

WATER RESOURCES AUTHORITY



REPUBLIC OF
KENYA



WATER ALLOCATION PLAN

LAMU SAND DUNES AQUIFER
LOWER TANA SUB BASIN

TANA BASIN AREA

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ABSTRACT

Water resource allocation is an important aspect of water resource management. It is the means by which regulation of water use is done through sharing the water resource among different competing users with due regard for the environment, the economy and the social wellbeing of all beneficiaries of the water resource. The main purpose of regulating water use is to ensure equitable allocation of available water resource for various competing needs in a sustainable manner.

Like the rest of Kenya, water resource endowment in the Amu Island is unevenly distributed both in space and time. Various water uses needs are also inclined to various seasons. This situation warrants for a well coordinated action plan on how to share the available water resource across all needs equitably.

Available water resource within Lamu sand dunes aquifer in terms of quantity is established through aquifer studies. The amount abstracted was established through an abstraction survey and water balance was further estimated using recharge estimates and abstraction.

Different water resource uses are considered, giving priority to reserve which includes environmental flow and basic human needs.

This water allocation plan for the Lamu sand dunes aquifer sets out thresholds to guide in sustainable ground water resource use. Enforcement and compliance plans have been incorporated in this water allocation plan as well as strategies that can be employed for acceptance and ownership by different users and stakeholders.

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Acronyms

APR	Annual Potential Recharge
BBM	Building Block Methodology
BHN	Basic Human Needs
BWRS	Basin Water Resources Strategy
BWRC	Basin Water Resource Committee
CAAC	Catchment Area Advisory Committee
CBO	Community Based Organization
CEO	Chief Executive Officer
CME	Compliance, Monitoring and Enforcement
CMS	Catchment Management Strategy
CMU	Catchment Management Unit
CW/SB	Coast Water Services Board
EDCP	Effluent Discharge Control Plan
EFA	Environmental Flow Assessment
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
EMP	Environmental Management Plan
GIS	Geographical Information System
GOK	Government of Kenya
GW	Groundwater
GWP	Groundwater Potential

IWRM	Integrated Water Resource Management
MoWD	Ministry of Water Development
MWI	Ministry of Water and Irrigation
MWS	Ministry of Water and Sanitation
NEMA	National Environmental Management Authority
NWSHA	National Water Storage and Harvesting Authority
NWRMS	National Water Resources Management Strategy
NWRS	National Water Resources Strategy
RQO	Resource Quality Objective
SWR	Self Regulating Weir
WAP	Water Allocation Plan
WAS	Water Abstraction Survey
WQ	Water Quality
WRA	Water Resource Authority
WRM	Water Resource Management
WRMA	Water Resource Management Authority
WRUA	Water Resource Users Association
WRCS	Water Resource Classification System
WSP	Water Service Provider
WSTF	Water Sector Trust Fund

DEFINITION OF TERMS

Item	Meaning/Description
Authorization	A written approval issued by the Authority to construct works When WRA approves a permit application, it issues an Authorization to Construct which allows the water permit applicant to construct the necessary works or to drill a borehole. This does not allow the applicant to abstract. Once the works are complete and inspected, then WRA issues a permit which allows the applicant to abstract.
Basin	Area from which rainwater flows into a water course. The basin area is defined by WRA and gazetted. In the Kenyan context, a basin area is the largest surface water hydrological area. This may also be classified as a 1st Order water course (<i>Classic stream order system</i>)
Catchment	Equivalent to a basin and previously used under Water Act 2002 to denote the largest surface water hydrological area.
Compensation flow	The flow released from a dam or weir which is required for downstream uses and the Reserve;
Reserve	The quantity and quality of water required: a) to satisfy basic human needs for all people who are or may be supplied from the water resource; and b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the water resource c) For aquifers, the Reserve Quantity shall be 40% of the mean annual aquifer recharge in the case of aquifers whose recharge rate has been determined by the Authority. (d) For aquifers whose recharge rate has not been determined by the Authority, the Reserve Quantity for each point of abstraction shall be 40% of

	the tested yield expressed in cubic metres per day as determined by test pumping analysis;
Resource Quality	The quality of all the aspects of a water resource including a) the water quality stipulated for the reserve; b) the quantity, pattern, timing, water level and assurance of in-stream flow; c) the physical, chemical and biological characteristics of the water; d) the character and condition of the in-stream and riparian habitat; and e) the characteristics, condition and distribution of the aquatic biota
Resource Quality Objectives	The level to be achieved and maintained in each aspect of resource quality for a water resource
Permit	Documentation issued to allow for activities to be carried out in or in relation to a water resource, which is prescribed by Regulations made under this Act to be a purpose for which a permit is required WRA issues a water permit to an applicant after it has approved the applicant and after the applicant has developed the abstraction works.
Sub-basin	A sub-basin describes a portion of a basin which is itself defined as the area draining to a water course. The sub-basin area is defined by WRA and may be composed of a number of small hydrological areas referred to herein as sub-catchments
Sub-catchment	A sub-catchment is a portion of a sub-basin which is itself defined as the area draining a water course. However, it can be used interchangeably with Sub-basin and can be made of smaller hydrological areas.

1. INTRODUCTION

1.1 Background Information

Water allocation plan is a process that aims to share the available water resources between water demands for environmental sustainability, economic growth, water utilities and livelihoods. Where water resources are inadequate to meet all the demands decisions must be made based on priorities and an evaluation of public benefit. The plan provides a framework to guide water allocation to various uses.

Water Resources Authority (WRA) through Section 12 of the Water Act 2016 is mandated to regulate sustainable use of water resources through Permitting (allocation). WRA uses a permitting system to reflect the water allocation decisions. Water use permits, detailing quantities, timing and other conditions are issued to specific water users for specified purposes. The system of water use permits is therefore an integral part of the water allocation process.

1.2 Purpose of the Water Allocation Plan (WAP)

The goal of a WAP is to establish a reasonable and practical framework for water allocation and water abstraction within a specified aquifer.. This is anchored in current policy and legislation, and aiming to safeguard the natural ecosystems from over abstraction while supporting equitable and sustainable multiple demands on the water resources.

Amu Island sub basin is situated in Lamu County about 700km from Nairobi Capital city of Kenya through Garissa route. It is an island approximately 51km² cast into the Indian Ocean, off the east coast of Kenya. Administratively it is sub divided into four (4) locations namely: Langoni, Shella/Manda, Matondoni / Kipungani and Mkomani. The Island has a population of about 56,064 as per 2019 census.

Shella – Kipungani sand dunes aquifer is the only source of fresh water to the island. The aquifer is in the alarm status as per water resources authority classification and is under threat of over abstraction, human encroachment, contamination and saline water intrusion.

The pressure on the aquifer is enormous to meet the water need and there is an ever growing demand for the resource in the tourist attraction area which is a UNESCO world

heritage site. It has been found necessary to have a WAP in place to provide a rational way to allocate the groundwater resources from the sand dunes aquifer.

It is essential to recognize the purpose and scope of a WAP as an agreed framework for water apportionment, allocation and abstraction which sets out how the following components will be addressed:

- i. The Reserve, comprising of environmental flows and water for basic human requirements;
- ii. Best use of the available water resources for equitable public benefit;
- iii. What happens when resource availability is significantly reduced;
- iv. Measures to build compliance to water permits including enforcement procedures;
- v. Indicators to monitor the effectiveness of the WAP.

A WAP is also a tool that informs stakeholders of WRA's approach to water allocation and therefore helps form part of WRA's communication with stakeholders.

The WAP development also serve to build a consistent approach across all the offices of the WRA regarding a process that addresses a fundamental but complex part of the WRA mandate.

1.3 Duration of a Water Allocation Plan

It is anticipated that a WAP for Amu island will be implemented for a period of 5 years, with provisions for review subject to emerging issues. There are various factors to consider in defining the duration which include but not limited to:

- i. Period of the prevailing Tana Basin Water Resources Strategy (TBWRS).
- ii. Knowledge base on which the WAP is developed. If the knowledge base is poor, then the duration of the WAP may be short (say 5 years) to enable the requisite studies and surveys to be undertaken to provide a better knowledge base;

- iii. Cost of developing a WAP. The process of developing a WAP requires financial and human resources which should not be underestimated. It is preferable to develop a WAP that is robust enough to last as much as 10 years;
- iv. Rate of change to catchment hydrology. If the catchment hydrology is changing rapidly due to major land use changes (e.g., urbanisation, de-forestation, Climate change, groundwater declining levels- reduced base flows) or development of flow regulating infrastructure (storage dams or inter-basin transfers) then it would be appropriate to keep the duration of the WAP short (say 5 years) so that the WAP can be updated on a more frequent basis to make use of the more recent hydrological data that reflects current conditions.

1.4 BASIS FOR WATER ALLOCATION

Water allocation starts with considering the apportionment of water for different uses in compliance with the provisions and priorities in the Water Act 2016, the Water Resource Regulations and best practices. Conceptually the total water resource availability or natural yield for a particular water body is apportioned to the different types of uses and users as per the prioritization reflected in

Figure 1-1 namely:

- The Reserve. This is the portion of the water resource set aside to meet ecological demands and basic human needs (BHNs), The BHNs is defined as 25 l/p/day in the water resource Regulations 2021;
- The groundwater recharge minus the Reserve is the amount available for allocation to users (groundwater potential) through the system of permits;
- A portion of the allocable quantity that is set aside to meet domestic demand;

A portion of the allocable yield must be defined to meet existing or future strategic commitments for inter-basin water transfers. This portion is informed by water balance studies at the national level (e.g. NWMP 2030) and involves the redistribution of the water resources to meet strategic priorities

Note that any inter-basin transfer into a particular sub-basin or sub-catchment will be included as part of the allocable yield for that sub-basin or sub-catchment.

- The remaining portion of the allocable quantity is available for commercial uses.

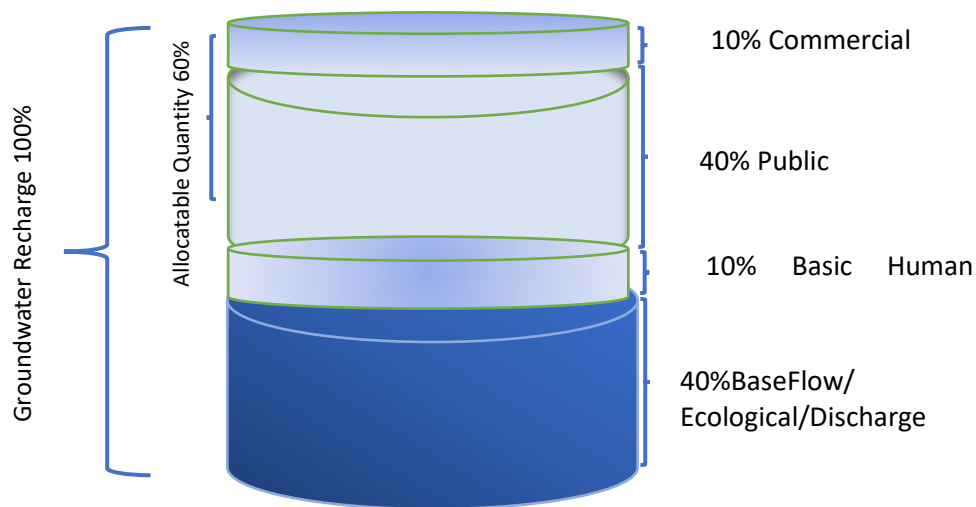


Figure 1-1 : Water Apportionment for Different Uses

1.4.1 Principles underlying Water Allocation

A number of underlying principles are reflected in the National Water Policy of 2021, the Water Act 2016, and the Water Resources Regulations 2021.

