case is defined as the water leaving the unsaturated zone. Besides outflow to the Atlantic Ocean and Gambia River, the largest outflow is the water abstractions from the semi-confined aquifer. Further in Table 14 it can be seen that approximate half of the recharge goes to abstractions, which is in harmony with the other – more simplified – water balance considerations presented earlier (ref. Section 4.2.3).

Table 14 also shows that there is an inflow (in general modest) of water to the aquifers from the Atlantic Ocean and more pronounced from the Gambia River. The inflow is more concentrated in the northern part of the area, where – as seen in Figure 25 – the water table is simulated to be at least -1.0 m.a.s.l. in the northern part of the Fajara area towards Bakau. It can be concluded that with a negative (meaning below m.a.s.l.) groundwater table, the abstractions here combined have reached a stage where saltwater intrusion into the aquifers are threatening and the upper shallow wells risk drying up.

This latter model result is substantiate the decision by NAWEC to decommission 6 of the old production boreholes in the Fajara well-field in 2015.

An important outcome of this study and the introduction/application of a computer-based modelling tool is a better understanding of the processes and water flow within GBA, now that data for geology, hydrogeology, climate, water abstraction and groundwater table have been combined in the model.

4.4.2 Scenario analyses

The model set-up can also be used to examine the response of the groundwater level (visualized as contour iso-lines) vis-à-vis additional abstractions in the GBA and also to test the impact of climate change. Hence, the model has been applied given the following two scenarios both relating to year 2040:

Scenario 1: A doubling up of the ‘present day’ abstraction rate to match the water demand projections towards the end of the 25-year planning horizon given that water demand management and water supply efficiency measures are introduced (ref. sub-section 4.3.6); and

Scenario 2: Superimposed on the doubling up of the abstractions, a likely climate change impact manifested in a 20% reduction in the infiltration to the aquifers (decreased recharge rate) has been tried. In a simplified manner, this scenario reflects the combined effects of a reduction in rainfall and a temperature rise.

In the scenario analyses the above mentioned 6 Fajara well-field boreholes under decommissioning have been excluded. For the purpose of the model application, the additional abstraction boreholes required to meet future demand, including substitutes for the 6 Fajara boreholes to be closed down, have been located within three new well-fields to the south and east within GBA as indicated in Figures 26 and 27. The well-fields are only ‘intuitively’ located with an even spread of the boreholes within these well-fields. It is, however, recommended in subsequent analyses that each well-field be further sub-divided into 2 or 3 sub-fields to avoid local groundwater ‘mining’.

The result of the model applications, including the water balance calculations, with input data reflecting these two scenarios are presented in Figure 26 and Table 15 (for Scenario 1), and Figure 27 and Table 16 (for Scenario 2).

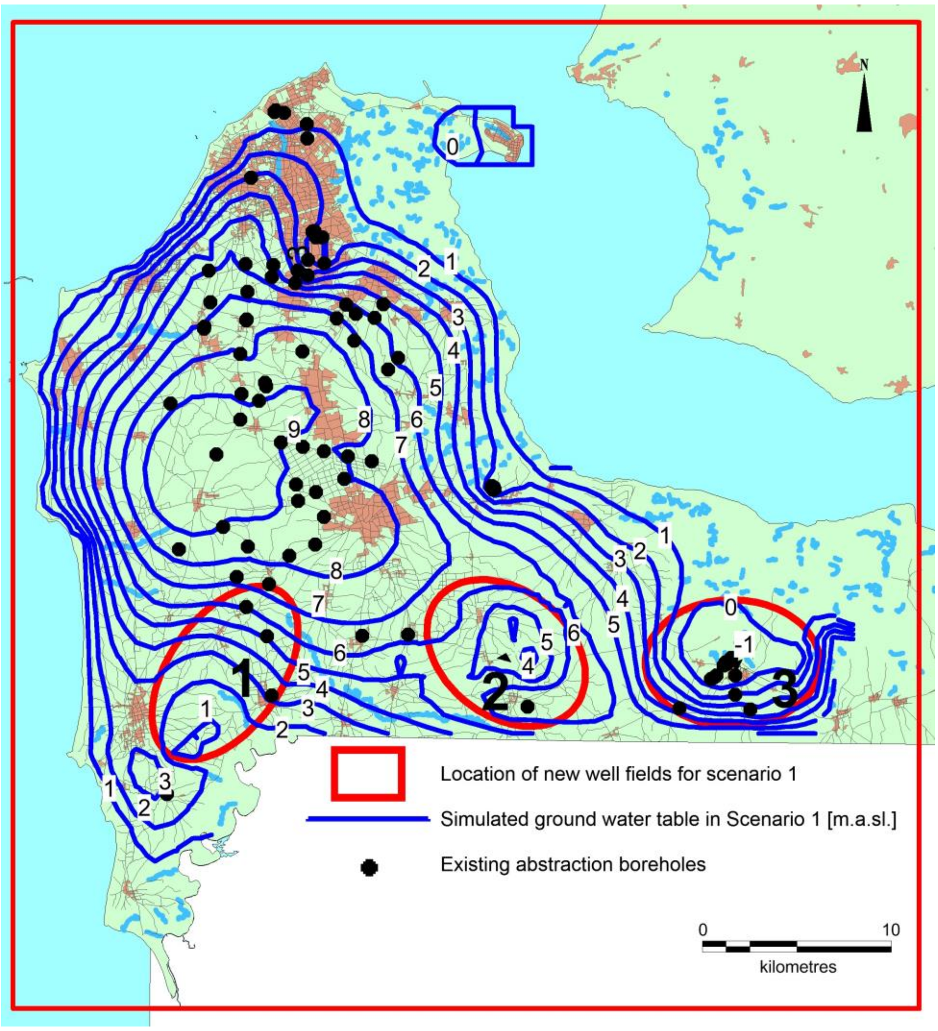

Figure 26: Simulated groundwater table contour lines for GBA (2040) Scenario 1

Table 15: Water balance for GBA (2040), Scenario 1 (m^3/day)

Water balance component	In (m^3/day)	Out (m^3/day)
Recharge:		
- upper phreatic aquifer	524,000	-
- semi-confined aquifer	280,000	-
Abstraction:		
- upper phreatic aquifer	-	3,600
- semi-confined aquifer	-	216,700
Atlantic Ocean:		
- upper phreatic aquifer	0	60,100
- semi-confined aquifer	1,000	47,400
Gambia River:		
- upper phreatic aquifer	200	60,000
- semi-confined aquifer	3,900	23,900

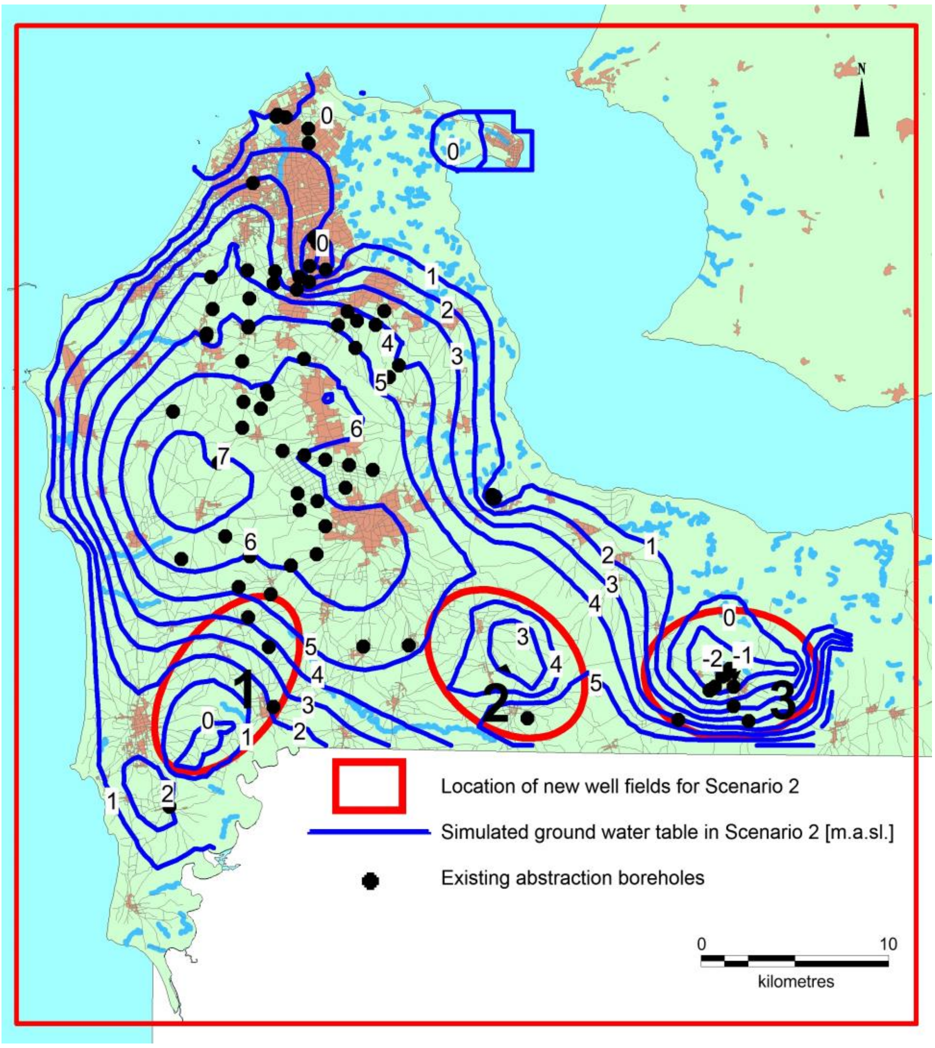

Figure 27: Simulated groundwater table contour lines for GBA (2040) Scenario 2

Table 16: Water balance for GBA (2040), Scenario 2 (m^3/day)

Water balance component	In (m^3/day)	Out (m^3/day)
Recharge:		
- upper phreatic aquifer	428,000	-
- semi-confined aquifer	250,000	-
Abstraction:		
- upper phreatic aquifer	-	3,600
- semi-confined aquifer	-	216,700
Atlantic Ocean:		
- upper phreatic aquifer	0	44,400
- semi-confined aquifer	1,300	36,100
Gambia River:		
- upper phreatic aquifer	200	43,200
- semi-confined aquifer	3,500	17,000

When comparing the three maps depicting the groundwater table contour lines, i.e. Figures 25-26-27, it is easy to detect the impact of a doubling up of the total abstraction as well as climate change effects.

The three new well-fields alter the present contour map quite substantially to the extent that in Scenario 1 the groundwater level in well-field 1 (GBA southwest) approaches the critical ‘0’, i.e. mean sea level, which indeed is realized in well-field 3 (GBA east) with groundwater level modelled to be below ‘0’ (-1.0 from mean sea level). These trends are reinforced in Scenario 2 with the climate change, i.e. reduction in groundwater recharge, added.

The contour lines are mainly affected in the southern part of GBA for the obvious reason that the three new well-fields are located there, although it should also be noted that the decommissioning of the 6 Fajara boreholes will alleviated the situation south of Bakau with the effect that the groundwater level stays above ‘0’, whereas today it is below zero. In general terms it can be concluded that moving from the present situation to Scenario 1 and to Scenario 2, the groundwater level will be lowered by around 1 meter in the central part of GBA and 5 to 6 meters in the new well-fields. In Scenario 2 this is altered with a further lowering of about 2 meters in the central part and additional 1-2 meters in the well-fields.

It can also be concluded that the location of well-field 3 is not optimal in as much as the contour lines show negative values in both scenarios. The location of well-field 3 needs to be reconsidered as part of further hydrogeological investigations at the time when additional boreholes will be required east of Brikama.

From the water balance analysis results, i.e. Tables 14-15-16, it can be deduced that an increased abstraction (Scenario 1) results in an increase in recharge to the semi-confined aquifer, and a reduced outflow to the Atlantic Ocean and the Gambia River. Likewise, in Scenario 2, a reduction in the recharge leads to a further decrease in outflow to the sea and the river.

Also from this model application it should be noted how the abstraction from the semi-confined aquifer in both scenario runs has reached an unsustainable rate of 77% of the recharge in Scenario 1 and more alarming 87% of the recharge in Scenario 2.

4.4.3 Concluding remarks on future prospects for GBA water supply

From the analyses presented in this chapter, the observation is clear that within the plan horizon of 25 years the water requirements will tap the remainder of the ‘exploitable’ recharge to the lower (semi-confined) part of the Shallow Sand Aquifer prevalent all through GBA.

In the NAWEC 2005 Master Plan four alternatives were presented and analysed as likely alternatives for augmentation of the source for the GBA future water supply system. In summary the alternatives were:

(i) Build a large-scale desalination plant to supplement the water requirements after 2020.

(ii) Build a standard water treatment plant to treat Gambia River water at a location upstream of the furthermost saline front.

(iii) Drill additional boreholes and tap further the Shallow Sand Aquifer and supplement with a number of boreholes sunk into the Deep Sandstone Aquifer in GBA, and build a water treatment plant (lime dosing and aeration only) for this deep groundwater. The Deep Sandstone Aquifer water could then be mixed with the traditional Shallow Sand Aquifer water to reduce the fluoride and total dissolved solids (TDS) levels to acceptable potable water standards.

(iv) Continue to use the Shallow Sand Aquifer by incorporating additional well sites moving south and east of the present well-fields.

Based on the economic and cost-benefit analyses presented in the NAWEC 2005 Master Plan, it was then concluded that the alternative to tap both the Shallow Sand Aquifer and the Deep Sandstone Aquifer (option (iii) listed above) would be the most financially viable option – although not much different from option (iv) – and, hence, put forward as the recommended option.

The present study opts to argue for a continuation and augmentation of the present water source/supply configuration (in line with option (iv) above), whereby the Shallow Sand Aquifer also in the future will be the backbone of the GBA water supply system.

With reference to the findings from the scenario analyses presented above, it must be realized that after a certain additional number of boreholes to be drilled in the area between Gunjur and Brikama (proposed well-field 1) and 10-15 km southeast of Brikama close to the Senegal border (proposed well-field 2), further abstraction boreholes – probably in another 10-15 years' time – will need to be located in well-fields much further to the east from the present boreholes, starting around 30 km east of Brikama. It goes without saying that this will entail higher costs related to e.g. construction of transmission mains compared to what has been the norm in most of the previous groundwater exploitations to serve the GBA population.

Having said that, this source alternative does have a number of appealing features as listed:

- continuation of a well-known and in The Gambia well-tested technology;
- convenient phasing when it comes to investments in the new boreholes (constructed and brought into the supply system when needed) meaning investments are spread fairly evenly throughout the plan horizon;
- flexibility to establish the augmented supply scheme in harmony with realities as the future unfolds (harmonization with settlement pattern, changed development trends and further evidence of climate change); and
- matching the future population growth of GBA, namely moving towards the east of Brikama, with the hydrogeological realities of having to tap additional groundwater to the east of GBA, when the 'traditional' locations and new well-fields within GBA have exploited the remainder of the usable recharge to the Shallow Sand Aquifer.

NAWEC's present (2013/14) water supply configuration for GBA incorporates 63 main production boreholes. With reference to Table 13 (item 8) in sub-section 4.3.6, the additional future water requirements projected for NAWEC (2040) is (222,412 – 90,870) m^3/day = 131,542 m^3/day equivalent to approximately 94 boreholes[66]. Of this number it is conservatively estimated that close to half of these boreholes can be accommodated in the two proposed well-field locations (indicated as well-field 1 and 2 in Figure 26) and the remaining as mentioned above in well-fields to be located east of Brikama, even east of the modelled area towards Somita.

In the future, NAWEC's abstractions will constitute some 80% of the total water abstractions in GBA, and it is further presumed that the 'other supplies' (solar-powered

[66] *To this figure should be added substitutes for the 6 Fajara well-field boreholes to be decommissioned*

systems, private and horticulture boreholes, and hand-pump supplies) can continue to tap water from the aquifer system within GBA.

It should be reiterated, that the calculations and conclusions related to future water requirements presented above have used the option whereby a rigorous water demand management and water supply efficiency programme is introduced. The impact introduced in this analysis has focussed on a lowering of the per capita consumption and a curtailing of the system (physical) water losses. Other measures can also be sought to be brought into play in such water conservation campaigns aimed at further reducing the groundwater requirements.

In Chapter 5 further details are given related to water demand management, supply efficiency, prevention of wastage and alternative water sources for specific purposes – all elements which should be considered as part of The Gambia' future water supply and water resource utilization strategy.

4.5 Surface water use

After the detailed analysis in the previous sub-chapters 4.2 to 4.4 concerning groundwater exploitation with focus on Greater Banjul Area, the other important water resources management issue concerns the use of the seasonal and perennial freshwater resources in the Gambia River system. In this section, a discussion is presented on the use of the surface water resources primarily for the purpose of rice fields irrigation set against the fresh water stock in the river with due regard to the changing hydrological regime to be realized when the Sambangalou dam project should be in full operation in a few years (scheduled for 2018).

4.5.1 Irrigated agriculture

Agriculture in The Gambia centres around the cultivation of rice, vegetables, fruits and peanuts. Salt water (>1.0 g/l) is detrimental to the life circle of all these crops coupled with soil salinity. For future agriculture, irrigation is considered to be the most profitable adaptation strategy to cope with irregular precipitation. Through irrigation, yields are expected to increase and, moreover, year-to-year variations decrease substantially. Despite its promising potential, irrigated agriculture in The Gambia has not developed as expected due to a number of issues such as drying up of suitable land resulting in increased salinity, design faults, lack of technical assistance to the rural population and other problems.

The irrigated agriculture using surface water, primarily from the Gambia River, is used only for rice production. Mixed crops (vegetables and fruits) are either rain fed or irrigated by using groundwater resources – mainly found in the Greater Banjul Area as already elaborated on in the water demand analysis in Section 4.3 above.

Although the irrigation potential undeniably is high, it is estimated that only some 3,000 ha of land at the most is usually under irrigation. There have been several soil and land 'fertility' and maintenance interventions carried out in the sector, which have led to preparedness of further 3,000 to 4,000 ha of lowlands for rice production, but implementation has not been as intended. In addition, one of the components of the current Gambia National Agricultural Investment Plan (GNAIP)[67] in a long-term perspective targets 24,000 ha of land under various lowland ecologies with the aim of

[67] *Gambia National Agricultural Investment Plan (GNAIP) 2011-2015. Republic of The Gambia (September 2011).*

expanding rice production through improved tidal and pump irrigation, freshwater tidal swamps and rain-fed paddies combined with construction of water control structures (water retention dikes and conveyance systems). This is clearly an ambitious vision, and a more likely development in the foreseeable future, i.e. the planning horizon, is to realize a much smaller area to be under irrigation for rice production – rather in the range of 9,000 to 12,000 ha – using Gambia River water.

Due to the flat topography, tidal irrigation in the flood plains along the north and south banks of the river is practiced in the Central River Region. Swamps subject to tidal flooding are also present further downstream, however, these cannot be put under cultivation during the dry season due to the saline intrusion (ref. Figure 20 and 21 in Section 3.4.2). In the Upper River Region where the river banks are much higher, pump irrigation have to be used.

Tidal irrigation is a system whereby river water flows to the fields at high tide. When preferable, the land can be drained at low tide in order to allow the rice to ripen and the soil to be cultivated. Tidal irrigation sites require high tide water levels that are high enough to inundate the fields and low tide water levels low enough to drain the fields adequately. These conditions are present in the areas situated below a 300 km upstream limit.

In the Central River Region a yet unused area of about 5,000 ha is highly suitable for tidal rice irrigation. The most prominent of these areas are depicted in Figure 28[68].

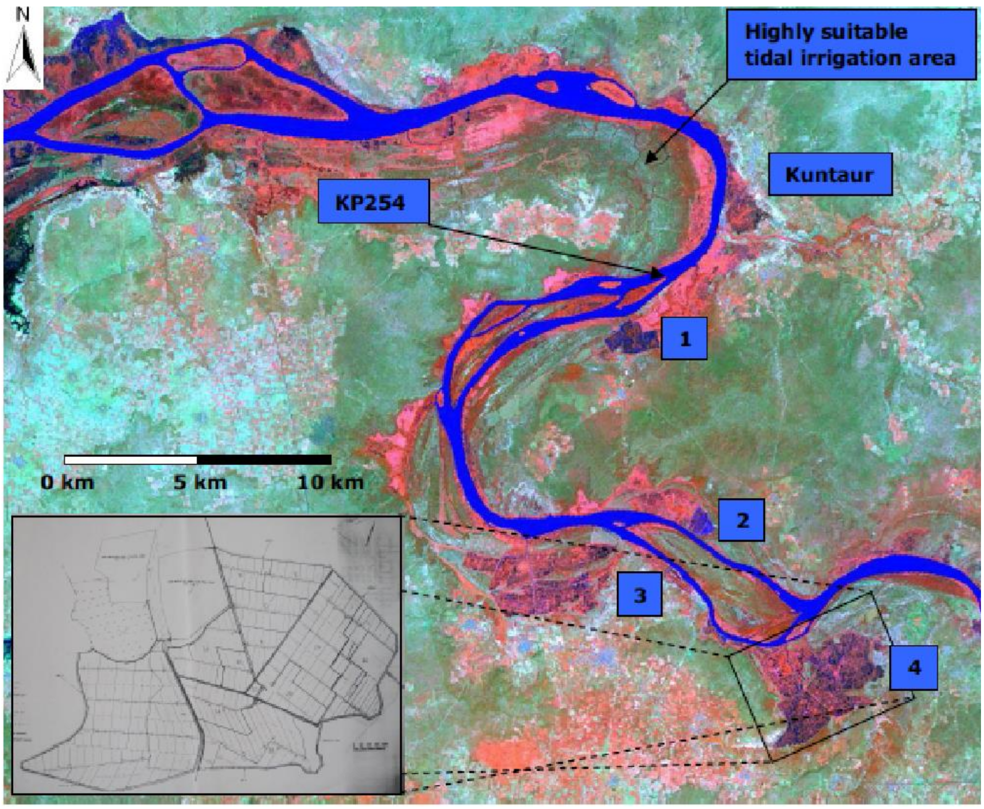

Figure 28: Tidal irrigation schemes along Gambia River
[1] Sukuta; [2] Kayai; [3] Jahaly; [4] Pacharr

68 *Saline intrusion in the Gambia River after dam construction – Solutions to control saline intrusion while accounting for irrigation development and climate change. M.P. Verkerk and C.P.M. van Rens. University of Twente – The Netherlands, 2005*

4.5.2 Freshwater availability set against irrigation requirements

Gambia River in its 'natural' state

From Table 4 in Sub-section 3.4.1 it can be found that the average flow during the four low-flow months (February-March-April-May) at Gouloumbou is 2.9 m^3/sec, and in May dwindles to below 1 m^3/sec – and nowadays occasionally literally shows no freshwater inflow at all.

To maintain the delicate equilibrium between flow and salinity intrusion, and with due regard to the riverine environment and aquatic ecosystem conservation, it is necessary to maintain a certain minimum flow during the dry season. It has previously been proposed[69] that a maximum abstraction rate in the order of 1.0 m^3/sec should be the upper limit for irrigation water abstractions during the dry season. This seems to be a most relevant recommendation under the current situation where it is possible that a further decline in the river flow – particularly affecting the minimum flow regime – will prevail with consequences such as:

- drying up of certain upstream river courses and a general decline in water levels;
- rise in the fresh- saltwater interface further than its present limits (250 km upstream) with adverse impact on the rice irrigation in the areas between Kuntaur and Bansang.

In the forward planning for the irrigated agriculture (rice) development in regard to land areas to be brought under irrigation as presented in, e.g. the Gambia National Agricultural Investment Plan (GNAIP) 2011-2015, little attention has been paid to the actual amount of freshwater available when it is needed in the dry (and low flow) period of the year. To put this in perspective, the above cited 1.0 m^3/sec limit for irrigation abstractions from the Gambia River during the low flow season indicates a total area for irrigation to sustain full rice production of not more than around 600-650 ha[70]. Having said that, it should also be considered that the river course with its vast ponds and wetland areas possesses a huge buffer (storage) 'facility' to draw from in addition to the actual flow which occurs.

Sambangalou project imposed changes on Gambia River low flow regime

In Sub-section 3.6.1, the likely impacts of the Sambangalou Dam project on the river's natural flow regime is discussed. The dam across the Gambia River will make it possible to regulate the dry season inflow into The Gambia, with the dual purpose of (i) augment the low flow regime to facilitate irrigated agriculture, and (ii) to some extent be able to 'push' the saline intrusion downstream in the low-flow season with the benefit of being able to add additional areas under irrigation.

The proposed operational rules of the hydroelectric dam project, although not known in details, indicate a release during the dry season in average of 60 m^3/sec through the turbines. As also pointed out in Sub-section 3.6.1, the portion of this flow which eventually may be available in the river when it reaches The Gambia is also not known. If it tentatively (conservatively) is assumed that one-third, i.e. 20 m^3/sec, is still

[69] *Government of the Gambia, Department of Water Resources (2002). The Hydrological Survey for Lowland Agricultural Development Programme (LADEP).*

[70] *Water requirements for rice irrigation is conventionally estimated at 25,000 m^3/ha/year (2,500 mm-equivalent) considering the location of the rice paddies in the riverine environment, which under the assumption of an abstraction of 1 m^3/sec during a half-year irrigation season translates to an irrigated area of some 620 ha.*

remaining for irrigation abstractions in The Gambia, it would indicate a potential area for irrigation of about 12,000-13,000 ha.

From this analysis it can be noted that the total area to be earmarked for irrigated rice production is not only determined by the number of hectares identified as 'suitable land', but as much determined by the availability of the Gambia River water for irrigation. In other words, the operational rules to be agreed on when the Sambangalou dam project is implemented is vital for The Gambia's prospects of increasing its much needed rice production towards achieving (at least half way or so) the ultimate target of 24,000 ha as stated in the Gambia National Agricultural Investment Plan. In this regard, the forthcoming dialogue and firm agreement under the OMVG to settle the 'guaranteed' low-flow regime needs to be pursued in a well prepared and constructive manner for the betterment of the nation's economic prospects and not least to maintain an acceptable level of food security.

Other surface water uses, including livestock

In recognition of the fact that family gardens, on which vegetables are grown in the dry season, are present throughout the rural areas, the horticultural produce from these plots can also be strengthened through water management by establishing water control structures, e.g. water retention dikes coupled with conveyance systems, and utilizing seasonal ponds in natural incurring depressions. It is complimented that the current Gambia National Agricultural Investment Plan in its identification of investment programmes focuses much on these aspects.