1. Water resources are ***vested in the state*** to be managed by the government on behalf of the public. Rights of use, where permits are required, are conferred to users through a permitting system, administered by WRA. The implication is that the water resources or water bodies are not owned by any arm of government, by any community or individual, even if the source of the water bodies are geographically located in a specific area, whether on public, community or private land.

2. Water resources are *finite and valuable*. The implication is that there are insufficient resources to meet ever increasing demands and therefore choices will have to be made on who should be allocated the resource and on what conditions. The value of the resource implies that the resource should be allocated for beneficial use;
3. *The Reserve* commands the highest priority in terms of water allocation. The COK 2010 (S43) provides for the right to safe water of adequate quantity and quality. The implication is that in the context of a very severe drought, even domestic water supplies may need to be rationed to safeguard the Reserve which includes the portion for ‘basic human needs’;
4. The water resources are *vulnerable* to over allocation, over abstraction and pollution. The implication is that there is a tangible risk to the environment, economy and social well-being if the water resources are not properly allocated and conserved. It is in the public interest to establish a reasonable and transparent water allocation process and to require compliance to the same;
5. The *precautionary principle* implies that decisions can or indeed must be made even where information is incomplete in relation to:
 - taking preventive action in the face of uncertainty;
 - shifting the burden of proof to the proponents of an activity;
 - exploring a wide range of alternatives to potential harmful actions; and
 - Providing for public participation in decision making.
6. To ensure transparency, water allocation is subject to a process of *public participation*. Participation of water users requires proactive steps to ensure that all groups, including marginalized and vulnerable groups, are informed and able to articulate their concerns and interests;

7. ***Water use conflicts cause social and economic disruption.*** Inequitable allocation, uncontrolled abstraction and unregulated access to the water resources provides fertile ground for water use conflicts. Stakeholder participation is essential to ensure broad agreement to the water allocation plan. Alienating basic livelihood water users from the resource can trigger water use conflicts;
8. ***Equity.*** Equity implies that there should be fairness in the allocation of the water resources for different water uses paying attention especially to the more vulnerable groups including women, children, the elderly and disabled among others. Transparency and stakeholder participation are important to determining an equitable system of allocation. Furthermore, downstream users should have equal access to the resource as upstream users. This applies to groundwater as well, where the people in the recharge zones need to be fair to those in the discharge zones.
9. ***Efficient and Beneficial Use in Public Interest.*** Efficiency in allocation implies that water uses with higher ‘public benefits’ will be prioritised over other uses. The purpose and efficiency of use are reasonable criteria to consider in water allocation. Social, economic, environmental and commercial returns per quantity of water are acceptable criteria in prioritising water for allocation.
10. ***Water resources to be treated as an Economic Good.*** Water resources constitute a strategic input to economic growth and social development. Water users have a responsibility to invest in the conservation, management and proper use of the resources.

1.5 Planning Stage for Water Allocation

The planning stage starts with objective setting which involves establishing the particular objectives for the water resources in the sub-basins. This step may make reference to any established water resource quality objectives or other objectives established through a credible and participatory process. Essentially this means that consideration has to be given to the legal obligations and priorities between environment, livelihood and commercial demands on the water resources.

The planning stage also looks at whether there are sufficient water resources to meet all the water demands within a specific area or from a specific water body. This exercise typically involves the establishment of a water demand balance for the sub-basins which provides information regarding whether all the expected demands can be met from the total available resource and whether seasonal storage is required.

The different types of water demand include:

- Environment;
- Basic human needs;
- Domestic (rural & urban)
- Agriculture (Irrigation);
- Livestock;
- Energy;
- Industrial;
- Tourism and wildlife;
- Aquaculture.
- Spiritual,
- Recreation

Details on quantifying the demands can be found in chapter 5.

The water demand balance can be summarized as follows:

- $\text{Water Balance} = \text{Groundwater recharge} - (\text{Reserve} + \text{base flows} + \text{Summation of all Abstractions}).$
- A positive water balance implies the condition where the resource is sufficient to meet all the water demands

- A negative water balance implies the condition where the resource is insufficient to meet all the water demands
- The planning stage of the water allocation process is meant to support long term planning for sustainable water resource management.

1.6 Management Stage for Water Allocation

The management stage in water allocation involves the allocation of water to specific users and uses. The right to use water is conferred by the government to the user by means of a water permit which is issued by the Water Resources Authority.

In evaluating a water permit allocation, WRA will need to refer to the portion of water within the particular sub-catchment that was set aside for the type of use in question and how much of this has already been allocated. The balance is referred to as the water allocation balance.

Furthermore, when evaluating a water permit application, two clear cases arise:

1.7 Water allocation where there is sufficient water resource

In this case, although the permit details will be checked to establish that the appropriate quantities of water have been applied for and allocated, there is less scrutiny on prioritization of use as all demands can be met.

1.8 Water allocation where there is insufficient resource

Where there is insufficient resource to meet all demands, in addition to verifying that the correct quantities of water have been applied for, the Authority shall apply any of the following approaches:

- a. Prioritization;
- b. Reallocation/ Proportional allocation.

In Amu island, water resources are insufficient to meet all the different water demands. It is this situation which, if not properly managed and controlled, can result in situations where either the Reserve is violated (which can lead to water use conflicts), strategic or domestic

supplies are threatened, economic opportunities are denied, inefficiency is not discouraged, and potential water users are denied legitimate access to the resource.

1.8.1 Prioritization

It is important to reinforce that the first priority on the water resources is the Reserve. Details on the quantification of the Reserve are provided below. For aquifers, the Reserve Quantity shall be 40% of the mean annual aquifer recharge in the case of aquifers whose recharge rate has been determined by the Authority. (d) For aquifers whose recharge rate has not been determined by the Authority, the Reserve Quantity for each point of abstraction shall be 40% of the tested yield expressed in cubic metres per day as determined by test pumping analysis;

With respect to the portion of water that can be allocated to specific users, domestic water has a higher priority than other uses (Water Act 2016, Section 43). Priority should be given to WSPs but nothing should stop the WRA from authorizing drilling for any other uses where necessary.

With regard to all the other types of demand, the Water Act 2016 is silent with respect to priority, although various considerations must be made (Section 43) in regard to:

- a. Existing lawful uses;
- b. Efficiency and public benefit;
- c. Commitments or priorities stated in the Basin Water Resources Management Strategies;
- d. Potential impacts on other water users and the water resources;
- e. The class and resource quality objectives;
- f. Existing investments by the applicant;
- g. Strategic importance of the application;
- h. Quality of the water resource which may be required for the Reserve;

- i. Probable duration of the water use activity or the service life of the investments made.

The National Water Master Plan 2030 has adopted the following prioritization for water allocation:

1. Reserve consisting of ecological and basic human needs;
2. Existing water uses for domestic, industrial, irrigation and hydropower and existing inter-basin transfer water (international obligations would be included here but there are no commitments so far);
3. New domestic and industrial water use;
4. New livestock, wildlife and inland fishery water uses;
5. New irrigation water use;
6. New hydropower generation water use.

1.8.2 Reallocation and Proportional Allocation

Water Act 2016 Sections 46 and 47 provide the basis for reallocation and proportional allocation of the resource. Essentially these sections provide the Authority with the powers to review and amend or cancel a permit or permits where there is reasonable cause so as to promote sustainability, equity, public beneficial interests, efficiency and to protect the water resource quality.

1.9 Water Demand Management, Efficiency and Compliance

In the process of water allocation, there is an inherent tension between allocating a “fair” quantity of water for a particular use, and the long term need to manage and reduce the demand and promote water use efficiency. It is recognized that many factors, including compliance, monitoring and enforcement (CME), are important to ensure that water allocated is used appropriately and within the conditions of the permit. A well designed water use tariff structure can also serve as an instrument to promote water use efficiency. In the context of financial and technical capacity constraints, efficient CME may be achieved

by focusing enforcement on a few larger scale users rather than spreading meagre resources across all users – Most large-scale groundwater abstractors are not compliant because they abstract more than the permitted quantity as verified from commercial records and abstraction surveys.

In this regard, the plan is considered to present a fair system of allocation of water for each use and users. This means that where there is a discrepancy between the plan and the water demand, adequate justification is required to show why exceptions to the plan are warranted.

1.10 Structure of the WAP

Chapter 1 deals with introductions to the WAP. Chapter 2 sets out the policy and legislative framework that guides water allocation planning. Chapter 3 discusses the overview of the aquifer. Chapter 4 discusses Water resources availability. Chapter 5 discusses water demand, Chapter 6 sets out methodologies for quantifying the allocable yield and the reserve, water use and the development of a water balance. Chapter 7 discusses the permitting system and specific issues related to decisions on individual permits. Chapter 8 sets out the components for the compliance and enforcement plan and includes monitoring and evaluation. Chapter 9 presents recommendations for water allocation plan implementation.

2. POLICY AND LEGISLATIVE FRAMEWORK

2.1. Introduction

The policy and legislative framework is important in that it helps to understand the guiding policy direction and what is constrained or required by law and would affect the WAP development process. This helps to identify what aspects within the WAP development process are mandatory, negotiable or optional.

2.2. Constitution of Kenya 2010

The Constitution of Kenya 2010 (S42) states that every person has a right to a sustainable, clean and healthy environment and (S43) to clean and safe water in adequate quantities. These provisions have a bearing on water allocation. The COK (S62) classifies water bodies as public land held in trust for the people of Kenya by the national government. The government (S69) has a responsibility to ensure sustainable utilization, management and conservation of the environment and the equitable sharing of benefits. Public participation is to be encouraged in the management, protection and conservation of the environment. COK Schedule 4 states that the national government is responsible for the protection of the environment, whereas the county governments are mandated to implement specific national policies on environmental conservation. While the management of the water resources are a shared responsibility between national and county governments the primary responsibility for setting up a system of water allocation is held by the national government.

2.3. National Water Policy (1999)

Key elements of the water sector reforms were captured in the Policy Paper (Sessional Paper No. 1 of 1999). Key shifts in policy included:

- Institutional reform and the establishment of independent institutions responsible for water resources and water services separately;
- Decentralization of decision making;
- Recognition of water as an economic and social good;

- Stakeholder participation, with specific application to women, communities and the private sector.

The policy is consistent with an integrated water resource management (IWRM) approach that sets out the importance of strong institutions focused on water resource management which operate in consultation with other stakeholders.

2.4. National Water Policy (2021)

The National Water Policy (2021) sets out guiding principles for the management of the country's water resources which include the principle of sustainability and the importance of maintaining the reserve. The NWP commits to the following specific policy directions:

Ensure that the allocation of water abstraction permits observes equity, giving priority to domestic uses, and considering the interests of local community members, vulnerable members of the society, and the ecological reserve. This ensures that administration of water permits is undertaken within sustainable limits, and with public and community level consultations;

- a) Develop a water body classification system and register. The government will also ensure compliance with water Resource Quality Objectives (RQOs) for the various categories of water resources to protect, conserve and ensure that water quality regulations are observed.

2.5. The Water Act 2016

The Water Act 2016 provides for the management, protection, conservation, regulation and use of water resources and for the acquisition and regulation of rights to use water. The purpose of the Act is to align the water sector with the Constitution's primary objective of devolution and thus the Act recognizes that water related functions are a shared responsibility between the national government and the county government. The Water Act 2016 states that the water resources are a national resource vested in and held by the national government in trust for the people of Kenya (S6) and is to be regulated by a national body

Water Resources Authority (WRA) as established under S11 of the Act, is mandated to “*regulate the management and use of water resources*” and “*to formulate and enforce standards, procedures and regulations for the management and use of water resources and flood mitigation*”. WRA has the unique responsibility of regulating the water resources sector. Water resources are allocated for use through a permitting system for which a user must apply. WRA’s functions include managing the system of water permits (S 12(d), classifying the water resources and setting resource quality objectives (RQO) (S20).