Such low-cost, community-based measures and interventions are also to a large extent meant to provide water points for herds of cattle and sheep/goats. Their combined water requirement country-wide is estimated within the plan horizon to increase from around 20,000 m^3/day to 25,000 m^3/day[71] equivalent to 0.3 m^3/sec – a factor which may have importance at a specific local level, but not in context of the overall national water budget.

Environmental flow requirements

Environmental water demand is the minimum river flow required to maintain the integrity of aquatic ecosystems. In the Gambian context, minimum flows also have the function of protecting investments in rice production from the effects of saline intrusion. Previous studies[72] have concluded that a river flow of 20 m^3/sec in the dry season is required to limit saline intrusion in the estuary all year round to less than 200 km upstream from Banjul. A saline front retreat of this size would then free most of the identified 'suitable' land in readiness for full-scale irrigated rice cultivation.

However, with reference to the section above concerning a future low-flow regime being made possible by the Sambangalou Dam, it is noted that a 'competition' may evolve between the use of this low-flow source, i.e. either for irrigation purpose or for pushing the saline front downstream. Obviously, the right solution will pursue a comprise between these two uses of the fresh water.

[71] *Momodou Njie (2003): National Water Security in the 1st half of the twenty-first Century.*

[72] *A. Manneh (1997): Assessment of Vulnerability of the Water Resources Sector of The Gambia to climate Change (in GoTG- USCP, 1997, pp 78-97)*

4.6 Summary of water demand estimation by sectors

Based on the figures and other information given in Table 7, which summarizes the various means of groundwater abstractions per region and nation-wide, and Table 13, which gives a breakdown of sectoral water demands covering the Greater Banjul Area, it has been possible to estimate the annual water demand of The Gambia as a whole enumerated according to economic sectors for 2014 and projected over the 25-year plan horizon, i.e. 2040. This information is provided in Table 17.

Table 17: Annual sectoral water demand of The Gambia

Economic sector / user category	2014		2040[a]		Source
	Demand (Mm^3/year)	Percentage	Demand (Mm^3/year)	Percentage	
Domestic[b]	40.4	24.0%	84.6	29.2%	Ground water
Industry	9.4	5.6%	21.3	7.4%	
Institutional	2.4	1.4%	7.1	2.5%	
Tourism	2.4	1.4%	3.0	1.0%	
Horticulture	6.8	4.0%	14.6	5.0%	
Irrigation	100.0[c]	59.3%	150.0[c]	51.8%	Surface water
Livestock[d]	7.3	4.3%	9.1	3.1%	
Total	**168.7**	**100%**	**289.7**	**100%**	

[a] *Based on the water demand projection scenario which includes introduction of water demand management and water use efficiency measures to curtail losses and wastage of water.*

[b] *In the domestic water demand projections it is included that the coverage of population served will increase from the present 70% with access to 'safe' water to 90% by 2040.*

[c] *These figures should only be considered rough estimates and of guiding nature. In this overview they are based on an assumed area under irrigation (tidal and pumped irrigated rice cultivation) of 4,000 ha in 2014 growing to 6,000 ha by 2040, and with water requirement for rice irrigation conventionally set at 25,000 m^3/ha/year.*

[d] *Ref. sub-section 4.5.2, third heading.*

5. WATER DEMAND MANAGEMENT AND SUPPLY EFFICIENCY

5.1 'Supply-side' and 'demand-side' water resource management

The common approach to water resources development – also in The Gambia – has focused on developing new supplies and infrastructure to meet perceived water needs. This water supply management approach considers water needs as requirements that must be met, and not as demands that may be variable and controllable.

The 'water demand gap' between the projected water demand and present water supply infrastructure during the plan period (2040) as elaborated on in sub-chapters 4.3-4.4 above should be met not only from the construction of new sources of supply, but also through implementation of a targeted program aimed at introducing a range of *water conservation and water demand management measures* to reduce the perceived water requirements.

In the literature the term *water conservation* is often referred to as initiatives towards minimization of water loss or waste, preservation and protection of water resources, and the efficient and effective use of water. On the other hand, the term *water demand management (WDM)* is commonly referred to as the adaptation and implementation of a strategy (policies) by a water utility or authority to influence the water demand and usage of water to meet a number of objectives, e.g. economic efficiency, social equity, environmental protection, and sustainability of water supply services.

In spite of the differences in the definition, the meaning and implications of these terms are nevertheless very similar, and hence in this chapter the two terms are used synonymously.

The alternative approach places water demand itself – not immediately structural solutions – at the centre of concern, and only develops capital-intensive structures after opportunities have been fully analyzed for lowering or mitigating the proposed demands in a more socio-economically beneficial manner. In other words, water demand management deals with a reduction of the need to expand traditional water supply sources, e.g. further groundwater abstractions.

In contrast to conventional approaches, demand management is much more aggressive in its use of economics to influence water usage, and it depends critically on raising public awareness, on adopting a number of technical and legislative/regulative measures to improve the efficiency of water usage, and to expand the use of non-conventional sources to supplement the traditional sources of water supply.

Table 18 provides an overview of potential benefits and likely constraints associated with the introduction of water demand management programs[73].

[73] *Adopted from Department of Water Affairs, Botswana, 'National Water Conservation Policy and Strategy Framework' (NIRAS, November 1999).*

Table 18: Benefits and constraints of water demand management programs

Benefits to be derived from Water Demand Management Programmes	Obstacles and constraints in introducing Water Demand Management Programmes
• May reduce water demands considerably with no deterioration in lifestyle. • Sizeable reduction in capital requirements can be the result. • Assure adequate funding to sustain water services and to provide expansion where required. • Promote development and adoption of new technologies. • Provide enduring solutions to water pollution problems. • Develop a more water conscious public able to understand issues involved in water service provision. • Facilitate improved consumption monitoring procedures to serve as basis for better approaches to analyzing water demands.	• Financial constraints; funds are often made available for supply-side management options, whereas little is made available for demand management initiatives. • Resistance to change by politicians and water utilities. • Water conservation measures are perceived only as drought relief mechanisms. • Fears that water conservation will result in reduced service levels. • Supply-side management options appear easier to implement. • Lack of understanding of principles, scope and potential of demand management. • Demand management strategies are often incorrectly perceived as punitive measures to consumers.

5.2 Introduction of a water demand management (WDM) programme

In spite of the fact that The Gambia appears to have sufficient water resources available to maintain an acceptable level of 'water security' to meet future demands, including requirements related to the economic development and social uplift of the population, it is also a fact that seasonal water scarcity and shortage of water occur more frequently than before. Furthermore, because of the limited spatial extent and being located at the downstream end of a large river basin, it is in a vulnerable situation concerning adaptation to the impact of climate change (possible decline and altered variability in annual rainfall) on the replenishment of the water resources.

Experience shows that the success of any broad-based national water conservation programme hinges on an array of factors:

- firstly, it is of importance that an articulated political support exists, including adoption of facilitating regulations;
- secondly, it is also important that a commitment to the cause and capacity to handle the issues are prevalent among water administrators and water providers such as DWR and NAWEC; and
- thirdly, since we are all water users, water conservation is one important area in which everybody can play their part – and in order to sensitize the population about the importance of conserving water, a major public education and awareness raising campaign is needed. In this regard NGOs, schools and colleges of education as well as the media (newspapers, radio and television) have a crucial role to play in winning public support for the cause.

The technologies, educational and public awareness measures as well as other instruments of economic and regulative nature, on which to base a holistic water conservation and demand management program are all available, and as such has been applied and in use in different settings in many parts of the world. Therefore, the situation in The Gambia does not call for a re-invention of ideas, but rather requires a sound and realistic assessment of the available measures to ensure their feasibility and adaptability in the Gambian context in terms of social acceptance, costs and expected impact on the water sources to be protected.

5.3 Water demand management measures

An outline of the strategies and measures to be considered for implementation as part of a multi-faceted water conservation and water demand management program is given below. The various methodologies of managing water demands have been grouped in categories in accordance with the intervention being sought, i.e. technical measures; public awareness education; and water pricing and regulative measures. It should be noted, that the interventions and strategies are not presented in any order of priority.

5.3.1 Technical measures

Water efficient devices in buildings

In new buildings a prerequisite would be to review the Building Code and Regulations to ascertain that water efficient devices and plumbing fittings are stipulated (made mandatory) for water and sanitation installations in all new buildings. Examples are:

- low-flow shower heads,
- low-volume toilet cisterns and dual flush toilets,
- self-closing taps in public, institutional and commercial establishments,
- accurate water meters,
- water pressure reducers,
- flow controllers, and
- self-closing yard and public water point taps.

In existing buildings, retro-fitting of fixtures, which refers to modification of existing water systems to lower water use, should be carried out. Retro-fitting of plumbing fixtures in private houses and use of water efficient household appliances cannot be made mandatory, but should be promoted as much as possible. Consumers should be informed – and hence convinced – that modest investments in these devices are paid back within a relatively short period of time due to the subsequent savings on the individual households' water accounts.

It is a known fact that public institutions tend to realize high water consumption, among other things caused by a poor state of repair of their water and sanitary facilities. Government, or the institution concerned as the case may be, should initiate a re-fitting programme with water efficient fixtures focusing on taps and cisterns/urinals.

Water-wise gardening and landscaping

Water-wise gardening should be promoted much more than it is today. The fact is that gardens in average consume about 20% of all domestic water used in the urbanized high-cost residential areas in The Gambia. The concept of water-wise gardening combines creative landscaping, use of indigenous plants and conservation principles with efficient watering practices.

Furthermore, architects, planners and landscapers should be encouraged to create water efficient designs. Many of the physical features of The Gambia' evolving urban environment are water intensive: sports grounds, median strips, parks, shopping centres, public building complexes and so forth. A careful design of these green features and recreational areas in the urban settings can help avoid unnecessary water use.

Rainwater harvesting for households and institutions

Roof catchment systems as back-up and supplementary supply for public buildings such as schools, government institutions and larger residential compounds have clear potential. The above suggested review of the Building Code should also consider an introduction in the use of roof catchment systems on new buildings to reduce the load on the piped supplies, specifically for outdoors purposes like garden watering, car washing and other cleaning purposes.

Re-use of 'grey' water and recycling of wastewater

Recycling of wastewater refers to the process of reclaiming the water by restoring it to its original quality, whereas re-use merely refers to the use of (partly) treated wastewater for purposes which do not necessarily require quality standard of potable water. One important obstacle to the concept of using reclaimed water is the rather general attitude among consumers towards wastewater effluents. Here public education efforts definitely would have their role to play.

At the individual household level, the general public should be informed about the advantages of adopting a lifestyle of re-using the 'grey' kitchen water and other rinsing water generated in their homes for purposes of watering plants and vegetable gardens. A number of relatively inexpensive technical gadgets to intercept and direct the 'grey' water flow are commercially available.

For larger institutions, like hotels and lodges, not attached to water-borne sewerage systems, the Building Code should be amended to stipulate – where appropriate – the introduction of reed-bed/pond (often referred to as 'constructed wetland') purification structures to facilitate safe use of wastewater specifically for external use of watering gardens and grass fields (golf courses). Commendable initiatives along these lines are already being practiced today at some of the larger tourist lodges and resort areas.

Figure 29 presents a flow diagram giving principles of water recycling process.

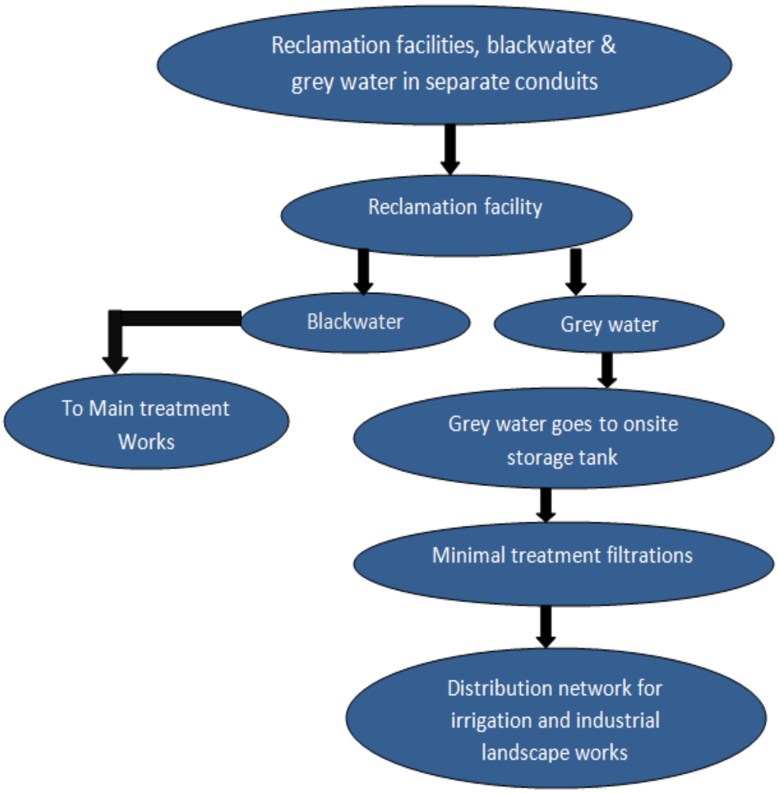

Figure 29: "Grey" wastewater recycling principles

5.3.2 Public awareness raising and education

A cornerstone in any water conservation and demand management programme is to create awareness among water users, administrators and politicians for the need to conserve water. People are often quick to demand freshwater, but slow to accept responsibility for conserving and protecting it – although it should be emphasized that most people do not waste water on purpose. Excessive water use is often due to lack of understanding of the resource, having no skills to manage it and lack of affordable alternatives. With the right information and knowledge provided, all users should be in a better position to use water in a more prudent manner.