The Water Act 2016 provides for stakeholder representation and inclusion in water resource management through Basin Water Resource Committees (BWRCs) (S25) and Water Resource User Associations (WRUAs) (S29). BWRC are statutory bodies established as advisors to the Authority regarding water apportionment and use, the permitting process, catchment management, as well as to facilitate the establishment of WRUAs. The option for WRUA establishment, a voluntary body at the sub-catchment level, is provided in the Act for collaborative management of the water resources and resolution of water use conflicts.

One of the functions of the BWRC as set out in the Water Act 2016 is the equitable sharing of water within a basin through the development of water allocation plans (S27) and the formulation of a Basin Water Resources Management Strategy (BWRMS), which should contain a water allocation plan for the basin (S28) and which needs to be gazetted. This does not exclude the need for water allocation plans at sub-basin or sub-catchment levels.

The Water Act 2016 (S43) sets out criteria to be considered in determining a permit, including:

- a) Existing lawful uses;
- b) Efficient and beneficial use of the water in the public interest;
- c) The prevailing BWRMS;
- d) Likely effect of the proposed water use on the water body and other users;
- e) The classification and RQOs for the water body;
- f) Investments already made and to be made by the water user;

- g) The strategic importance of the proposed water use;
- h) The quality of water required for the reserve;
- i) Probable duration of the undertaking.

It further states that domestic water will take precedence over other uses of water and that WRA can reserve a portion of the water resource specifically for domestic use.

Additional considerations for water allocation are specified (S47) during the review of water allocation in water stressed situations. These include the need to:

- a) Achieve a sustainable allocation of the resource;
- b) Achieve equity in allocation;
- c) Promote beneficial use of water in the public interest;
- d) Facilitate efficient management of water resources;
- e) Protect water resource quality;

2.6. Water Resources Regulations 2021

The Water Resources Regulations 2021 are drawn up to enable implementation of the Water Act and addresses all areas touching on water resources uses and management.

The water Act, 2016 provides for the regulation, management and development of water resources, water and sewerage services and other water connected services. The Water Resources Regulations 2021 assist WRA discharge its regulatory mandate on the regulation of the use and management of water resources. The new regulations retain key provisions provided for in the Water Act 2016 that touch on water allocation and water use permits as highlighted below:

- a. **Stakeholder participation and consultation.** Legally formed WRUAs will be registered with WRA to support collaborative management of the water resources. WRUAs are expected to comment on water permit applications which are also expected to go

through a process of public notification and to demonstrate compliance to EMCA which includes a process of public consultation.

- b. **Permitting System.** Part II, VII and the fifth schedule of the rules sets out categories of permits, the procedure, forms and fees associated with the processing of water permits. Specifically, the regulations define four categories of permits (A to D) with A reflecting a water user who individually has minimal impact on the resource and Category D reflecting a water user who is likely to have a significant impact on the water resources. This system, reflecting data gathered from water abstraction surveys was designed so that Category C and D applications would be subjected to robust technical and stakeholder review, while Category A water users, although more numerous than the other categories, are provided with a simple procedure to avoid bogging down WRA with an excessive bureaucratic workload. The WRA has specified the thresholds for each sub-basin and for surface and groundwater that apply to distinguish the different categories of permits.
- c. **Water Apportionment.** The criteria to determine the portion of the water resource that is set aside for the reserve is specified for both surface water bodies and aquifers. For surface water bodies, the Rules define criteria to establish two different states of flow, namely “normal” and “flood” flow. Essentially this provides WRA with the ability to allocate water from a water body but to restrict when that allocation applies. This arrangement enables WRA to comply with the requirement to give precedence to domestic use over water for other purposes.
- d. **Water Use Charges.** A system of water use charges has been introduced which requires water users in permit classes B, C and D to pay for abstracted water. The water use charges serve three primary functions:
- To improve efficiency in water use;
 - To provide WRA with data on water use; and
 - To generate revenue to support water resource regulatory activities.

The Second Schedule of the WRM Rules 2007 lay out what should be in a water allocation plan namely:

1. A description of the class of resources and their resource quality objectives;
2. An analysis of current and future water demands;
3. Allocation of the resource to the reserve and to different types of uses;
4. Measures to be taken to ensure that water use approvals remain true to the allocations;
5. Measures to be taken when resource availability is limited;
6. A compliance plan;
7. An enforcement plan;
8. Mechanisms for reviewing the allocation plan from time to time as the need arises.

2.7. Kenya Vision 2030

Kenya Vision 2030 provides a blue print for Kenya's development and transition to a middle income country by 2030. Water is defined as an essential resource that underpins national development. With water per capita of 647 m³ in comparison to the United Nations' recommendation of 1,000 m³ per capita per year, Kenya's Vision 2030 recognizes the water and sanitation deficiency facing the country (Kenya Vision 2030, pg 96, 2007).

2.8. National Water Master Plan 2030

The National Water Master Plan 2030 provides an update on the NWMP (1992) and aims to set water resource development and management on a path to support the realization of Kenya Vision 2030, while taking cognizance of increasing demands, climate change and other factors affecting water resource utilization and management. For each basin the NWMP 2030 sets out a current and future water balance and sectoral plans, plus various plans applicable at a national level.

2.9. Resource Classification and Water Resource Quality Objectives

The Water Act 2016 Section 20 mandates WRA to establish criteria for the classification of the water resources for the purpose of determining the water resource quality objectives for each class of water resource. The water resource quality objectives for each class is a management tool that establishes the desired state of the resource given competing demands for environmental conservation and water use for economic growth and development.

The prevailing Catchment Management Strategies developed by WRA with stakeholders sets out a system of delineating and classifying catchment management units which, in the absence of explicit resource quality objectives, can be used as a framework to guide water apportionment and the development of a Water Allocation Plan.

2.9.1. Delineation of Shella-Kipungani sand dunes aquifer

This section discusses the delineation of the shella- kipungani sand dunes aquifer. The aquifer is a sedimentary aquifer that is mainly composed of sands sediments. It is currently managed as a unit. For effective management, groundwater bodies should be assigned specific river basin areas due to the integral relationship between groundwater and surface water. In its management considering the challenges impacting the groundwater resource, there is need to consider the following factors.

- The type, scale and nature of the water demands and the severity of their impacts on the water resources;
- The status of the water resources with respect to the risk to the reserve and stress on the water resource quantity and quality;
- The vulnerability of the water resource quality and the need for protection (ecological importance and sensitivity);
- The land use;
- Equity and sustainable utilization of the water resources

In addition to the above considerations, the Authority has also considered the mandate given to the National Government by the Constitution of Kenya (CoK) 2010; Chapter 5

Article 62 (i) (j) (k) (l), which states public land also includes: this includes aquifers as defined by the WA 2016

(j) All rivers, lakes and other water bodies as defined by an Act of Parliament;

(j) The territorial sea, the exclusive economic zone and the sea bed;

(k) The continental shelf;

(l) All land between the high and low water marks.

2.9.2. Classification of Catchment Management Units

WRA defined a Water Resource Classification System (WRCS) (as reported in the **Catchment Management Strategies for different basins**) which specifies the level of importance attributed to the resource in each CMU with respect to three broad types of demands, namely; ecological, livelihood and commercial.

The three major demands are further categorized into three sub-classes of importance, namely: - high (1), medium (2) and low (3) as elaborated hereunder. A catchment management unit might comprise a combination of any of the three classes but the main management focus is based on the major classification as shown in Figure 2-1.

A. The Ecological (E) WRM Units

These are areas with almost natural ecological characteristics. They target protection of natural ecological characteristics, recreational and development of tourism with economic importance. It is noteworthy that livelihood and commercial values do not have any significant importance.

This class is divided into three sub-classes, namely;

- E₁-High ecological importance: Areas with almost natural ecological characteristics or areas which are protected by legislation due to their ecological importance (e.g. National Parks, Ramsar Sites, International Bird Areas, wetlands, groundwater recharge points etc.). Livelihood and commercial demands are of insignificant importance.

- E₂ - Medium ecological importance: Areas with minor modifications to the natural ecological characteristics.
- E₃ - Low ecological importance: Areas with significant modifications to the natural characteristics

B. Livelihood (L) WRM Units

These are areas with predominantly rural characteristics i.e. rural and scattered settlements with low population density and small-scale subsistence-oriented economic activities, which include small-scale irrigation, fisheries and livestock production. This zone targets protection of water resources to ensure sustainable rural livelihoods.

This class is divided into three sub-classes, namely:

- L₁-High livelihood importance: Areas where small scale subsistence oriented economic activities dominate with over 70% of the population relying on the water resources for their livelihood.
- L₂-Medium livelihood importance: Areas where small scale subsistence oriented economic activities dominate with 40-70% of the population depend on the water resources for their livelihood.
- L₃-Low livelihood importance: Areas where less than 40% of the population depend directly on the water resources for their livelihood. Ecological or commercial demands on the resource are more significant.

C. Commercial (C) WRM Units

These are typically urban and/or industrial agglomeration areas including their periphery, which could be commercial. They focus on ensuring quality of water resources to develop the economy and prosperity in urban areas/industrial centres.

This class is further subdivided into three subclasses, namely:

- C1 - High commercial importance: Areas where the level of commercial activities predominates. The level of commercial activities in these areas is of national significance.
- C2 - Medium importance: Areas where the level of commercial activities are significant at the management unit level.
- C3 - Low importance: Areas where the level of commercial activities might be significant at the inter-management unit level

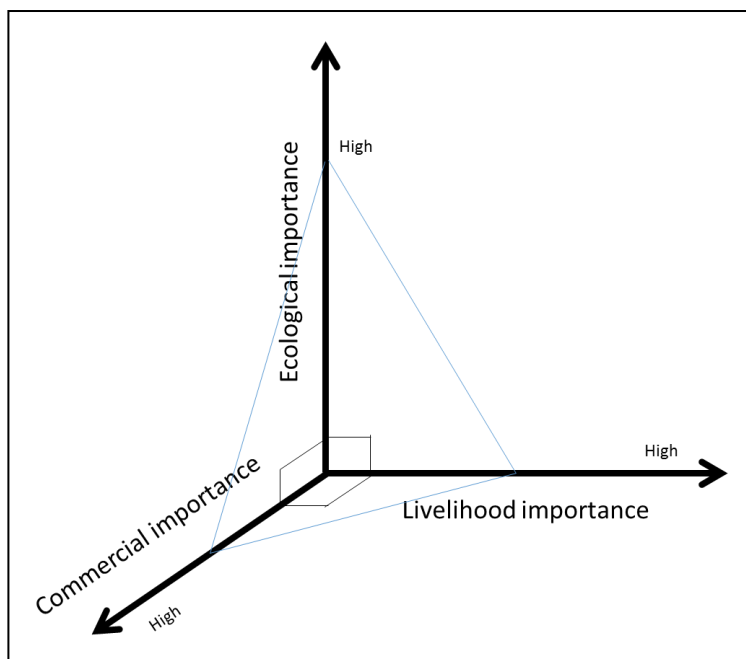


Figure 2-1 : Classification of Catchment Management Units

It is recognized that this classification system is likely to change after further development of the resource classification system and development of a framework to define water resource quality objectives (WRQOs).