The general aims of such public awareness raising and education campaigns are:

- to promote awareness of water in daily life; this would develop awareness outside of crisis situations such as droughts;
- to promote awareness of conservation issues and the links to environmental quality aspects;
- to promote awareness of the economic benefits produced by water savings;
- to promote awareness about unauthorized consumption/theft;
- to provide an understanding of the possible need for higher prices (tariffs); and
- to promote and hence readjust The Gambia towards being a water conscious and water efficient society in general.

A public awareness programme should play on several strings to achieve an impact. It should be targeted the various segments of society either individually or as a group, and as appropriate it should be able to address issues on an acute 'crisis' basis or be looked at as a long-term investment. In particular, water efficiency education within the agricultural sector seems to have been missing so far.

The activities and methods most likely to be applied in these campaigns can be grouped as outlined in the following paragraphs.

Educational activities in schools and colleges

Water conservation issues must feature prominently in educational material and be incorporated in curricula development on a broad basis. Likewise, production of learning materials for formal and non-formal education will be required. Other activities under this heading could be development of school/learner activities, e.g. demonstration projects, school competitions, award programmes and drama venues.

Promotional material and activities

An important aspect of public education and awareness campaign activities is the production of brochures, leaflets and posters to advocate the use of water efficient devices and water conservation practices in general. Also well edited promotion efforts to sensitize the public through the media, i.e. newspapers, radio and television, should be part of the strategy. It can also be noted that commemoration of special events like the World Water Day provides a powerful platform to spread messages.

Customer advisory services

Customer advisory services on the efficient use of water at household level, in the gardens etc. should be provided, for instance in collaboration with nurseries. Publications and discussions should be followed up with demonstration projects. Water audits and technical information on water saving methods should be provided free of charge to industries by specialist staff from DWR, NAWEC or elsewhere.

5.3.3 Water pricing and regulative measures

An appropriate pricing policy is central to any water demand management strategy. The role of water charges and subsidies as instruments in promoting a sustainable water supply sector can be summarized as follows:

- higher prices will normally have three positive impacts, namely (a) they generate funds for required investments and maintenance, (b) they may (depending on the price elasticity of demand) stimulate efficient water use, and (c) they render non-conventional water supply and conservation techniques more economically feasible.
- subsidies have a mixed impact. They are necessary to guarantee adequate access to water for all citizens to meet their basic needs, but at the same time, they may lead to wasteful resource use. Therefore, subsidies must be clearly targeted and managed to benefit the least privileged segments of society only, and to facilitate households and the private sector in general to invest in water saving devices;
- unbilled authorized water services. This term is normally defined as metered consumption which is unbilled for various reasons, including e.g. water supplied to government institutions free of charge or consumption by the water utility itself. Often higher level political interventions are required to rectify such situations. Undoubtedly, a strategy to, firstly, increasing the number of metered connections, and secondly, to fully bill all metered consumers will improve not only the revenue base of NAWEC, but importantly also the efficient utilization of the water resources, i.e. assist towards lowering the future water requirements.

A prudent policy governing the water sector is to price water resources where possible to cover all costs so that the water services are financially sustainable without government subsidies. This approach also adopts pricing policy as an integral part of a demand management strategy to influence the quantities of water resources supplied and used.

Furthermore, an important part of a long-term water demand management strategy is also to introduce a conducive water abstraction permit system. Water abstraction licensing is a powerful tool to both manage and guide future demands for water. It should be noted that the proposed new water legislation has incorporated the notion of a water abstraction licensing system.

5.4 Efficiency and productivity improvements

Unaccounted-for water (UfW)

It is a known fact that the amount of water wasted in older and expanded piped water supply systems – whether it occurs at source, in transmission mains or in distribution networks – counts for a sizeable portion of water abstracted; and The Gambia is no exception. Section 4.3.5 above discusses the prevailing situation with regard to the proportion of 'unaccounted-for water' (UfW), i.e. non-revenue water and physical losses, in the water supply systems. As far as the measurable impact on water saving is concerned, reduction in the amount of UfW can well be the single most important area to direct funds and efforts initially as part of a national water conservation programme.

Furthermore, a number of additional measures should also be put in place aimed at lowering the non-revenue water and utilizing the present water abstractions in the most optimal and efficient manner. Some examples are:

- All water supply system components must be designed appropriately and constructed accordingly, i.e. over- and under-design should be avoided, and in accordance with sound water conservation principles.
- Pressure reduction below conventional standard values, particularly during night time, should be considered.
- Preventive maintenance, including leakage detection with immediate repairs and systematic pipe replacement programmes, must be in place, and should be followed vigorously.
- Regular water balance calculations should be carried out on a pressure zone basis within the individual water supply systems.
- Water metering must be carried out efficiently with the water meters to be relocated over ground, and the subsequent billing must be customer friendly and informative.
- Water use audits should be conducted of all major water users (industrial, commercial, institutional and the larger hotel/lodging facilities) by professional staff from NAWEC or elsewhere. The aim is to identify existing water use pattern, detect clear cases of over-consumption and potential for saving.

It is important that the above measures to lower the utility's 'own' water consumption are carried out with proper information disseminated to the customers. If this is done it will provide an assurance to the industrial/commercial and irrigated agriculture sectors, and the public at large that water conservation issues are taken seriously and remain high on the agenda of the utility. At the same time these measures will most likely have a catalytic effect and provide a form of moral incentive and reason for the various water consuming sectors and individual consumers also to take their part in the water conserving activities.

Borehole design

Since all potable water and much of the horticultural irrigation requirements are based on groundwater abstractions, an important factor to consider in improving water productivity is to exploit the groundwater resources in the most optimal manner.

It is imperative that the boreholes and groundwater abstraction systems are based on state-of-the-art hydrogeological assessment methods, efficient borehole siting techniques as well as proper design, construction and development of the boreholes. The drilling depth should be sufficient to penetrate the water yielding zones and to accommodate the seasonal fluctuation of the water level even in very dry years, including the drawdown caused by the pump.

The decision about the use of a new borehole as a production borehole and the operational yield should be based on proper pumping tests. This involves determining the long-term and short-term hydraulic behaviour of the aquifer and the borehole to avoid future over-pumping with resulting clogging of borehole screens and subsequent increased draw-downs.

It is also implied that future groundwater abstractions may have to be rely on larger diameter boreholes than usually constructed to obtain the required amount of water, and also would need considerably longer pumping mains to bring the groundwater the well-fields to the point of utilization.

New boreholes should not be sunk in along the sea coastline and in the vicinity of flood plains of the Gambia River and its tributary network, where salt- and brackish water persists. A distance of at least 2 km is recommended to avoid salt water intrusion in the boreholes.

5.5 Physical measures towards water loss reduction

Water conservation targeted on an individual basis, and applicable to The Gambia is well documented, inter-alia:

- refrain from running the tap when it’s not necessary;
- use water saving devices such as press taps, aerators on taps to produce the same pressure while using less water, low flow toilet flushing or shower head mechanism, inclusion of a water bottle within a toilet cistern, etc.;
- repair leaks without delay;
- car wash and gardening, if possible in the wet season, using rainwater collected from the roof;
- recycling grey water for gardening and irrigation.

In many instances, the shortage of water experienced at destination is not as much due to actual supply shortage as it is due to inefficient individual plumbing systems, corroded pipes and fittings and numerous bends in the plumbing system.

Corroded galvanized iron pipes and fittings impact very adversely on the performance of a home plumbing system. Chlorinated water corrodes the internal lining of galvanized steel pipes and fittings at a very fast rate, and the build-up of corrosion constricts the pipe bore, reducing residual pressure at delivery quite drastically. Another major problem with the plumbing system is the proliferation of low quality defective pipes and fittings in the local market.

5.6 Non-conventional water sources

Desalination

Normally, potable water derived from desalination is only considered a viable alternative to conventional water sources if a real water scarcity is prevalent, which is not the case in The Gambia. In spite of recent advances in membrane technology, the desalination process is still expensive and impractical on a large scale, but as an interim and emergency measure – it may be useful at a few locations where the need to expand the distribution system may be excessively costly.

Desalination is presently not used in The Gambia. It should be emphasized that where desalination is practiced on a larger scale elsewhere in the world, it is usually because there is a relatively cheap source of energy available, which permits the water to be used for low value activities.

Artificial recharge of groundwater aquifers

Injection and infiltration into groundwater aquifers of surface water during times of excess surface runoff could attribute to water conservation through diminished evaporation and yet increased storage capacity. From a water resources management point of view, the concept represents an ideal and advanced solution to practice conjunctive use of surface water and groundwater, and at the same time an opportunity to enhance the efficiency in the utilization of existing supply sources.

However, due to lack of data on actual storage capacity available within the aquifers, location of suited artificial recharge sites, and for that matter on the recovery rates to be expected on retrieval, requires further applied research on a realistic scale to prove the feasibility and viability of this option in The Gambia.

5.7 Rainwater harnessing for agriculture use

Rainwater harnessing for agricultural use is one of the priority areas advocated in the ongoing National Agricultural Investment Plan[74] (often referred to as Water for Productive Use) based on the following considerations:

- contribute to increased food-security by facilitating increased cultivation productivity and expanded area under irrigated agriculture;
- contribute to increased income generating capacity of vulnerable groups; and
- contribute to a better and expanded capacity of livestock rearing by providing cattle watering accessibility through an increased number of well-spaced water points.

The rainwater harnessing infrastructure will typically combine water storage facilities such as small dams, water retention dikes, treatment of natural occurring landscape depressions (pond sites) to lower bottom leakage – all combined with innovative alignment of conveyance canal systems (lined or unlined).

5.8 Concluding remarks on water demand management

Against the background of the discussions in the previous sections, it should be reiterated that the projected water requirements for the potable water sector presented in

[74] *Gambia National Agricultural Investment Plan (2011- 2015), The Republic of The Gambia (Sept. 2010)*

Chapter 4 incorporate the anticipated results of the ongoing – albeit long-term – investment programme by NAWEC to reduce the proportion of the physical losses as part of the UfW of the total water production. The aim is gradually to have it lowered to 10% – or even below – towards the end of the planning period. Undoubtedly, the reduction in UfW is the single most important *‘supply-side’* management measure in determining future water requirements.

Likewise, as seen in sub-section 4.3.6 (second development scenario, Table 13) other water use curtailing possibilities within the category of *water demand management* measures as outlined above have been factored into the water demand projection calculations manifested in a lowering of the unit consumption rate from 120 l/c/day to 100 l/c/day. Other measures such as rainwater harvesting at institutional and household level and re-use of ‘grey’ water must also be considered aimed at lowering even further the demand for piped NAWEC water.

With the uncertainty imbedded in any forecast which reaches out to a planning horizon of 25 years, it can be argued that the mechanisms and measures included in a multi-faceted long-term water demand management campaign in many respects can be considered a well perceived strategic initiative to assist in coping with likely climate change impacts. It is imperative that such strategies and initiatives be pursued in tandem with the further planning for construction of additional water mobilization infrastructure. Experience shows that a mix of ‘supply-side’ and ‘demand-side’ measures yields the most tangible results.

In conclusion, the major issues in water resources management in The Gambia are set to revolve around protection of water resources, prudent water use, including public awareness raising, demand management interventions, and development of water supply and transmission infrastructure to facilitate and sustain economic growth and promote social well-being.

PART III

STRATEGIC PLAN

(Chapters 6, 7 and 8)

6. STRATEGIC INTERVENTION AREAS

6.1 Rationale and objectives of the strategy

Rationale

To provide the necessary improvement in management of the nation's water resources, and to establish a platform for informed and balanced decision-making on water resource exploitation, the Government of The Gambia prepared a National Water Policy (2006) and an ensuing IWRM Roadmap for The Gambia (2008).

The Roadmap comprised a number of priority actions to facilitate the transition from the then prevailing unsatisfactory water sector management practices to a fully-fledged, mainstreamed integrated water resources management paradigm. During the National Water Sector Reform Project (2012-2015) the pertinent actions/interventions outlined in the Roadmap were addressed and advanced considerably. The present strategy and identified strategic intervention areas logically take departure point and build on the foundation now created as result of the activities carried out under the National Water Sector Reform Project.

These 'building blocks' (or 'tools') can be summarized as follows:

- Reorganization of the present institutional set-up with establishment of two new authorities decided on with the proper documentation prepared, inclusive of 5-year Business (Strategic) Plans[75].
- New water sector legislation prepared, including three legislative bills ready for enactment by the National Assembly[76], cabinet briefing papers and draft priority regulations.
- New 'modernized' water resource data collection networks in place, including 38 monitoring boreholes, 8 surface water observation/monitoring stations equipped with data-loggers, 2 automatic weather stations and upgrading of the DWR water quality laboratory.
- A water resources management information system (national database for water related data and information) established and existing data imported to the GeODin database.
- Groundwater modelling software application (Visual Modflow) introduced and annual water balance modelled covering the Greater Banjul Area.
- Formal diploma and M.Sc. training of a number of staff, and on-the-job training carried out in the use and maintenance of the new equipment and software.
- IWRM Communication Strategy prepared and public awareness raising activities piloted in two regions (Lower River Region and Kanifing Municipal Council), ready to be rolled out country-wide.