2.9.3. Categorization of Sub-Catchments according to Status

The MWI 2007 report *Operationalization of the Water Act 2002 with respect to Water Resources Management* suggested a framework to categorize sub-catchments according to the level of stress on the water resources, as assessed by WRA staff as shown in Table 2-1.

Table 2-1 : Categorization of Sub-Catchments according to Stress Status

Category	State of the resource
Category 1	ALARM
Surface Water	Resource is periodically scarce Water reserve threatened
Groundwater	WQ or levels declining
Water Quality	Catchment severely degraded Pollution levels high Risk to human life is high
Conflicts	Potential for conflicts is high
Category 2	ALERT
Surface Water	Trend is towards scarcity
Groundwater	Trend is towards over abstraction
Water Quality	Declining trend in water quality
Conflicts	Ingredients for conflicts, e.g. ethnic, religious, language divisions
Category 3	SATISFACTORY
Surface Water	Water resource sufficient in quantity & quality
Groundwater	No tangible impact

Water Quality	WQ adequate, low risk
Conflicts	Low risk of conflict

This framework provides a description on the status of the resource to guide the prioritization of sub-catchments and to support water resource management decision making.

3.0. OVERVIEW OF THE AMU SAND DUNE AQUIFER

3.1. Location, area, and topography

3.1.1. Location

The Amu sand dunes have a size of 19.7122 km² spreading for 11Km from Shella to Kipungani along the Lamu south coast with the aquifer thickness varying between 50m at Kipungani (no human settlement) and 5m at Shella (settled with water company wells operating)

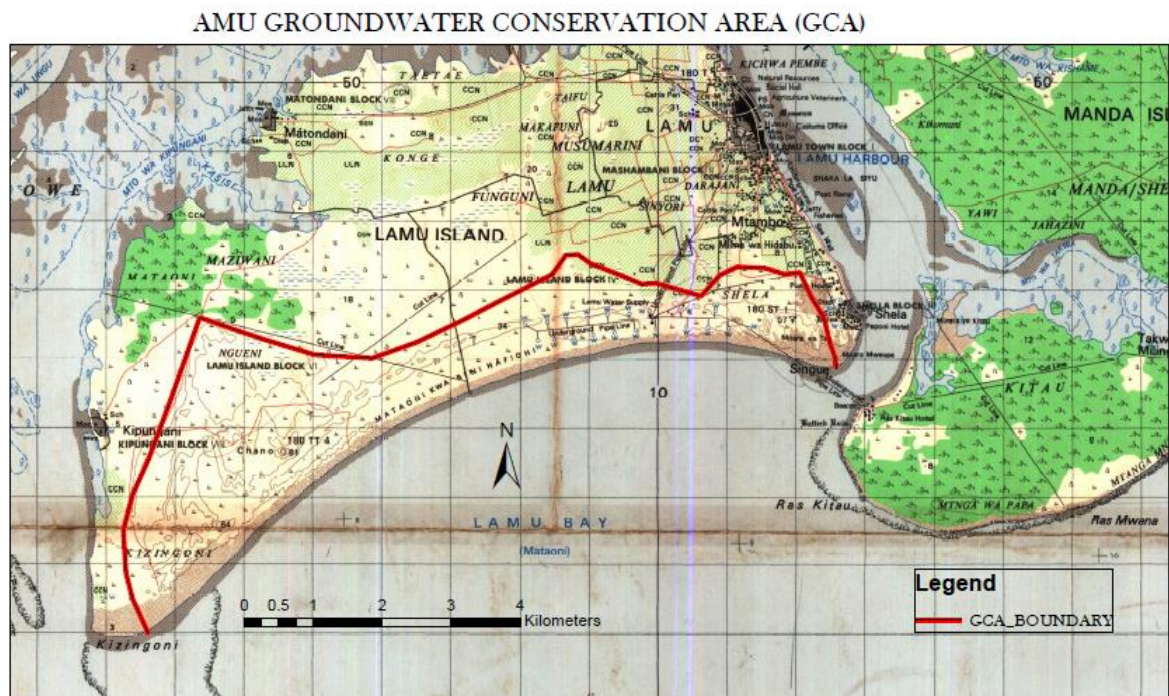


Figure 3.1: A map showing delineation of the Amu sand dunes conservation area

Lamu Island's aquifers are mostly unconfined and occur at relatively shallow depths (10-15 m bgl). Direct recharge from local rainfall and, in rare situations, indirect recharge from poorly established surface water run-offs are the primary sources of aquifer replenishment. The topography of the sand dunes, with its flat terrain and mild slope, provides the ideal location for optimal recharging. The amount of rainfall, which is moderate in this area, ranging from 550 to 1100 mm, is the limiting factor (KMD, 1984). At a gradient of around

0.001 to 0.005, the water table descends gently towards the coast (sea) (1-5 metres per kilometre). The ability of fine-medium grained sands to extract fresh water is determined by geological variables as well as location of the fresh-saline interface (El Yaouti, et al., 2009).

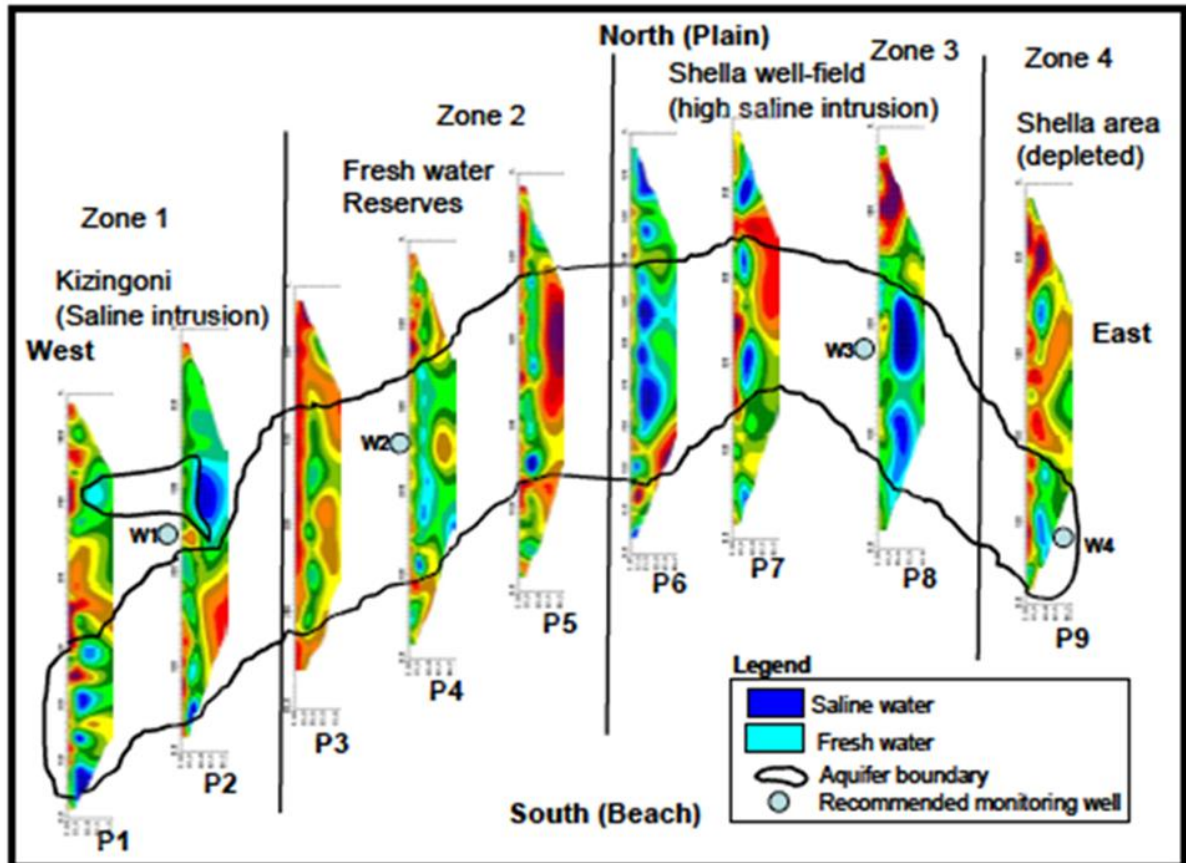


Figure 3.2: Simplified Amu aquifer profiles showing saline, fresh and depleted groundwater resources within the sand dunes

Because fresh water has a lower density than seawater, it can create a lens on top of the salt water, lowering the interface below mean sea level. The size of the depression is determined by the formation's porosity and permeability, as well as fresh-water recharge and losses, such as evapotranspiration, lateral drainage, and mixing with sea water (Slater and Sandberg, 2000). Safe groundwater abstraction is only achievable under conditions of hydrodynamic equilibrium, when relatively high recharge rates prevent considerable salt-water upconing, which would result in irreversible pollution of the fresh-water aquifer. It

is possible to determine actual losses if the extent of the interface depression can be characterized and values for transmissivity and fresh-water losses can be approximated.

3.1.2. Topography

The physical structure of Lamu Island is characterised by east–west graduated height variations, which include coastal plains ranging from 0 to 30 meters above sea level. From Mokowe to Bodhei, a distance of 58 kilometres, the ground progressively rises to an altitude of around 0-50 meters above sea level. The drainage pattern into the Indian Ocean is dictated by a reasonably gradual slope from Bodhei to Mokowe.

3.2. Climate and Precipitation

3.2.1. Climate

The large-scale pressure systems of the western Indian Ocean govern the climate and weather systems along the Kenyan coast. The resulting climate (fig. 3.4) is equatorial - coastal, with high tropical temperatures with very minor changes, high humidity, pronounced rainy seasons, high evaporation, and monsoon winds.

The monsoon season is divided into two halves. The Northeast Monsoon (Kazkazi) dominates the Coast from November/December to early March, keeping it relatively dry, whereas the monsoon winds blow east to south-easterly (Kuzi) throughout March and April, with large incursions of marine air from the Indian Ocean bringing heavy rains. The south-easterly Monsoon influence gradually creeps in over the months of May, June, July, and August, and the weather becomes more consistent, with dull and comparatively colder temperatures. The Northeast Monsoon progressively takes over between September and November, and by December, the northern influence has returned.

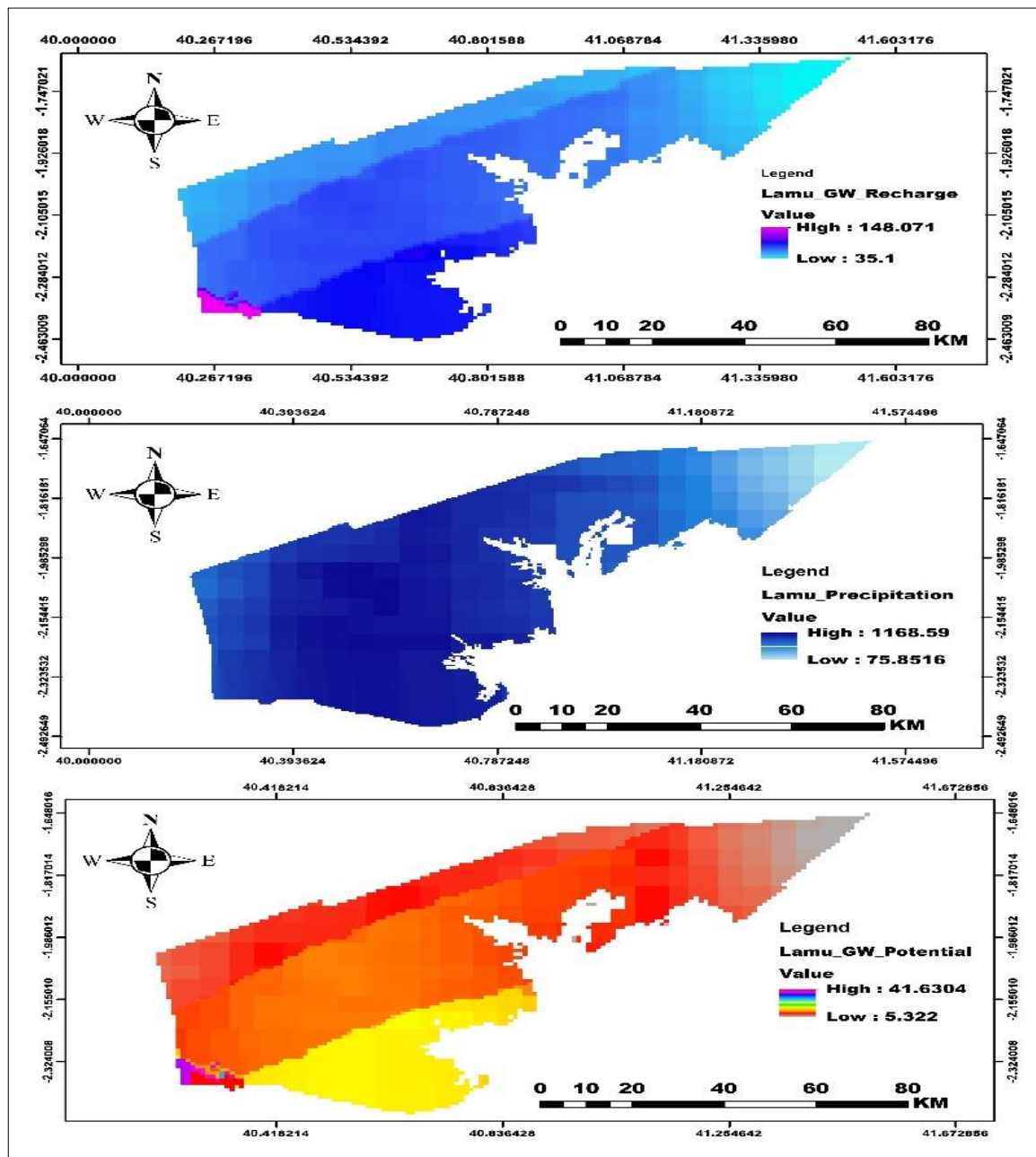


Figure 3.5: Lamu area recharge, precipitation, and groundwater potential maps

The steep (sand dunes) and flat topography with permeable top sandy soils provides the best conditions for maximum recharging, with rainfall being modest in this area.

The possibility for freshwater abstraction of fine-medium grained sands is determined by geological parameters as well as the location of the fresh-saline interface. Fresh water has a lower density than seawater, therefore it can form a lens on top of the salt water, depressing

the interface below mean sea level. The porosity and permeability of the formation, as well as fresh-water recharge and losses, all influence the size of the depression (evapotranspiration, lateral drainage, and mixing with sea water).

Safe groundwater abstraction is only achievable under conditions of hydrodynamic equilibrium, when relatively high recharge rates prevent considerable salt-water up-coning, which would result in irreversible pollution of the fresh-water aquifer. It is possible to estimate the aquifer's real storage and recharge capabilities if the extent of the interface depression can be quantified and values for transmissivity and freshwater losses can be approximated. In regions where permeable strata, such as medium-grained sands, are directly exposed to the ground surface, high recharge estimates can be predicted.

The aquifers are likely to be found in the upper 10 - 15 meters of the sands at this location. The aquifers are thought to be refilled directly by precipitation percolation. Lateral recharging is anticipated as a result of steep sand dunes.

3.2.2.Precipitation

Rainfall is bimodal, ranging from 550 to 1100 mm per year, and is reasonably consistent, though unevenly distributed. The long rains provided by the southeast monsoon winds fall between April and June, accounting for the majority of the rain. The month of May is usually the wettest in the area. The wettest months are November and December when the prevailing northeast Monsoon winds provide the shortest showers.

3.2.3. Evaporation and evapotranspiration

Evapotranspiration is the result of a combination of surface evaporation and plant transpiration. This is the most significant water loss from the hydrological cycle in most situations. SDIT (1954) includes empirical data from Piche evaporimeters on evaporation (E_o) from a free surface. By multiplying the values by 0.5, we were able to calculate the monthly and annual evaporation. The monthly evaporation pattern is inversely proportional to the rainfall distribution. The mean annual potential evaporation for Lamu Meteorological Station is high, at 2327 mm per year, with the maximum and minimum only 5% off the average.

The amount of rainfall, surface runoff, and groundwater recharge determine the actual evapotranspiration (ET). The slight dune relief combined with the good infiltrability of the top sandy soil enhances the amounts of vertical recharge, but the rest of the water ends up being lateral recharge on the steep section, implying that no surface runoff is expected. As a result, actual evapotranspiration is likely to be moderate: less than half of the annual rainfall.

3.2.4. Temperature

Temperature values are usually hot, ranging between 24 and 30 degrees Celsius, with minimum and highest temperatures of 19.5 and 36.4 degrees Celsius, respectively. December to April are the hottest months, while May and July are the coldest. Lamu highland and its environs has been characterized by the agroclimatic zone of Africa to be semi-humid to semi-arid zones.

3.3. Hydrology

The hydrology of Lamu is influenced by Kenya's topography and oceanography. The Tana River, which flows from Kenya's water towers on Mt. Kenya, and the Mangai River, which flows through the forest rich Basuba and Kiunga Wards, are two of the county's main waterways. The Mangai River is a seasonal river that flows heavily during the wet season. In comparison to other seasonal rivers that flow from Garissa County through the Hindi and Mkunumbi wards, the Mangai River can be regarded a source of fresh water inside the County, with the possibility of a dam being built on its channel in the future. It however important to note that Lamu Island does not have river flows, drainage patterns in case of a run-off can be delineated as shown in below. This can enable the understanding of recharge patterns and flow directions. It can also be used in delineating the Island into sub-catchments for purposes of management.

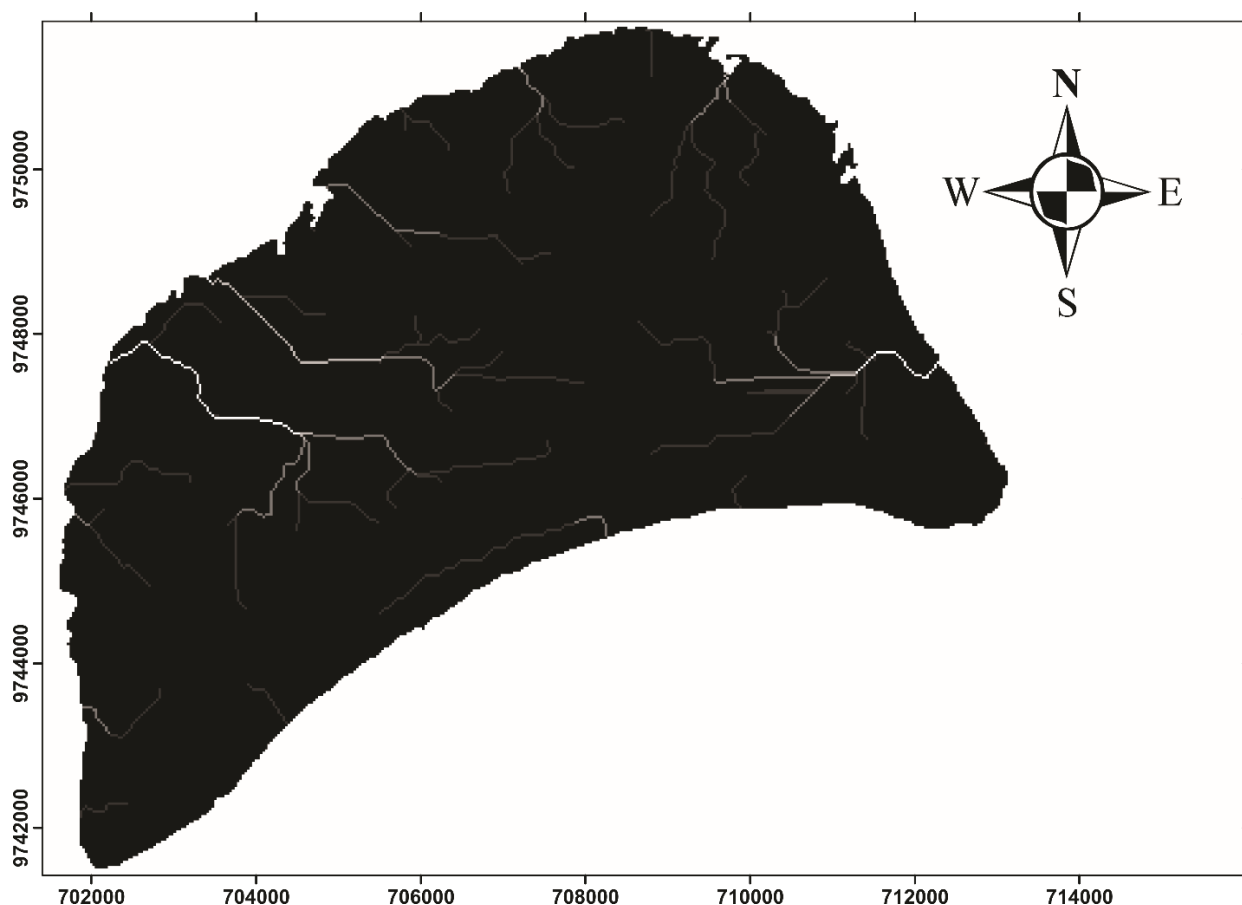


Figure 2: Run-off flow accumulation direction within Lamu Island

3.4. Geology

There are no sufficiently deep wells in Lamu Island to suggest the general rock types and their lithostratigraphic succession. However, the area is generally covered by fine to medium grained sands that cover almost the entire island. Other isolated and localized outcrops include fine grained brown calcareous sandstones observed at two locations near the beach at Shella and Pumping station, while “young” coral pink-red coral limestone was encountered at Kizingoni area at the beach area.(Kuria

In general, the medium grained sands occur near Shella area and they progressively become fine westwards towards Kizingoni area. These different textural properties in sands also occur variably with depth, even at shallow depths of 10 metres. In some cases, the sands consist of small broken sea shells indicating their origin from the ocean.

Geologically study area is almost entirely covered by fine-medium grained sand, other rare and isolated rock types include calcareous sandstone and pink-red coral limestone. In Lamu Island the aquifers are unconfined and found at relatively shallow depth (10-15 m bgl). The water table slopes gently towards the coast (sea), at a gradient of about 0.001 to 0.005. Drainage from the southern edge of the sand dune ultimately discharges into the sea.

3.4.1 Regional Geology

The Kenyan coastal environments are set in a passive continental margin, the evolution of which was initiated by the break-up of the mega continent - Gondwanaland - in the Lower Mesozoic. The initial opening of the Indian Ocean was preceded by doming, extensive faulting and down warping similar to that observed in the modern Great Rift Valley of East Africa. These tectonic movements formed a North-South trending depositional basin.

3.4.2 Geological Setting

The earliest fairly accurate description of the geological units along the Kenyan Coast was made by Gregory (1921). Updates and revisions on the regional geology were provided by Caswell (1953, 1956), Miller (1952), Thompson (1956), Buckley (1981) and Carruthers (1985).

The geology of the coastal area reflects a predominantly Quaternary history of marine sedimentation, with numerous ocean transgressions and regressions, and associated sedimentary features. The area is essentially composed of lagoonal deposits and fossil coral reefs. At depth, the area is underlain by the older Jurassic shales, which are covered by the Kilindini sands and the Mombasa crag to the west and fossil coral reefs to the east. It seems probable that the two formations finger into each other.