[75] *The authorities are: National Water Resources Management Authority (NWRMA) and The Gambia Meteorological Authority (GAMA).*

[76] *The legislative bills have been subject to' public hearing' following the normal process of being vetted at a Validation Workshop. Furthermore, members of the National Assembly were also consulted and briefed about the intent and implications of the proposed legislation as part of drafting the bills.*

The above listed 'tools' are interrelated and need to be looked at in conjunction, but together have created a platform on which concrete activities now can be launched aimed at consolidated the IWRM paradigm fully.

Objectives of the strategic plan

The general objective of the Strategic Plan for water resources management is to provide the National Water Policy and the IWRM Roadmap for The Gambia with the required implementation guidance and technical direction to fully establish a sustainable framework for managing the nation's water resources whilst adhering to IWRM principles founded on an enabling legal and institutional framework.

The more specific objective of the strategy plan is that the institutional, legal and technical framework now created under the National Water Sector Reform Project shall be made operational during this (first) strategy period, and routinely applied practically to plan for and manage and regulate the water resources with the aim to maximize socio-economic development in an equitable manner and at the same time safeguarding The Gambia's environmental integrity.

6.2 Strategic intervention areas

In the preparation of the strategic plan, it has been convenient to define a number of broad categories of issues that can be referred to as 'key strategic areas'. While these are to some extent overlapping, it is useful to do this categorization as a step towards identifying and defining the activities to be carried out aimed addressing the water resources management issues.

The strategic intervention areas address water resources management issues encompassing the full array of IWRM, viz. enabling environment (legislation and regulative framework); institutional framework (creation of new authorities); and management instruments (assessment, information and allocation instruments). However, feasibility studies, pre-design activities etc. exclusively directed towards investment in water infrastructure, e.g. augmentation of water supply facilities, e.g. borehole constructions, and irrigation infrastructure, are not part of the key areas and derived interventions under this strategic plan. These aspects are handled under the responsibility of the respective 'implementing' institutions and departments, e.g. NAWEC, DWR Rural Water Supply Division, Ministry of Agriculture etc.

To achieve the objectives given above, the following strategic intervention areas will be addressed:

- Strategic Area 1: Legal and institutional transformation
- Strategic Area 2: Water resources information and knowledge
- Strategic Area 3: Water resources development and monitoring
- Strategic Area 4: Climate change implications and ecosystems
- Strategic Area 5: Trans-boundary water sharing and collaboration
- Strategic Area 6: Stakeholder awareness and participation
- Strategic Area 7: Human resource development

7. ACTIVITIES BY STRATEGIC AREAS

7.1 Strategic Area 1: Legal and institutional transformation

During the National Water Sector Reform Project (NWSRP) compilation and analysis of the laws of The Gambia and relevant water sector documentation were made, and on that basis a legal audit was completed in preparation for drafting the new legislation. A drafting process, depicted in Figure 30, included a sequence of three drafts and two technical workshops after which final drafts were prepared and presented at a validation workshop.

Figure 30: Legal drafting process

Advocacy and promotion was undertaken with key stakeholders and also with the National Assembly Select Committee on the Environment. Additionally, close liaison with the Ministry of Justice was maintained throughout the drafting process. This process concluded with the delivery of:

- The Gambia Water Bill
- The National Water Resources Management Authority (NWRMA) Bill
- The Gambia Meteorological Authority (GAMA) Bill
- Cabinet Briefing Papers
- Draft Gambia Water Use Regulations
- Code of Conduct for the Development and Use of Groundwater
- Legal Audit and Transposition Tables

The Gambia Water Bill is a framework Bill which establishes the principle legal elements of Water Law in The Gambia, beneath that Bill are the two bills to establish institutions as shown in Figure 31. The Bills allow for subsidiary regulations which are intended to contain aspects of the law that will change regularly such as fees and fines.

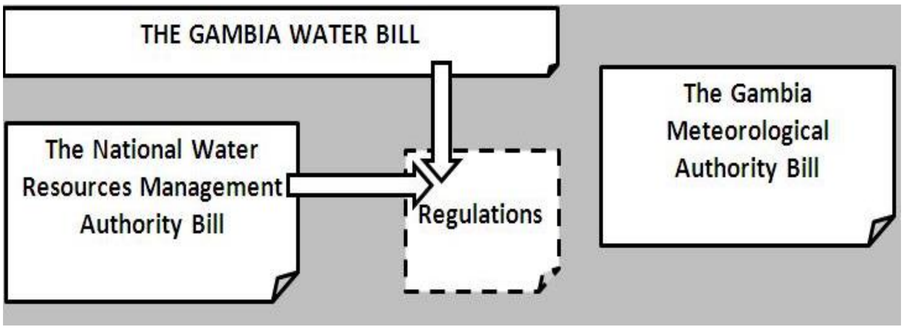

Figure 31: Overall structure of new water legislation

Necessary powers and responsibilities are established in the Bills. With regard to water permits there are enforcement tools, including the appointment of inspectors, serving an administrative fine and serving compliance notices. This enforcement system is shown in Figure 32.

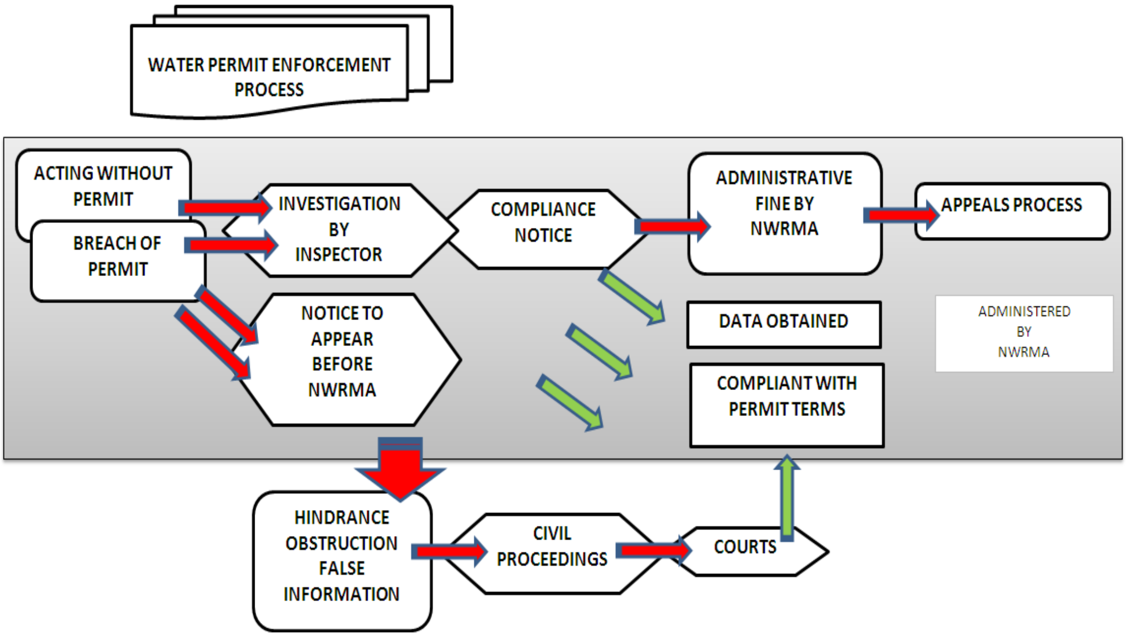

Figure 32: Water permit enforcement process

Subsequent to the new Bills being submitted to the Ministry of Justice for final scrutiny and tabling of the Cabinet Briefing Papers, it is expected that the bills will be enacted by the National Assembly in 2015. With the enactment of these Bills further input will be required to operationalize the Acts, in particular to enable the new National Water Resources Management Authority (NWRMA) to fully utilise the powers and procedures available to it in order to meet its responsibilities.

During its first period of operation (establishment phase), the recently prepared business (strategic) plan to guide the NWRMA[77] is framed around the following objective:

"*Capacity of NWRMA enhanced in fulfilling the mandated role that aims at promoting IWRM with focus on abstraction regulation, water demand management, pollution monitoring and water resource assessment activities*"

It can be stated that the activities stipulated below towards addressing Strategic Area 1 at the same time also provide the platform for dealing with the NWRNA business (strategic) plan to some extent.

Strategic Area 1 (legal and institutional transformation) will be addressed through implementation of the following activities/interventions:

Activity/Intervention 1.1

<u>Finalize the regulative framework</u> to make the new legislation 'operational', including:

- the Water Use Regulations (draft prepared under NWSRP) and develop additional regulations as required;
- drillers' licence and borehole construction regulations to be built upon the Code of conduct for the Development and Use of Groundwater (drafted under the NWSRP activities); and
- information/awareness campaigns to educate and brief about the new legislation targeting the public, private sector, governmental institutions etc. using various means of communication (ref. Strategic Area 6)

Activity/Intervention 1.2

<u>Provide modalities for effective coordination in the water sector</u>, including:

- working procedures (operational guidelines) to create a well-functioning National Water Resources Management Board and internal linkage to the Authority;
- establishment of collaborate technical committees across sectors (roles, functions and composition) based on MoUs between NWRMA and e.g. NEA, NAWEC, PURA and Local Government Authorities on management of water resources.

Activity/Intervention 1.3

<u>Introduction of the water use (abstraction) permit system</u>

The commonly accepted method to implement and regulate water use is by means of granting the users abstraction permit. The new Act authorizes the NWRMA to manage and administer the water use permit system, to process and approve applications, to keep a register of permits, and to monitor and enforce conditions attached to water licenses, including the cancellation of a license and suspension of activities when conditions are violated.

One of NWRMA's main revenue sources will be from raw water charges remitted by the water users/providers (abstractors) as part of being granted a water permit, which then will contribute to the sustainability of the Authority's IWRM activities and NWRMA's operations.

The steps towards introducing the water use permit system are:

[77] *Republic of The Gambia, National Water Resources Management Authority (NWRMA), 5-year Strategic Plan. Study report by NWSRP/NIRAS (November 2014)*

- develop guidelines and procedures for allocation and approval/issue of water permits accordance with The Gambia Water Act (ref. Water Use Regulations under Activity 1.1 above);
- establish the basis/criteria to determine the various charges and fees to be imposed for the abstraction of water – groundwater and surface water – in accordance with guidelines in the National Water Policy, The Gambia Water Act and the NWRMA Act.
- undertake a pilot roll-out of the water permit system in Greater Banjul Area, which would take the path of (i) conducting a water user/use census (including registration of 'unknown' privately drilled boreholes) to come up with a comprehensive record of water users in GBA, and (ii) carrying out a public information campaign, including dissemination of practical guidelines on the development and use of water;
- define the dispute resolution mechanism, and enforcement tools and guidelines (offences and corresponding fines/penalties) necessary to ensure effective regulation under The Gambia Water Act to safeguard the national water resources;
- based on the experiences from the pilot water permit exercise in GBA, initiate a phased roll-out of the permit system countrywide.

7.2 Strategic Area 2: Water resources information and knowledge

Since water resource systems are dynamic and highly weather/climate driven, a prerequisite for any water resources planning and management initiative is to have well founded knowledge about the water resources, quantitatively and qualitatively, as well as the distribution in space and time. It is indispensable therefore that the water resources managers have available updated and detailed assessments of the availability of water resources to be able to make informed decisions.

For that reason, new 'modernized' water resource data collection networks have been established during 2014, which include 38 observation boreholes and 8 surface water monitoring stations all equipped with data-loggers and continuously recording flow instruments (at Fatoto and Sami Tenda).

A Water Resources Management Information System (WRMIS) has been introduced at DWR in 2014, and a great number of existing data has been imported to the GeODin application (national database for water related data and information). The GeODin software can be expanded with a number of pertinent applications – the groundwater modelling software application (Visual ModFlow) now introduced is one example.

Such development can be designed towards advancing the WRMIS to a fully-fledged Decision Support System (DSS). Basically, a DSS is a 'tool' for water resource planners to facilitate sound and well informed decisions related to water resources allocation. It should build on information and knowledge about water resources, socio-economic information, and national priorities.

The activities under this strategic intervention area are directly intended as a follow-up on the NWSRP activities through on-the-job training to consolidate the results and to further advance the application of the various water resources data 'hardware' and 'software' now introduced.

Strategic Area 2 (water resources information and knowledge) will be addressed through implementation of the following activities/interventions:

Activity/Intervention 2.1

Improving the monitoring networks set-up information and calibration. Although the various equipment for groundwater and surface water monitoring have been installed and are functioning, certain necessary information is still lacking about the specific monitoring sites, viz.:

- the elevation of the observation boreholes as well as their exact locations should be defined (measured) more precisely than at present, for instance with the use of a Differential GPS which can measure the elevation with an accuracy of +/- 3 cm.
- in carrying out the calibration of the ModFlow model, the water abstractions from the boreholes in GBA, including ‘unknown’ privately owned boreholes, should be better defined to improve the results emanating from the water balance equation. Hence, it is recommended to increase the knowledge of water abstractions and location of especially private boreholes/pumps (ref. Activity 1.3, third sub-activity: water user/use census).
- when new information is gathered about geology, hydrogeology, abstractions and the water table, the groundwater model should be updated and re-calibrated. Also, when National Water Point (NWP) numbers have been assigned to additional boreholes, data sheets and the model should be updated with the correct ID names.
- specifically for the two river flow monitoring sites (Fatoto on the Gambia River and Sami Tenda on the Sandugu Bolon) equipped with SLD instruments, the river bed cross-sectional profile must be routinely measured to check if changes have occurred. If affirmative, a re-calibration of the computer-based set-up must be done.