3.4.3 Lagoonal Deposits

Calcareous sands are present to the south of the coastline. They consist of coarse calcareous sands interbedded with quartz sands, coral sands, clays, and shelly crags. Due to cementation and interbedding with clay, they are generally of low permeability, while their marine origin accounts for highly mineralized pore water. Significant infiltration of rainwater is limited, while evapotranspiration of near-surface groundwater is high, suggesting extremely poor water quality and aquifer properties.

The sandy facies of the reef complex consist of sands (ranging from very fine to coarse and gravelly), with embedded layers of clays and limestones. The heterogeneous sequence reflects a lagoonal origin, with locally strong deltaic, fluvial and wind-blown components. While the unit is commonly known as the "Kilindini Sands", this is a rather misleading name, considering the diversity of the deposits. It has therefore been proposed to adopt the more general term "Kilindini Formation", when referring to the Pleistocene back-reef deposits of the Kenyan Coast (JVSA/GSK, 1996; GSK, 1999).

The Kilindini Sands are eroded and reworked sediments mainly derived from the Magarini Sands, and to a lesser extent from the older Marafa Beds and Mazeras

Sandstones. They occur predominantly east of the Foot Plateau, and appear to have been flushed into the back-reef depression by fluvial action, before being reworked by tidal currents and wave action. The poorly-consolidated, sandy parts of the formation provide excellent aquifer properties. In addition, the embedded limestones are generally highly porous, due to chemical dissolution and resulting cavities.

3.4.4 Fossil Coral Reefs

Old coral reefs are very extensive along the coast. In many places, the coral is exposed and utilised for making building stone. The reef has grown upwards with rise of the sea-level, in an attempt to keep pace with the rise, but during a pause in the rise they were forced to extend laterally, the extensions being subsequently covered by other sediments when the sea-level started to rise again. The last phase in the growth of the reef was probably a prolonged halt in the rise of the sea-level that caused a lateral extension of the reef over an area which extends to near the main coast road to the west, and at least several hundreds of metres into the present Ocean to the east. The formation of the reef was followed by a marine regression with subsequent cutting-in of rivers into the freshly-formed deposits and later the abrasion of the reef by the Ocean, forming cliffs and abrasion platforms.

The raised Pleistocene coral reef is found along the entire length of the Kenyan Coast. It has a relatively narrow, commonly 1-4 km wide outcrop, and is believed to be about 100 m thick. Further inland, it passes into sandy lagoonal deposits, and/or becomes obscured by Recent wind-blown sands. On the western side, the limestone is marly and highly weathered into a mixture of clays and partly decomposed rock debris. Inter-fingering with the sandy back-reef facies becomes increasingly important towards the West. As a result, there is no distinct lateral boundary between the limestones and the Kilindini Formation. Sometimes, the interfingering limestones, clays and sands are referred to as the "North Mombasa Crag", but this is not really a separate geological unit.

Towards the east, the reef becomes more purer: it consists of a tough white to yellow-white limestone that is relatively dense and compact compared to other Pleistocene reefs. No reef structure is immediately obvious and much of the rock consists of shell and coral debris rather than in situ coral growth. However, quarry works near the seafront produce a clean, white building stone.

3.4.5 Recent "Post-Reef" Deposits

The recent sediments in the coastal area include wind-blown sands, beach deposits (sands, mud and little gravels), oyster beds and mixed alluvium. These are in general unconsolidated along the coastline due to the turbulence of the sea. Further inland, cemented sands may occur. Among these, the wind-blown cover

sands are probably the most significant. They form a thin veneer (mostly 1-3 m thick) of very loose topsoil material over large parts of the Coastal Plain, and may easily be confused with the very similar sandy facies of the Kilindini Formation.

3.4.6 Local Geology

The geology of the Lamu Island is comprised of fine to medium grained sands that cover almost the entire island. Other isolated and localized outcrops include brown coloured very consolidated fine grained calcareous sandstones observed at two locations near the beach at Shella and Pumping station. While “young” pink-red coral limestone was encountered at Kizingoni area at the beach area.

In general, the medium grained sands occur near Shella area and they progressively become fine westwards towards Kizingoni area. This different textural property in sands formation also occur variably with depth even at shallow depths of 10 metres and in some cases consists of small broken sea shells indicating the origin of the sands. Table 2.1 shows the stratigraphical succession of rock along the Kenyan coast. Those encountered in Lamu Island are highlighted to show their relationship with other coastal rocks.

Table 2.1: Stratigraphical Table (After: Adams 1986)

ERA	PERIOD (age)	ROCKS & SEDIMENTS DEPOSITED	LITHOLOGY	ENVIRONMENT	CLIMATE	EVENTS
CENOZOIC	Recent (0.1 milj.)	<i>Alluvial & Coastal Beach Sands, Coastal Sand Dunes</i>	Superficial unconsolidated sands.	Coastal and near-coastal	Present day	Gradual rise in sea level
	Pleistocene (2 milj.)	Coral Reef and Lagoonal Kilindini Formation	Coral Limestone unconsolidated and cemented sand & clays.	Marine, coastal and near-coastal	Pluvial and Interpluvial	Fluctuating sea level
	Pliocene (7 milj.)	Magarini Sands: -Upper -Lower Marafa Form.	Fine grained, red windblown sands. Coarse quartz sands, gravels & silty clays. Sandst/ sands/ shales	Continental Fluvial and deltaic	Arid ≠ Wet	Extensive erosion of Mesozoic deposits Faulting
	Miocene Oligocene Eocene (58 milj.)	Baratamu Form.	Marls/ limestone/ clays & sands	Shallow water littoral	Warm	Deposition, extensive continental erosion

M E S O Z O I C	Cretaceous (135 milj.)	Mtomku Form.: - Upper - Middle	Shales & limest Shale, limest. & sandst.			Faulting?
	Jurassic (195 milj.)	Mtomku Form.: - Lower Kambe Limestone Mazeras Form.: - Upper - Middle	Shales, siltst. & sandst. Limest, shales & siltst. Sandst./Arkoses Sandst.	Marine Continental	Warm	Marine invasion of coastal plain, subsequent limestone deposition
	Triassic (225 milj.)	Mariakani Sandst: - Upper - Middle - Lower Maji ya Chumvi: - Upper	Sandst. Sandst. Sandst. Sandst., shales, siltst.	Deltaic and lacustrine Deltaic	Generally semi- arid	Continental subsidence to form basin of deposition
P A L A E O Z.	Permian (286 milj.)	Maji ya Chumvi: - Lower Taru Grits: - Upper - Lower	Black, shaly siltst. Arkoses/Sandst. siltst., shales Arkoses/Conglomerates.	Lacustrine Continental	Generally semi- arid	Downwarping of continental margin

3.5. Demography

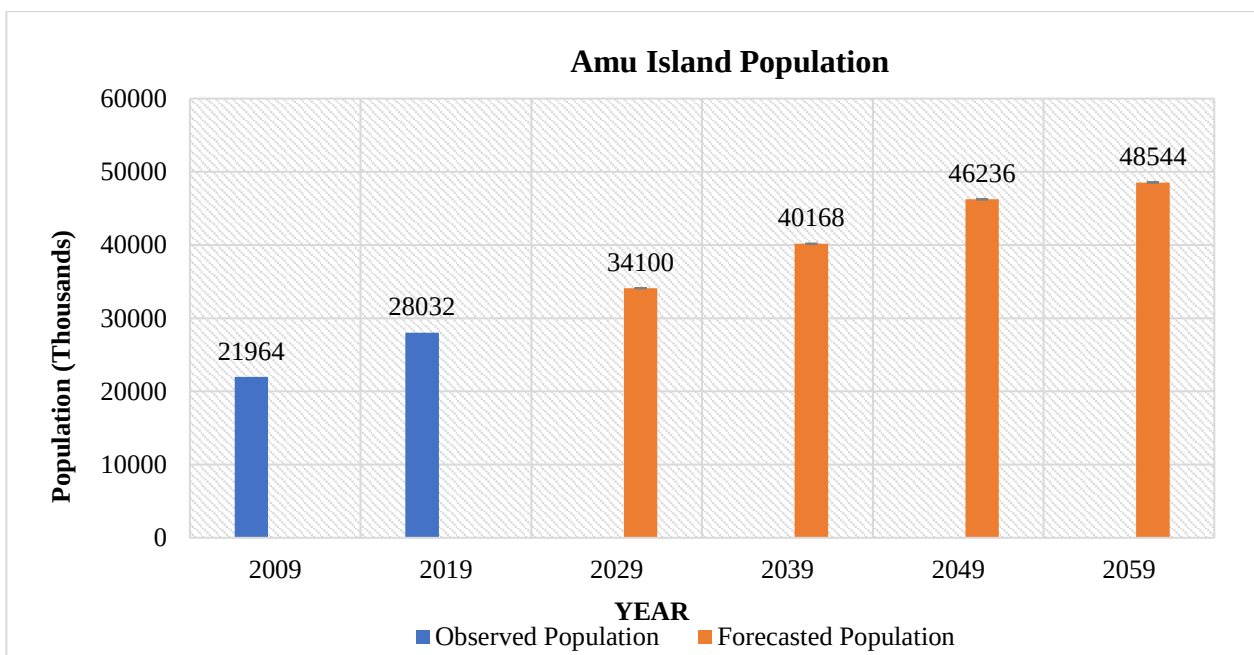
Amu Island is constituted by several locations namely;

- i. Langoni
- ii. Matondoni (Kipungani & Matondoni)
- iii. Mkomani
- iv. Shella/Manda

Table 3-3 shows Population projections within the Amu Island area

Lamu County	1999	2009	2019	2029	2039	2049	2059
Amu	14,055	21,964	28,032	34,100	40,168	46,236	48,544

Table 3-3 Population projections from Kenya population census, 2019



4 WATER RESOURCE AVAILABILITY

4.1 Groundwater

4.1.1 Previous studies

Lamu Island attracted a lot hydrogeological attention as early as 1950s. The first studies on groundwater were carried out by Grundy (1953). Following the results of his study a well field consisting of 20 wells was established in 1957 at sheila area. In his report Grundy (1957) emphasized the possible effects of the pollution of the Lamu aquifer from the waste disposal within Lamu Township (Urban area). He noted that the migration of the waste materials and leachate from the disposal sites would ultimately pollute the groundwater resources. Apart from the pollution from the leachate, Grundy (1957) note the presence of the pervasive saline water into the groundwater resources that posed a great danger. However, he indicated that such an invasion comes from the deep-seated saline water. Selby (1969) documented the hydrogeological set-up on the Lamu water supply. The report highlighted most of the water problems of the Lamu Island and re-emphasized the possible invasion of the saline due to the over-abstraction which is expected to render the water unsuitable for drinking purposes.

CowiConsult (1983) evaluated the possible options for water source available for the Lamu District. The preliminary design report provided 3 options which were evaluated: The first option was to deliver water to the area through an open channel, treat it and then pump to the consumers. The second option was to provide pumped water from Tana River, treat and pump it to the consumers. The third option was exploiting the groundwater resources by constructing shallow boreholes in the sand dune area. In the view of the financial implications at the time it was found out that the most feasible option was to exploit the groundwater resources in the sand dune catchment area.

Van Dongen and Kruseman (1985) gave an overview of the Lamu water situation and proposed a series of the investigations to assess the overall groundwater conditions of the southwestern part of the island and estimate of its groundwater potential. A course was proposed which embodied the inventory data, reconnaissance drilling, surface geophysical measurements, monitoring network, water balance study and modeling techniques. They also recommended that the Lamu well field be extended further westwards but thorough resistivity survey be conducted to delineate the fresh water body. The report also observed that the Lamu water supply provides about 150 cubic meters per day to Mokowe which is rather inadequate to meet the demand of the rapidly growing town.

Additionally, the MOWD/WRAP (1998) published groundwater conditions of the southwestern part of the Island. During this survey a total of the 23 sounding were executed in the area. From the findings, it was concluded that the extension of the Lamu well field would satisfy the water requirements of the island. It was however noted that due to the leakages from the supply pipes and failure from certain wells or even the pumping equipment the water needs are not essentially met. The sand dune west of the present the well field was considered capable of supplying the long term needs of the Island since it has appreciable groundwater storage. It was concluded that high transimissive properties of the sands would supply the required quantities of water.

UNDP (1991), among other issues, published the information on the existing and waste water infrastructures and needs, assessment of the water and sanitation situation and suggested through proposals different ways of ameliorating water supply, drainage and sewerage systems. MRDASAW/UNESCO (1991) conducted groundwater resource assessment of the Lamu Island including Hindi-Mokowe areas of the Lamu District. The study comprised of hydrogeological and geophysical investigations of an area covering about 25 square kilometers. The preliminary findings on available water resources for Lamu Island available for exploitation estimated more than 3,400 cubic metres per day in an area of area of 21 square kilometers. The area included the dunes bordering the southern part of the Island and Makafuni area located 2 kilometers west of the Lamu Town. The recommended exploitation of the existing shella well field including the new wells (all numbering 20 wells) is 750 cubic metres per day which represents 22% of the exploitable water resources of the Island.

4.1.2 General Hydrogeology of the Lamu Island

The hydrogeology of an area is determined by the nature of the geological host material, structural features, weathering processes and precipitation patterns, and prevailing recharge mechanisms. The semi-humid hilly environment of Lamu Island catchment area offers reasonable groundwater potential. The relatively high rainfall, hilly topography and highly transmissive sands are all comparatively favorable characteristics. Under the prevailing hydraulic gradients within the catchment area, drainage is (fairly) slow, which allows fairly significant volumes of groundwater to be available for exploitation.

A simple hydrogeological model can be used to describe the occurrence of groundwater within the Lamu Island. Generally, the aquifers are unconfined and found at relatively shallow depth (10-15 m bgl). Aquifer replenishment occurs primarily from direct local rainfall and in rare cases indirectly as groundwater inflow from poorly established surface run-off. The hilly (sand dunes) and flat topography characterized by permeable top sandy soils offers the most appropriate setting for

maximum recharge and the only limiting factor is the amount of rainfall, which is moderate in this area.

The potential of the fine-medium grained sands for fresh water abstraction depends both on geological factors and on the position of the fresh-saline interface. As fresh water has a lower density than sea-water, it can form a lens which floats on top of the salt water and which can depress the interface to below mean sea level. The actual extent of this depression is a function of the porosity and permeability of the formation, fresh-water recharge and losses (evapotranspiration, lateral drainage, and mixing with sea water).

Safe abstraction of the required groundwater quantities is only possible under conditions of hydrodynamic equilibrium, where significant salt-water up-coning, resulting in an irreversible contamination of the fresh-water aquifer, is avoided by sufficiently high recharge rates. If the extent of the interface depression can be quantified, and values for transmissivity and fresh- water losses approximated, it is possible to estimate actual storage and recharge capacities of the aquifer. High recharge figures can be expected in areas where permeable formations such as the medium grained sands are directly exposed to the earth surface.

At the present site, the aquifers are expected within the upper 10 – 15 metres within sands. It is assumed that the aquifers are recharged directly due to percolation of rainwater. Lateral recharge is expected from steep dunes; however, this is locally affected by tidal fluctuations of the sea levels.

Along the coastline, seawater encroachment is a natural and common process. The greater density of the saltwater causes it to form a wedge below the discharging freshwater, which counterbalances the inland movement. Consequently, fresh groundwater in a typical coastal environment literally floats on the heavier saline water.

The water table slopes gently towards the coast (sea), at a gradient of about 0.001 to 0.005 (1-5 metres per kilometer). Drainage from the southern edge of the sand dune ultimately discharges into the sea. Whereas water will be encountered anywhere below the sand dunes, saltwater intrusion can be a serious problem. Considering that the investigated catchment is indeed prone to saline encroachment, this issue is more extensively discussed in Section 3.3.

Where brackish or saline water underlies the fresh water aquifer, abstractions must be undertaken with great care. In addition, wells should be relatively shallow, in order to keep sufficient distance to the fresh-saline interface. A conservative approach to drilling and pumping seems to conflict with the common desire to obtain as much water as possible. However, it is always in the best interest of the authority in-charge to wisely manage the available groundwater resources, instead of over-exploiting them.

4.1.3 Fresh - Salt Water Relations

4.1.3.1 Introduction

The length of the salt-water wedge is a function of the freshwater discharge and the aquifer characteristics. Where the geological formations are highly transmissive, underground drainage towards the sea is very rapid and the hydraulic head is only slightly above mean sea level. As a result, only a thin (if any) freshwater body can develop. Saline water may thus penetrate further inland than in less permeable deposits.

Usually, the fresh water is separated from the salt water by a brackish transition zone of variable thickness. The thickness of the fresh water body is determined by the difference in specific density (ρ) between fresh water ($\rho_f = 1.000 \text{ g/cm}^3$) and seawater ($\rho_s = 1.025 \text{ g/cm}^3$), and the hydraulic head of the aquifer. The head, in turn, is a function of recharge (rainfall and groundwater flow), aquifer conductivity and thickness. At hydrostatic equilibrium, the following equation applies:

$$Z = h \times \rho_f / (\rho_s -$$

$\rho_f)$ where:

z = the depth (below sea level) to the saline interface, and h = the head of the fresh water above sea level.

This relation is known as the Ghijben-Herzberg principle, after the Dutch engineer-officer W. Badon Ghijben and the German engineer A. Herzberg. Around 1900, both independently concluded that the presence of surprisingly thick fresh water lenses under coastal islands and dune areas was caused by the difference in density between fresh and saline water. Using the specific densities of 1.000 and 1.025, respectively, it follows that **$z = 40h$** .

Hence, if the fresh water level is found to occur at 1 metre above mean sea level, the depth of the saline interface should be expected at 40 m below mean sea level; if the fresh water head is 2 m amsl, salt water is expected to occur at 80 metres, etc.

The Ghijben-Hertzberg relationship is based on uniform and homogenous aquifer conditions, with horizontal flow lines. In practice, the position of the interface may differ considerably from this theoretical simplification. Even in completely homogenous material, the depth of the interface is indeed somewhat less than $40h$, due to the component of fresh water flow towards the sea. In addition, the vertical layering of the water bearing deposits plays an important role. In areas where layers of low permeability overlie highly conductive deposits, the interface will be encountered

at a much shallower depth than suggested by the piezometric head. If the conductivity of the aquifers decreases with depth, the opposite situation is likely to occur.

4.1.3.2 Water Abstraction and Up-coning of the Saline Interface

Abstraction of water from a well or borehole will generally cause some change in the fresh-salt-water equilibrium. Evidently, this shift will be in favour of the saline component. Due to the lowering of the fresh water head, the saline interface will tend to move upward, and seek a new equilibrium with the pumped water level. Thus, in a continuous aquifer zone, any lowering of the water table (including the pumped drawdown in a well) will ultimately result in an upward movement of the saline interface and the brackish transition zone. If pumping is excessive, the interface will eventually reach the base of the well and spoil (pollute) the supply.

The fact that private well owners and local authorities do often not consider the eminent danger; saline intrusion has continuously caused the deterioration of many wells/boreholes in coastal environments. Due their generally high transmissivity, sandy aquifers found along the Kenyan Coast are very vulnerable. Although high yields are accompanied by relatively low levels of drawdown (i.e. high specific capacity), the fresh-saline interface is generally located at shallow depth, while the transition between the contrasting water qualities can be sharp.

If over pumped, the increase in salinity can either be gradual (over a period of years) or very prompt (after some hours of pumping). Where the brackish transition zone is very thin, the quality of the pumped water may suddenly collapse from fresh to saline, without prior warning. For this purpose, it is good practice to construct a deep monitoring hole next to the pumped well.

4.1.4 Hydrogeology of Catchment area of Lamu Island (Sand dunes)

The hydrogeology of the catchment area is controlled largely by the geological formations underlying the sand dunes. Geologically, the area is covered by vast sand deposits, calcareous sandstone and “young” corals.

The white to brownish coloured sand deposits characterizing the dunes have fine to medium grained texture. Along the Shella beach sands are slightly coarser i.e. medium grained and maintains this texture close to beach area 1.5 kilometers west of the pumping station. At this location sand mining for building purposes is a common practice. The sand is preferred for construction because of the coarser grain and high silica content. To the further west, the sands become very fine until Kizingoni area. The distribution of the sand grains was inferred to be related to sand dune formation process and possibly the

contribution of the strong winds that possibly carried the fine particles to increasing far distances.

The brown calcareous sandstone is very compact, massive and fine grained. It was found outcropping on the beach of Shella and at 2 kilometers from the pumping station along the beach. From the geophysical findings, the sandstones were found to be a rather extensive body measuring 50 - 100 metres in width and running sub-parallel to the sand dunes in northeast – southwest direction.

The third geological formation encountered in the catchment area was a much localized “young” coral pink-red coral. It was found outcropping at Kizingoni area at the beach in rather small and scattered patches. Further attempts to map out other locations with similar coral were futile.

The subsurface geology of the catchment area is not adequately known because most of the wells for Shella well field (LAWASCO) were drilled to depths below 15 metres. At this level only sands were observed.

The Island covers an area of about 50 square kilometers out of which about 19 kilometers are covered by the double row of the longitudinal sand dunes along the southern border. The two rows of the sand dunes have a width of 700 metres (in north-south direction) near Shella area. However, to the further west the dune become increasingly laterally extensive in width spreading over a distance of about 3 kilometers towards Kizingoni area.

The dunes in the central part of the southern border have the lowest altitude estimated at about 23 metres (using Garmin GPS). For those on the eastern near the Shella area the highest elevation measured was at about 51 metres, whereas the elevation of the dunes in Kipungani and Kizingoni area reached a height of about 65 metres.

The recharge mechanism within the sand dune catchment area is through direct precipitation. The rain water infiltrates and percolates within the highly permeable windblown sands to augment groundwater body at depth. Due to the highly transmissive property of the sands the Lamu Island has not marked surface drainage. The local run-off is limited to the few metres on the slopes of steep dunes during very heavy downpours. These water forms localized pools that soon disappear as the water infiltrates rapidly into the ground.

The infiltration rates through the sands have not been directly measured in the field. However, CowiConsult estimates that 13.5% of the rainfall recharges the aquifer. The rate of recharge also changes yearly depending on the rainfall intensity, duration and frequency. The main recharge takes place during the month of May when the

average rainfall is about 360 mm. The rainfall estimates made by CowiConsult were rather low considering that the average annual rainfall for Lamu Meteorological station varies between 550 – 1100 mm. Therefore, taking the average the mean annual rainfall would be about 825 mm. (Kuria et al., 2008).

4.2 Surface Water

There are no surface water resources within the Lamu sand dunes apart from several high tide channels.

4.3 Water Quality

In terms of water quality, ground water quality is usually and generally of good biological quality due to it being less vulnerable to anthropogenic pollution. However, the ground water physical and chemical characteristics are adversely altered due to the leachates (from dumpsites and landfills) and also as a result of natural geological formations.