Activity/Intervention 2.2

Consolidation of the WRMIS and data processing tools to be fully operational and routinely used, including:

- all data transfer routines from the field stations (borehole and surface water data-loggers, and SLD equipment) to the WRMIS hub at head office must be well anchored in the institution, which entails additional support to the staff in form of on-the-job training.
- data processing and modelling tasks should be routinely and professionally carried out by the assigned staff, which also would require further on-the-job training.

Activity/Intervention 2.3

Expansion of the WRMIS to a fully established decision support system (DSS). In the quest to eventually create a comprehensive DSS, an assessment should be made as to which further applications (‘tools’ and additional models) would be appropriate to procure and introduce. It should be said that this is a gradual process in as much as it is important that the now established WRMIS configuration is used as intended, and the needs of additional software applications with time are fully identified/justified.

Activity/Intervention 2.4

Development of a web-based tool (web-portal).

To promote openness and transparency an electronic capability should be created in the new NWRMA to promote the principles of IWRM and the objectives of the strategy and its interventions, and to provide participating stakeholders with information on programmes and general progress. It should be web-based and contain links to projects and programmes (underway and planned), hydro-meteorological statistics and special 'events', and generally provide an 'open window' on the management of the country's water resources.

The WRMIS, as well as other sources of relevant information, eventually should be accessed via such a 'web-portal' on the Internet. The web-portal will be one of the main communication channels for NWRMA towards its stakeholders with respect to information about its activities. The following types of information can be made available from the portal:

- knowledge products in terms of documents;
- GIS and earth observation data;
- observed data records, such as water level and flow statistics; and
- water permit information.

Not all the information should necessarily be able to be accessed by the public. Some information will be accessed through 'private' areas of the website, accessible to authorized personnel only.

Another key principle is that, to the greatest extent possible, knowledge gained about IWRM and lessons learned from experiences in implementing IWRM (in form of documents, videos and other 'knowledge products') should be shared (disseminated) and utilized. The NWRMA web-portal would be the logical repository for this knowledge to maintain collective 'institutional memory', also across agencies and institutions involved in IWRM.

7.3 Strategic Area 3: Water resources development and monitoring

The NWRMA will be responsible for management, assessment, conservation and control of the utilization of the nation's water resources to cover all necessary requirements of the various sectors of society, and as such, NWRMA is the custodian in all respects of the nation's water resources. This entails that NWRMA will take the lead role among the various sectors for coordination of larger water development projects in The Gambia.

Strategic Area 3 (water resources development and monitoring) will be addressed through implementation of the following activities/interventions:

Activity/Intervention 3.1

<u>Areal and temporal distribution of quantity (volume) of water resources</u> managed though accumulation of data and other information required to process and qualify water abstraction permit applications. This requires activities such as,

- revisit the appropriateness of the established set-up for water monitoring/control of both surface water and groundwater, and maintain – and amend/change as found necessary – the monitoring station network at hydrological measuring sites and groundwater monitoring boreholes;
- maintain, i.e. continuously update, the national database of water resource information (WRMIS), including such GIS and electronic data as are relevant.

Activity/Intervention 3.2

<u>Water quality managed through monitoring</u>. A successful water quality monitoring programme requires a preliminary phase aimed at providing a baseline of the existing water quality conditions. This background knowledge then is the background for subsequent 'design' of a long-term monitoring programme.

It is proposed to build up the water quality monitoring framework gradually. Priority should be given to groundwater quality monitoring in the GBA, since groundwater in this region is more prone to contamination due to high population densities and industrial activity. Monitoring can thereafter be expanded to cover groundwater countrywide, followed by the monitoring of surface water primarily affected by agricultural practices.

This activity/intervention will be done in collaboration with NEA.

This following activities will be carried out:

- utilize the findings and recommendations provided in the national framework for water quality monitoring[78] (both surface and groundwater) and on that basis prepare the programme and initiate activities;
- mechanisms should be put in place to enable NWRMA to influence land use planning decisions (collaboration with Department of Physical Planning), which could lead to unacceptable impacts on water resources. Consideration should also be given to the control of other activities which can have detrimental impact on water quality, but over which water managers currently have no direct control, such as location of dump sites and disposal of hazardous waste, and disposal of wastewater especially in the context of the sprawling estates coupled with the lack of piped sewage systems; and
- coordinate, harmonize and periodically review/update water resource quality standards.

Activity/Intervention 3.3

Establish groundwater protection zones around future boreholes and well-fields meant for potable water supply against polluting activities and saltwater intrusion. Zones are also important as a measure towards safeguarding the 'natural' recharge of the aquifer system, otherwise impacted by built-up (hard surfaced) areas as well as expanding surface water drainage facilities.

This activity/intervention will be done in collaboration with NEA and NAWEC, and would include:

- location and demarcation of proposed groundwater protection zones;
- in consultation with stakeholders and land owners agree on proposed zones (extent, activities allowed inside, enforcement measures etc.); and
- implement the physical demarcation of the protection zones.

Activity/Intervention 3.4

Implementation of a water demand management programme is a paramount factor towards exploiting the national water resource stock in the most efficient manner. A water conservation and water demand management programme is a multi-faceted venture often including technical measures, water pricing and regulative measures, and public awareness raising activities.

This activity/intervention will be done in collaboration with NAWEC and LGAs, and would include:

- as first priority, a groundwater demand management programme should be prepared and initiated in GBA in step with the exercise of registering all existing

[78] *Framework for a Water Quality Monitoring Programme. NWSRP/NIRAS (April 2014)*

boreholes and introducing a water abstraction permit system (ref. activity/intervention 1.3);

- in tandem, a public awareness campaign on prudent use of water and its conservation should also be initiated, including adoption of traditional knowledge and cultural practices (ref. Strategic Area 6); and
- carry out a technical study on water use in the tourism sector (hotels, lodges etc.) to map out how much water is used and in which manner, and how its seasonal demand is reflected and its impact.

Activity/Intervention 3.5

Water and agriculture. Politicians and practitioners are becoming more and more concerned about the gap between agricultural and water policies that is encountered almost everywhere, including The Gambia. Yet agriculture accounts by far for the greatest share of all water consumed for productive purposes. As competition for water increases, agriculture has to become 'water competitive' under an integrated water and agriculture policy landscape.

Given convincing water governance and a suitable enabling environment, development concepts for the agro-hydrological sector should follow an innovative paradigm that is based on economic rather than subsistence farming and includes well regulated but nonetheless profitable public-private partnerships. Hence, under this intervention area the following activities should also be sought (in collaboration with MoA)[79]:

- carry out a technical study resulting in a policy/strategy paper on management of water for agriculture, including analysis of water availability and requirements, and options for expansion of rain-fed agricultural cultivation, such as rice paddies, fields for vegetables/fruits and plantation crops, by applying innovative ideas concerning construction of water control structures (water retention dikes and conveyance systems);
- it has previously been shown[80] that cultivation of tidal swamps has rather little impact on saline intrusion, whereas, the amount/area of pump irrigation influences the salt front to a much larger extent. Therefore, cultivation of tidal swamps is preferable to cultivation of dry land. It is recommended to refine the knowledge about the cultivable tidal swamps. From a hydrological point of view, it is important to determine the difference in water demand between tidal and pump irrigation.
- establish a stakeholder forum for water and agriculture, and develop Code of Conduct for Water Use in Agriculture (what needs to be regulated regarding water for agriculture, and when and how could this start etc.).

7.4 Strategic Area 4: Climate change implications and ecosystems

As highlighted in Sub-chapter 3.2, in the latest publication[81] of the Gambian UNFCCC Focal Point, the following projections have been made for the region in which The

[79] *As part of this activity/intervention area it is recommended to adopt certain of the project activities outlined in The Gambia National Agricultural Investment Plan (2011-2015, Ministry of Agriculture (Sept. 2010).*

[80] *Saline intrusion in the Gambia River after dam construction – Solutions to control saline intrusion while accounting for irrigation development and climate change. M.P. Verkerk and C.P.M. van Rens. University of Twente – The Netherlands, 2005.*

[81] *The Gambia's Second National Communication under the UNFCCC (November 2012). Figures quoted are extracted from Section 5.2 of this publication.*

Gambia belong based on the application of three General Circulation Models (value in […] is the average derived from the three model results):

- an increase in mean temperature in the range of 1.7 to 2.1°C [1.9°C] by 2050 (this change should be added to the current long-term mean temperature);
- a decreasing trend in annual rainfall in the range of 1% to 23% [9.6%] by 2050. This wide range in the projection results underscores the fact that rainfall is the most difficult climate parameter to predict; and
- an increase in the rate of evapotranspiration in the range of 9% to 29% [16.3%] by 2050 (this change in evapotranspiration rate may necessitate a reassessment concerning agriculture water use caused by an increase in crop water demand for irrigation).

Additionally, other impacts which may be related to climate change have already been observed and can be expected to intensify, such as:

- increase in heavy precipitation events (downpours) with increased risk of local flash floods; and
- a tendency towards prolonged duration of dry seasons with more severe drought occurrences as a result, and hence shorter rainy seasons.

The direct consequences of these scenarios will in general lead to a reduction in freshwater availability.

Considering that the aquifer system from which the bulk of The Gambia's groundwater requirements are abstracted is replenished by local infiltration, and since significant deviations in annual rainfall totals from current levels are not predicted, and the aquifer system is semi-confined, which to some extent 'shields' the groundwater occurrences from evaporation, it has argued elsewhere that the climate change trend will have rather limited impact on groundwater recharge.

However, groundwater recharge may be lowered by 'man-made' interferences when expansion of agricultural land occurs at the expense of forest cover, and further areas are being 'urbanized' with an expansion of impervious areas (roads, parking areas, housing estates etc.) as result reducing the natural recharge zones. It is for this reason that demarcation of protected recharge zones around new well-fields are recommended as a climate change 'precaution' measure.

Concerning the Gambia River water, as highlighted in Sub-chapter 3.6, it is worthwhile noting that the evaporation losses alone from the new Sambangalou reservoir being constructed in the upper reaches of Senegal will be some 7% to 8% of the mean total flow of the river at the entry to The Gambia (upstream of Fatoto) given the present open water evaporation rate. This freshwater loss will increase in step with the climate change (temperature rise) impact on evaporation in general.

Environmental water demand is the minimum river flow required to maintain the integrity of aquatic ecosystems. In the Gambian context, minimum flows also have the function of protecting investments in rice production from the effects of saline intrusion.

Coastal and inland aquatic ecosystems play host to a large portion of the biodiversity in The Gambia – after all, some 20% of the total area of the country is taken up by the river system and its regularly flooded environs. It is therefore essential to promote measures aimed at reducing the impacts of climate variability and change on these ecosystems to enable them to continue to play their role of reservoirs and refuge of biodiversity.

There are other reasons for ensuring good wetlands management. Their functions include water storage, groundwater recharge, abating the magnitude of floods, stabilizing soil surface conditions and controlling erosion, water purification and carbon sequestration. Consequently, the 'maintenance' and sustainable management of wetlands constitute an important measure in adapting to climate variability and change.

Integrated water resources management (IWRM) provides an important framework to achieve adaptation measures across socio-economic, environmental and administrative systems. Actually, the best way to build capacity to adapt to climate change is to improve the ability to cope with today's climate variability. In other words, improving the way we use and manage water today will make it easier to address the challenges of tomorrow.

In addition to some of the already above listed activities, e.g. Activity 3.3 on borehole (well-field) protection zoning and Activity 3.5 on water harvesting for rain-fed agriculture cultivation, **Strategic Area 4 (climate change implications and ecosystems)** will be addressed by carrying out the following activities/interventions:

Activity/Intervention 4.1

Scenario analysis and modelling of groundwater availability and behaviour given likely climate change scenarios. In Sub-chapter 4.4, a scenario assuming a 20% reduction in the infiltration to the aquifers (decreased recharge rate) was modelled using the ModFlow software now introduced and applied for the Greater Banjul Area environs. In a simplified manner, this scenario reflects the combined effects of a reduction in rainfall and a temperature rise. Further work with the ModFlow would include:

- re-calibration of the ModFlow present set-up based on more accurate data and information compared to the present situation (ref. Activity 1.3, third sub-activity, and Activity 2.1, second sub-activity);
- expand the study area for the model or add a new area east of the present GBA set-up, and define additional scenarios to run the model with (different water requirements, other changes in climate parameters, different location of new well-fields etc.);
- discuss results and implications with NAWEC planning office to get feed-back and request for additional model applications.

Activity/Intervention 4.2

Capture Gambia River flow data and related hydrological information before Sambangalou Dam operates and continuously thereafter. The idea is to generate data on the 'natural' flow pattern in terms of volume (m^3 of flow) to have a baseline to compare with after dam construction, and hence be able to check compliance with the agreed operating rules of the hydroelectric plant vis-à-vis low-flow releases and artificial flood occurrences.

With such data and analyses available, The Gambia will be able to argue its case – if required – concerning low-flow releases as per agreed dam operating rules versus possible alterations made, which easily could be postulated (right or wrong) to be attributed to climate change, when in reality, perhaps, it may be caused by upstream irrigation developments.

This activity will require:

- regular uploading of data and ensure good maintenance of the automated flow velocity and discharge monitoring station now established on the Gambia River at Fatoto in Upper River Region; and
- processing of data and publishing of pertinent statistics on the flow pattern, and introduction of model applications to analyse the present and future situation concerning seasonal and annual inflow of freshwater from Senegal.

Activity/Intervention 4.3

Carry out applied research studies on ecosystems and development options to be more knowledgeable about the situation after Sambangalou Dam is commissioned. These interventions could comprise inter alia of:

- research on environmental flows in order to better understand water requirements of The Gambia's aquatic ecosystems for maintaining their essential functions;
- research on the interaction between wetlands and climate variability/change, and the importance of wetlands as a means of adapt and mitigate climate variability/change; and
- apply results from the Sambangalou Environmental and Social Impact Assessment (ESIA) study to facilitate planning of structural adaptation techniques and other measures (ref. Strategy Area 5 below).

7.5 Strategic Area 5: Trans-boundary water sharing and collaboration

The Gambia is a signatory to a number of international conventions and agreements. Those of specific importance to water resource management includes the Ramsar Wetlands Convention (1971), the Millennium Development Goals (2000), the African Ministerial Conference on Water (2001), and the UN '97 Watercourses Convention (which entered into force in August 2014). At the regional level, The Gambia promotes regional cooperation through various working groups and initiatives, prominently as member of ECOWAS and the Gambia River Basin Development Organisation (OMVG).

The OMVG is an essential body as the management of water resources in the signatory countries has the greatest impact on The Gambia being at the downstream end of the Gambia River. A case in point is the newly contracted construction of the Sambangalou Hydroelectric Power Project on the Gambia River located at the Senegal-Guinea border some 470 km upstream of The Gambia-Senegal border. The dam-reservoir structure, when ready for commissioning and reservoir filling (scheduled for 2018/2019), will forever change the natural flow pattern of the Gambia River downstream of the dam.

Various attenuation measures have been studied/included as part of the dam design in response to the Environmental and Social Impact Assessment (ESIA) carried out. Once built, it will be possible to create artificial floods (once or twice a year) for ecological purposes, e.g. to mitigate the resultant reduction of flooded wetland areas. Likewise, by virtue of being a hydropower dam, a certain flow through the turbines is required on a continuously basis, which gives the advantage to maintain a steady dry season low flow, which has specific importance for The Gambia to be able create a 'buffer' to keep the saltwater front further downstream than at present.

Nevertheless, a key observation from the ESIA is that environmental and social risks will necessitate diligent management and mitigation of likely negative environmental impacts in the downstream reaches of the river system in The Gambia.

Without firm operational rules in place concerning the use and possible artificial releases of the stored water in the Sambangalou dam-reservoir complex yet agreed to under the OMVG umbrella, a strategic area of concern is the means and ways of interaction through OMVG to protect Gambian interests, including how to negotiate in that forum, and which outputs would represent reasonable, equitable use of the shared waters and their benefits.

It should also be noted that the total area to be earmarked for irrigated rice production is not only determined by the number of hectares identified as ‘suitable land’ (24,000 ha as stated in the Gambia National Agricultural Investment Plan), but as much determined by the availability of the Gambia River water for irrigation. In other words, the operational rules to be agreed on when the Sambangalou dam project is implemented is vital for The Gambia’s prospects of increasing its much needed rice production.

Strategic Area 5 (trans-boundary water sharing and collaboration) will be addressed by carrying out the following activities/interventions:

Activity/Intervention 5.1

Participate proactively in the OMVG business and activities to support the nation’s regional and international interests concerning water resources with focus on food security and hydropower generation.

Activity/Intervention 5.2

Secure an acceptable solution on the ‘guaranteed’ low-flow regime after commissioning of the Sambangalou Dam. The issue concerns the operating rules (…who sets them, who operates the dam, and how can The Gambia monitor actual releases…). This would entail the following interventions:

- with specific reference to the two mitigating measures, i.e. artificial floods and artificial low water flows, and bearing in mind the vast riverine stretch of 470 km between the Sambangalou dam site and the crossing into The Gambia, a river routing model analysis needs to be carried out as a prerequisite to settling the operating rules of the dam; and
- in a well prepared and constructive manner pursue a dialogue to reach firm agreement under the OMVG to settle the guaranteed low-flow regime for the betterment of the nation’s economic prospects – and not least to maintain an acceptable level of food security.

Activity/Intervention 5.3

Year-to-year water budget agreement under the auspices of OMVG. Water is essential for both irrigation and hydropower generation, and both influence social-development equally much, which means they must not be dealt with in isolation from each other. It can be argued that IWRM principles can be used beneficially in this context. The pronounced variability in annual rainfall amounts across the basin, and hence the live storage capacity available in the Sambangoulou reservoir at the end of the high-flow season, necessitates year-to-year dam release scenario to be considered, leading to year-to-year water budget agreements. For each year such dam release scenarios should aim at optimizing power production, irrigation targets and the saline intrusion movements.

Activity/Intervention 5.4

Prepare State of The Gambia Water Resourcesr Report with specific focus on the Gambia River before the dam is commissioned (as a ‘baseline’ document), including technical analysis of river flow, saltwater front’s behaviour, identification of species of fish and plants (as effective indicators of the state of the river with particular respect to any saline/freshwater interface shifts) and water use options. The status report should then periodically be updated after the dam is commissioned, inter alia to serve as documentation in the annual water budget negotiations (ref. Activity 5.3 above).

7.6 Strategic Area 6: Stakeholder awareness and participation

In the past, communities and lower level civil society organisations have played a rather passive role in water resources planning and management. Generally, there has been little awareness and knowledge at local level of water issues, and limited efforts made by decision-makers to involve communities in any planning and management activities. It is realised that the community has a very important role to play, because the government does not have the resources to do all that is needed to implement integrated water resource management at local level across the country.

While the community or civil society organisation may not often have the education and experience to solve the many challenging problems facing water resource managers now and in the future, people at the grass roots level certainly understand their local environment and what the problems are. Sometimes local solutions are more effective than those proposed by ‘experts’ – provided that the means (resources) are made available to them.

There is therefore a need to involve these lower level organizations as well as the Local Government Authorities (LGA) pertinent departments by providing suitable mechanisms to do so. Their contribution can enhance some of the strategic interventions identified in this plan. But before that can happen effectively, the level of awareness of water resource management issues, and what can be done at local level, must be raised. This involve increasing awareness of civil society organisations and local communities, non-government organisations, LGA staff, parliamentarians and media organisations about conservation, utilisation and protection of natural and water resources (including rights and responsibilities) in the their individual areas of jurisdiction.

In the proposed new legislation, i.e. The Gambia Water Act and the National Water Resources Management Authority (NWRMA) Act, the importance of NWRMA to engage in awareness raising and information/data sharing activities vis-à-vis all stakeholders is clearly spelt out. Therefore, the NWRMA is expected to regularly undertake awareness campaigns to inform major water users and other publics concerned about NWRMA, its responsibilities and roles, and further to involve and educate the target audiences about integrated water resources management, its principles and implications, including gender equality, public participation and meeting the basic human needs for water as enshrined in the legally binding principles under the Act. Furthermore, the following issues are specifically highlighted to be included in public awareness activities:

- the regulations concerning water use and water resources abstraction, including water charges/fees to be borne as a result of protecting and fulfilling a person’s right to use water;
- gender equity: the right for women to have equal treatment with men, including equal opportunities in the water resources sector;
- the steps to be taken to protect water resources, minimize water use and save on the scarce resource;

- the steps that can be taken to change poor management practices of water resources; and
- the steps to be taken to enhance attitudinal change towards the use and management of water resources.

A Communication Strategy has been prepared (2014) as a 'guidance' for NWRMA to facilitate its efforts to put in place an effective and efficient mechanism to carry forward with its tasks related to public awareness raising and information sharing. The aim is to set the stage for properly structured and professionally delivered 'communication interventions' to facilitate a wider reach to the intended targets.

Subsequent to the validation of the Communication Strategy, a number of the awareness raising activities were piloted in two regions (Lower River Region and Kanifing Municipal Council) to garner experience in readiness for a country-wide roll-out of the communication strategy activities.

Against the background and recommendations presented in the Communication Strategy, and taking into account the 'lessons learnt' derived from the pilot implementation in the two regions, **Strategic Area 6 (stakeholder awareness and participation)** is envisaged to include the following activities/interventions:

Activity/Intervention 6.1

Establish a Public Relations / Communications Unit in NWRMA with responsibility to provide the required information and advocacy service to the public. The aim of the communication strategy is to provide a management tool (a 'blueprint') for NWRMA to administer its public awareness and other information activities as effectively and efficiently as possible.

Activity/Intervention 6.2

Implement programme of activities as stipulated in the communication strategy in a systematic manner targeting all regions of the country on a rolling basis. The activities to be carried out in each region basically follow the same path, but will be adjusted according the specific local needs and circumstances (urban settings, rural settings etc.) and also build on feed-back from the activities as they roll out.

The stakeholder awareness programme centres around the following activities:

- carry out audience studies, which involves overview of collaborators/partners, producers, consumers (institutions, communities, groups, individuals) etc., and their communicative characteristics such as language and socio-economic attributes;
- formulate relevant messages, which should be clear, simple, and concise readily understandable by the intended audience. Examples of message focus are: water supply (including the role of individuals, institutions, NGOs, National Assembly Members etc.), rainwater harvesting, and IWRM principles;
- produce awareness and communication materials, such as newsletters, fact sheets, posters, radio and television documentaries, audio-video tape etc;
- identify available channels for message sharing, such as radio stations and their reach, telecommunication, traditional communicators and print media as found best suited for use to share/distribute messages to intended stakeholders and partners;
- determine communication outfits of partner and stakeholders to identify most efficient modes of external institutional communication;
- identify opinion and decision leaders and carry out advocacy and lobbying to arrive at most effective approaches to mobilizing political support/cooperation;

- compile inventory of forms of communication with the characteristic of each form of communication identified to guide procurement or production of materials;
- develop criteria/modalities for outsourcing tasks, which includes list of partners, clear-cut criteria and procedures for selection of consultants, media houses, printers etc.
- develop multimedia matrices in form of charts of combinations of different means of communication and media for optimum message sharing;
- seek media exposure and appearances to obtain maximum media coverage, including events, proactive pull-outs/feature articles, radio/TV programmes, and ensure that officials, who appear on radio/TV and public for a, are effective to communicate the IWRM messages.

Implementation of the awareness raising and communication activities have been structured with a sequencing over a 5-year period as follows:

Year 1-2: Mainly preparatory such as information gathering and structural arrangements (develop messages, prepare audience studies, analyse communication channels, prepare outsourcing modalities, prepare relevant procedures, etc.).

Year 2-3: Implementation, and establishment of feedback and impact measurement mechanisms.

Year 3-4: Implementation and monitoring.

Year 5: Implementation continued, winding up the 5-year programme with impact evaluation, strategy review and sustainability assessment.

In regard to public participation it will also be of relevance to gather experiences with public participation in IWRM at regional and national levels. The establishment of regional WATSAN committees, regional Coordinating Committees (RCCs) and when established NWRMA's Water Resource Planning Unit can be used as 'laboratories' of public awareness:

- which type of topics are of public concern?
- what are the local/national barriers for effective action?
- where is local expertise available to advise on areas related to behaviour change in the use of water resources?
- get materials: good stories, 'everyday heroes' etc. for publishing, for instance, in the NWRMA Newsletter; and
- which traditional communicators are best suited for what message and audiences?

7.7 Strategic Area 7: Human resource development

Under this strategy, human resource development in form of training and educational initiates is targeting the staff of the new National Water Resources Management Authority (NWRMA).

This Strategic Area is to a large extent 'cross-cutting' in as much as many of the various strategic interventions described in the previous sections to a large extent require training and capacity building of the staff to be responsible for or assigned to the individual activities and interventions (in some cases as counterpart staff under specific technical studies). In that way it is also recognized that much of the capacity building initiatives will be conducted as on-the-job or in-service training.

Once established, NWRMA needs to embark on a structured programme for training and development of its human resources, and therefore will encourage staff to pursue relevant courses which will enhance the skills, knowledge and ability of the individuals. In-house programmes will be designed to improve the supervisory and management practices of staff as well as to improve their productivity and capability. In addition, the NWRMA will plan for continued training of new young professionals to replace retiring staff or staff members seeking employment opportunities outside the Authority.

An assessment of employee's performance will be done yearly and in this connection a plan of action will be developed for each employee's professional development.

Human resource development will be a continuous process and need to be planned and implemented well over a longer period to allow the Authority to function and not be hampered by key qualified staff being away for prolonged periods at the same time.

An important part of any initiatives aimed at strengthening an organisation's performance is to tailor a focussed and fit-to-the-job capacity building/training programme. The objective is to build job competence in senior and middle level managers as well as technical personnel by developing job-related skills. The management training should focus on practical management tools rather than the theoretical concepts of management and human behaviour often favoured by academics.

The previously referred to document[82] includes a detailed account of the institutional development and capacity building needs of NWRMA. In context of the present strategy, the salient points relating to training can be summarized in the following activities/interventions:

Activity/Intervention 7.1

Assess actual staff outfit and requirements in new NWRMA. Based on the result of the analysis of the actual institutional and human resource situation, an assessment will be made concerning the manpower resource (qualifications and expertise) required to perform the functions under the NWRMA. Basically, what will emerge from this 'comparison' will be the human resource and knowledge gap to be filled to get the new Authority to play its role and function satisfactorily in the future as per the new mandates and powers vested in them as per the new Acts.

Activity/Intervention 7.2

Carry out training needs assessment. Taking departure in the institutional and staff outfit assessment (Activity/Intervention 7.1), a detailed training needs assessment should be carried out to identify knowledge gaps and thereby key training areas to target the various categories of NWRMA staff. The emphasis will be on needs, as training, to be focussed and cost-effective, must be need-based and demand-driven, which is opposed to the supply-driven approach to training.

The aim of the training needs assessment is to compare existing qualifications of staff with the required qualifications necessary to perform the duties in the future, and to help identifying the training interventions, which are needed to fill the gaps in NWRMA.

Activity/Intervention 7.3

Formulate training programme for all cadre of NWRMA staff. The training needs assessment exercise will lead to the formulation of a training programme targeting the

[82] *Republic of The Gambia, National Water Resources Management Authority (NWRMA), 5-year Strategic Plan. Study report by NWSRP/NIRAS (November 2014)*

entire staff outfit covering the whole range of NWRMA's managerial, administrative and professional/technical tasks and duties. It is expected that the training programme will include some priority (immediate) training activities and some more long-term training/formal education strategies.

Activity/Intervention 7.4

Implement training programme. Funds will be required to carry forward with the various staff training initiatives detailed in the training programme. This will be done on a 'rolling basis' and in step with the actual realization of the staff (manpower) to be recruited or transferred to complement the staff outfit as per requirements.

Any performance improvements following training interventions must be properly monitored. For this purpose, the NWRMA administration as part of its Management Information System (MIS) should also have M&E module suitable for assessing the impact of capacity building activities. The M&E module should include criteria and performance indicators for measuring changes.

8. STRATEGY IMPLEMENTATION

8.1 Implementation plan

The National Water Resources Management Authority (NWRMA) will be the prime beneficiary of the outcome of a number of the activities and interventions outlined in this strategy, and as such is the 'custodian' and, hence, responsible entity to spearhead its implementation. It is envisaged that the strategy will be managed by a special WRM Strategy Implementation Unit to be set up within NWRMA to be responsible for the regular management of the proposed activities and interventions through the respective line sections and relevant stakeholders.

This also entails the need to mobilize financial resources to facilitate this responsibility, and importantly, to see a number of the activities/interventions being realized. In many respects, the present water resources management strategy constitutes a 'blueprint' for NWRMA's technical activities during its first years' of operation after its eventual establishment.

In general, the present water resources management strategy is to some extent closely associated the NWRMA strategic planning, and should be considered an important element of the Authority's forward planning in as much as it cuts across the various components and tasks to be carried out by NWRMA. The NWRMA planning operates with a 5-year plan horizon, which also can be adopted to many of the activities/interventions outline under this strategy.

Table 19 provides an overview of the water resources management strategic plan and summarizes the 7 key strategic areas and their respective activities/interventions (actions) – in total 25 – as defined and described in Chapter 7. In harmony with the NWRMA's establishment, the water resources management strategic activities are initially framed to be implemented within a 5-8 years period.

Cost estimates for each activity/intervention (action) are also given in Table 19. The cost estimates are broken into: (i) goods, materials and equipment; (ii) consultancies; (iii) administration and management by NWRMA Strategy Unit; and (iv) contingency funds (20%), which also will take into account sub-activities not yet defined and/or not foreseen.

The cost figures given in Table 19 can be summarized for the individual Strategic Areas as follows:

Strategic Area 1: Legal and institutional transformation:	EUR 196,800
Strategic Area 2: Water resources information and knowledge:	EUR 300,000
Strategic Area 3: Water resources development and monitoring:	EUR 552,000
Strategic Area 4: Climate change implications and ecosystems:	EUR 204,000
Strategic Area 5: Trans-boundary water sharing and collaboration:	EUR 223,200
Strategic Area 6: Stakeholder awareness and participation:	EUR 103,200
Strategic Area 7: Human resource development:	EUR 254,400

The total cost for implementation of the Strategic Plan as outlined in this chapter covering an initial 5-year period is estimated at EUR 1,833,600 – equivalent to approx. GMD 90 million (exchange rate by end of 2014).

Table 19: Overview of the elements comprising the strategic plan

Strategic Area	Activity/Intervention (action)	Timing and duration	Cost estimates (in EUR)	
			Elements[83]	Total, incl. contingencies
***Strategic Area 1*:** Legal and institutional transformation	***Action 1.1:*** Finalize the legal regulative framework	First year	(ii): 40,000 (iii): 4,000	52,800
	Action 1.2: Provide modalities for effective coordination in the water sector	Intermittent	(iii): 5,000	6,000
	Action 1.3: Introduction of water use (abstraction) permit system	Second year, later intermittent	(i): 5,000 (ii): 100,000 (iii): 10,000	138,000
***Strategic Area 2*:** Water resources information and knowledge	***Action 2.1:*** Improve the monitoring networks set-up information and calibration	Recurrent every second year or as need arises	(i): 20,000 (ii): 60,000 (iii): 10,000	108,000
	Action 2.2: Consolidation of the WRMIS and data processing tools	First year and as need arises	(ii): 40,000 (iii): 10,000	60,000
	Action 2.3: Expansion of the WRMIS to a fully established decision support system (DSS)	Second year	(i): 10,000 (ii): 40,000 (iii): 10,000	72,000
	Action 2.4: Development of a web-based tool (web-portal)	First year	(ii): 40,000 (iii): 10,000	60,000
***Strategic Area 3*:** Water resources development and monitoring	***Action 3.1:*** Areal and temporal distribution of quantity (volume) of water resources	Recurrent every year	(i): 30,000 (ii): 40,000 (iii): 10,000	108,000
	Action 3.2: Water quality managed through monitoring	Recurrent every year	(ii): 40,000 (iii): 10,000	60,000
	Action 3.3: Establish groundwater protection zones	Second to fifth year	(i): 20,000 (ii): 40,000 (iii): 10,000	84,000
	Action 3.4: Implementation of a water demand management programme	Intermittent throughout the plan period	(ii): 40,000 (iii): 10,000	60,000
	Action 3.5: Water and agriculture	Second and third year and as need arises	(i): 100,000 (ii): 80,000 (iii): 20,000	240,000

[83] *(i) goods, materials and equipment; (ii) consultancies, incl. travel and accommodation (EUR 20,000/month); (iii) administration and management by NWRMA Strategy Unit, incl. field allowances and transport (EUR 2,000/month); and (iv) contingency funds (20%).*

Strategic Area	Activity/Intervention (action)	Duration	Cost estimates (in EUR)	
			Elements[83]	Total, incl. unforeseen
Strategic Area 4: Climate change implications and ecosystems	***Action 4.1:*** Scenario analysis and modelling of groundwater availability	Second year, later intermittently	(ii): 40,000 (iii): 10,000	60,000
	Action 4.2: Capture Gambia River flow data	Recurrent throughout period	(ii): 10,000 (iii): 10,000	24,000
	Action 4.3: Carry out applied research studies on ecosystems and development options	Off and on throughout period as need arises	(ii): 80,000 (iii): 20,000	120,000
Strategic Area 5: Trans-boundary water sharing and collaboration	***Action 5.1:*** Participate proactively in the OMVG business and activities	Recurrent throughout period	(iii): 20,000	24,000
	Action 5.2: Secure an acceptable solution on the Sambangalou "guaranteed" low-flow regime	Third year	(ii): 40,000 (iii): 6,000	55,200
	Action 5.3: Year-to-year water budget agreements under the OMVG	After third year, recurrent every year	(ii): 20,000 (iii): 10,000	36,000
	Action 5.4: Prepare State of the Gambia River Report	Third year and fifth year	(ii): 80,000 (iii): 10,000	108,000
Strategic Area 6: Stakeholder awareness and participation	***Action 6.1:*** Establish a Public Relations and Communications Unit in NWRMA	First year	(iii): 6,000	7,200
	Action 6.2: Implement programme of activities as stipulated in the communication strategy	Recurrent every year	(ii): 60,000 (iii): 20,000	96,000
Strategic Area 7: Human resource development of NWRMA staff	***Action 7.1:*** Assess actual staff outfit and requirements in new NWRMA	Third year	(ii): 10,000 (iii): 4,000	16,800
	Action 7.2: Carry out training needs assessment	Third year, later as need arises	(ii): 10,000 (iii): 4,000	16,800
	Action 7.3: Formulate training programme for all cadre of staff	Third year	(ii): 10,000 (iii): 4,000	16,800
	Action 7.4: Implement training programme	Recurrent throughout period	(i): 150,000 (iii): 20,000	204,000

It should be emphasized that the costs must be viewed with caution realizing that a great deal of uncertainty is imbedded in the figures pending further detailed planning of the individual actions, duration of consultancies, specific implementation modalities etc.

The donor community and the relevant UN agencies shall be consulted on funding opportunities through, e.g. donor round table promotional discussions. The timeframe will be phased to accommodate national budgeting provisions and the need to build capacity within the participating institution, which again depends much on the actual establishment of the NWRMA. The process will include close coordination with all the relevant Government bodies, the Local Area Councils, NGOs and CBOs, private sector interests and civil society at large.

The implementation of the water resources management strategy shall be carried out on a 'rolling plan' basis with regular (annual) revisions to adjust to lessons learnt and means of financing, i.e. budgetary allocations and external support. The revisions will be included in the annual planning and budgeting exercise to be prepared for the NWRMA's general activities.

Activities and interventions presented here under the WRM Strategic Plan must be viewed as a set of priority actions, which need to be amended in the future whereby additional strategic areas and associated actions may be introduced. A strategic plan of this kind should be used as a 'dynamic' tool, which requires being re-visited regularly. Updating and amendment of the plan as and when needed is also a statutory requirement stipulated in The Gambia Water Bill (2014).

8.2 Monitoring and evaluation

The WRM Strategy implementation should be supported by a systematic and practical monitoring and evaluation (M&E) system. A M&E system enables implementers to regularly assess progress towards achieving performance indicators, ensures accountability, promotes visibility, and also facilitates cooperation with partners within the sector.

Whilst it must be acknowledged that it is difficult to measure the effects of various of the strategy's activities and interventions, due to the fact that a particular effect may have been caused by a number of variables as opposed to a single intervention, careful planning and systematic reviews need to be factored in to enhance the measure of selected effects, even if proxy variables are to be used.

The Strategy Implementation Unit under NWRMA will be responsible for the overall strategy implementation progress monitoring and evaluation to be based on a set of key performance indicators, which will be defined at the onset of the activities. NWRMA will invite partner institutions within the water resources sector and regional/lower level stakeholders regularly to contribute towards the performance (progress) evaluation.

As a starting point, a number of performance indicators are presented in Table 20, which in one form or another may be found relevant and then in a modified form can be applied during the course of implementing the WRM Strategy. Additional progress indicators may also be needed as the strategy implementation advances beyond its initial phase.

Table 20: Progress monitoring indicators

Strategic Area	Progress Indicator
1. Legal and institutional transformation	Number of regulations finalized during first two years.
	Number of technical committees established and meetings convened between institutions with water interests to consult and collaborate with on water management issues.
	Proportion (%) of water abstraction permit holders complying with permit conditions.
2. Water resources information and knowledge	Number of water resource monitoring stations producing reliable data.
	WRMIS used regularly; proportion (%) of new data collected in the field transferred to WRMIS at head office.
	Water management information is available to managers and other stakeholders; monitor timeline for creation of web-portal.
3. Water resources development and monitoring	Number of pertinent agro-hydrological studies carried out.
	Water demand management programme designed and launched in collaboration with stakeholders (NAWEC) with measurable results on water use versus wastage.
	Proportion (%) of groundwater monitoring boreholes with declining water levels.
	Number of groundwater borehole/well-field protection zones established.
	Proportion (%) of water quality samples complying with water quality objectives.
	Number of polluters licenced (granted wastewater permits) according to NEA regulations.
4. Climate change implications and ecosystems	Review and assess appropriateness of scenario analysis carried out and use of groundwater model on availability and water balance calculations.
	Number and outcome of studies on ecosystems and development options (saltwater front migration).
	Number of water related sector development plans where climate change adaptation is integrated; screening carried out (yes/no).
	Number/type of mitigation measures and interventions initiated in accordance with recommendations in the Sambangalou Project Environmental and Social Impact Assessment (ESIA).
5. Trans-boundary water sharing and collaboration	Number and outcome of meetings held under the auspices of OMVG, specifically related to the operating rules of the Sambangalou Dam.
	Number and outcome of annual water budget negotiations carried out under the OMVG.

	Timeline for preparation of State of the Water Resources (Gambia River) Report.
6. Stakeholder awareness and participation	Formal stakeholder structures established with clear roles and responsibilities in water resources management.
	Monitor the success of the communication methods and that the information provided is clear, relevant, needed, comprehensive, visible, and communicated via the right channels.
7. Human resource development of NWRMA staff	Focus should not be on inputs or activities (number of training events, number of staff given diploma/MSc education etc.), but on the specific outputs NWRMA is mandated to produce more efficiently and effectively.

It should be realized that an implementation programme of this nature requiring external support could expose NWRMA to be subject to exogenous factors, like reduced donor commitment, which subsequently could negate expected progress from the otherwise set plans.

ANNEX:

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