Draw from the aberration survey

5 WATER DEMAND

5.1 Water Demand

Groundwater is used for a variety of uses on Amu Island, including domestic in residential areas, public water supplies in authorized water supply zones, and recreational facilities.

5.1.1 Domestic water demand

The demand for water supply has grown over time within Lamu Island. According to a 1930's survey, there were a total of 91 wells, 30 of which were private wells, 31 attached to mosques, and 30 on the streets. Water transporters on hand carts were the main source of water in Lamu Town. With the advent of piped water supply for Lamu Town, these water suppliers have currently relocated to Shella, Gardeni, and Langoni areas (Siravo & Pulver, 1986).

In 1955, Lamu got a piped water supply with a pumping station in the Shella area. Water for this supply was obtained at the time from the Shella well-20 field's shallow wells spread along the sand dunes.

The Lamu Water Supply Augmentation Project began in 1986. During this project, 10 additional wells were dug while the existing wells (20) and distribution network were rehabilitated.

According to the abstraction survey conducted by WRA in March 2021, 94 groundwater abstraction points were verified, of which 92 were operational and 2 were abandoned.

The largest abstractor, Lamu Water Company (LAWASCO), operates 21 boreholes and has abandoned four non-operational boreholes. Six were abandoned due to salinity. Because of the salinity, the company has decided to place their pumping equipment much higher than the ideal point to avoid over-pumping and thus sea intrusion. All of the abstractions took place through shallow wells. 16 wells were jointly owned, and each household had multiple pumps. The majority of the wells were open, while others were partially covered, with only a few fully covered. There were 15 wells inside, 7 in the kitchen and 8 in the table room.

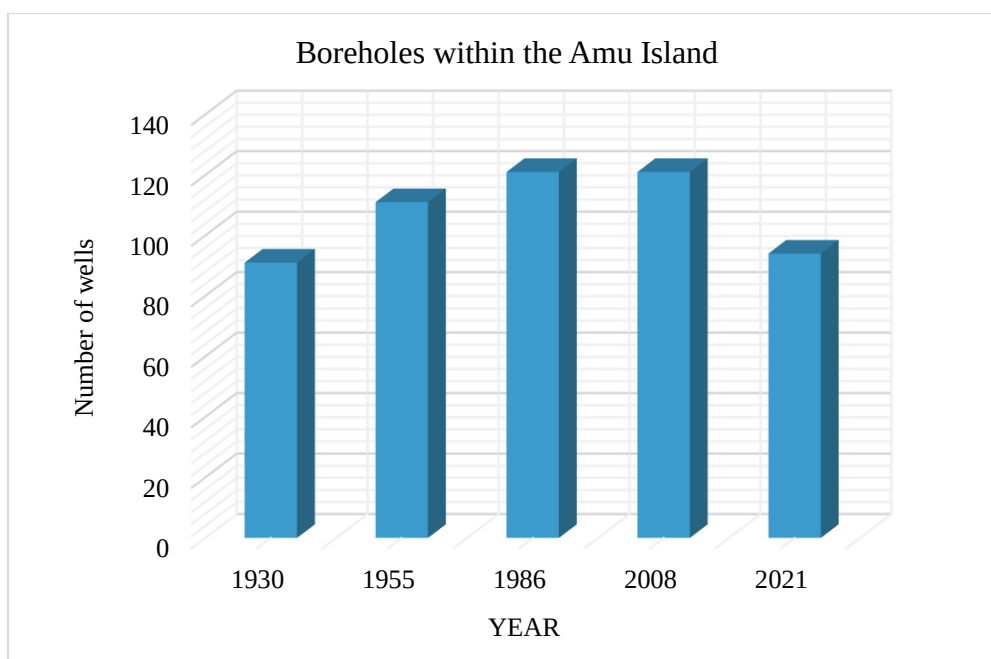


Figure 5.1.1. Trend of Boreholes in the Amu Sand dune Aquifer

To determine the domestic water demand, a rate of **50 L/h/day** has been adopted as an average assessment for the region under the Amu Island aquifer.

The water demand is based on an all-in per capita consumption of 50 litres/day.

Table 5-1 Domestic water Demand in cubic meters per day

District	2009	2019	2029	2039	2049	2059
Amu	1,098.2	1,401.6	1,705	2,008.4	2,311.8	2,427.2

Projections

Population projections from Kenya population census, 2019

5.1.2 Public / Commercial Water Demand

From the water abstraction survey conducted by WRA in the month of March 2021, Lamu Water, and sanitation company LAWASCO supplies more than 90% of water used within the Amu Island amounting to about **2031 cubic meters per day**. The total water abstracted from boreholes is estimated at **2450.7 m³/day**. Water used under public and commercial is estimated at 342.4cubic meters per day, this is inclusive of recreational facilities.

5.1.3 Livestock water demand

Another water consumption element is that of livestock production, both donkeys and camels, however, the Island has donkeys which are majorly used as form of transport. From the 2019 population census it was reported a total of 1086 in Lamu west in which 70% of the donkeys are located within the island. The total donkeys within the Island are therefore estimated at 760 donkeys which are likely to consume a total of **7.6 cubic meters** per day.

Table 5-3 shows the water demand in the Amu Island

Water Uses	population	Rate L/h/day	Quantity (m ³ /Day)
Domestic / Public	30807	50	1540.35
Livestock unit	760	10	7.6
Commercial	6840	50	342
Total			1889.95

Table 5-3 Water demand in Amu Island

6 WATER ALLOCATION AND BALANCE

Water allocation is the *process* in which an available water resource is distributed (or redistributed) to legitimate claimants, and the resulting authorization for use is granted, transferred, reviewed, and adapted as a water use right. Priorities for allocating water may be defined in law or through strategy development or planning processes.

This section provides the rules governing water allocation within the Amu Island. These rules are consistent with the water Resources Regulations 2021 and Water Allocation Plan development guidelines.

At present there is sufficient data regarding actual abstractions from the abstraction and pollution survey done within the sub catchment prior to the development of the WAP.

The report exposed many illegal abstractors responsible to the many inaccuracies in the allocation information. The approach is therefore to provide a framework for water allocation decisions which looks at the different cases of whether a new water allocation is being made or whether the decision is orientated towards bringing an existing water user (illegal) into compliance. Where water resources are inadequate to meet all the demands decisions are made based on priorities and an evaluation of public benefit. The plan provides a framework to guide water allocation decisions and specifically the development of water allocation and apportionment.

6.1 Groundwater Abstraction

LAWASCO (Lamu Water Company) is the main abstractor on the island, supplying the two islands of Amu and Manda with a total abstraction of 2,030 m³/day. However, almost every household on the island has a shallow well, which is either mechanized or not.

6.2 Groundwater Potential

Groundwater potential of the Shella - Kizingoni aquifer was assessed using aquifer geometry (lateral and vertical extent), aquifer storage capacity, and safe yields. The catchment zone is approximately 19, 712,200 m². It is broad in the Kizingoni area but narrows to 600 meters in the Shella area. The bulk water balance for the Shella Kizingoni Aquifer can be calculated using a contribution from the entire catchment area as follows: mean annual rainfall 1100 mm total recharge 2.85 Mm³/year (7,800 m³/day); effective precipitation 13.5 percent; mean annual recharge 148 mm (0.15 m);

total groundwater catchment area 19 km² (exempting dune slopes next beach area). If it is assumed that approximately half of the recharge can be safely abstracted (Kuria et al., 2008).

Table 5-4 estimate of groundwater abstracted from the Amu Island

Amu Island (Km ²)	Estimated Potential (m ³ /year)	Calculated Actual Abstraction (m ³ /day)	No. Of Boreholes
19	2,847,000 (7,800 m ³ /day)	2,450.7	92

The tables below show the available water resources, the demand, allocation and balance.

Table 6.1: Water Balance in the Amu Island

Calculated Yearly Rate Water Balance (m ³)				
Recharge	Ecological/ Baseflow	Public	Domestic	Commercial
2,847,000	854,100	1,423,500	284,700	284,700

Table 6.2: Water Balance in the Amu Island (based on groundwater model)

Model Daily Rate Water Balance (m ³ /day)				
Storage In	Recharge	Storage Out	Wells	Drains

Table 6.3: Water demand allocation status

Current Status (Annual quantity m ³)		
Allocable	Allocated Current abstraction in 2022	Deficit/Surplus
1,992,900	894,505.5	+ 1,098,394.5

Water Use Zones

Hotspots

The term hotspot was used to refer to areas where there are high existing well densities associated with demand for groundwater. Many such areas in the

Aquifer sub-catchments were identified using borehole spatial distribution overlying sab-basin and WRUA delineated areas as presented below in figure

Identified hotspot WRUA areas are:

1. Shella
2. LAWASCO wells area

Abstraction limits of **15m³/day** should be imposed in these identified hotspot areas to protect the resource from over abstraction.

7 Permitting System

The water resources regulations introduced a system of four different water permit categories, based on the risk that the water use activity poses to the water resources (First Schedule). WRA has issued *Water Resources Allocation Thresholds for Classification of Permits* (2007) that specify the thresholds for surface and groundwater to distinguish the different permit classes.

The category of permit determines three factors:

1. Procedure of permit application approval (See **Error! Reference source not found.**);
2. Timeframe for approval;
3. Fees to be paid (See WRR 2021 Second Schedule).

In an effort to improve public participation, the permit approval process involves obtaining comments from WRUAs, the BWRC, and other stakeholders. WRA should expect to provide the water allocation balance to stakeholders to determine whether the permit application is within the boundaries of the allocation balance.

7.2.1 Permit Application Process

The permit application process is shown in **Error! Reference source not found..**

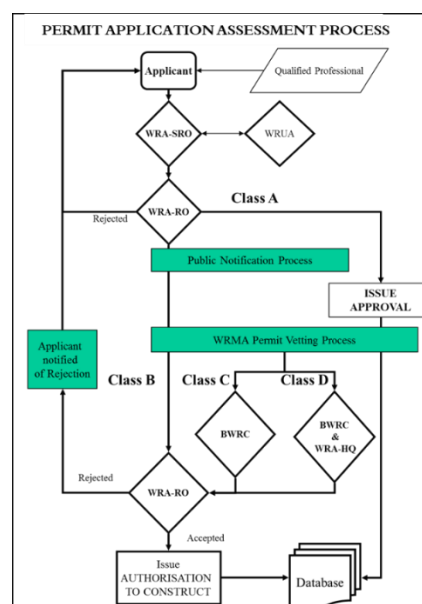


Figure 7-1: Permit Application Approval Process

7.2.2 Evaluation of a Water Permit Application

There are many factors that need to be considered in evaluating a water permit application including:

- **Water Allocation Plan.** Review whether the WAP has specific conditions that apply to the type of application being made;
- **Water allocation balance.** This means reviewing the water allocation balance to determine whether there is sufficient resource to support the application. This essentially takes into consideration existing authorization and investments. If the water has already been allocated, then consideration should be given to the priority of use in the application. This may trigger a wider permit review. Alternatively, the applicant is informed that the resource has already been allocated;
- **Land ownership.** Does the applicant have consent to use the land where water is to be used;
- **Access.** Does the applicant have legal access to the water body in question;
- **Investments and Public Benefits.** Does the applicant propose to make investments that would enable the water use to realise public benefits such as water services, employment, food security, revenue etc;
- **Water Use efficiency.** Has the applicant made provision to use the water efficiently?
- **WRUA comments.** Does the WRUA know of specific issues that should be considered;

7.2.3 Scale and Water Allocation Balances

A. Groundwater

The water allocation balance for groundwater assesses the groundwater availability over the entire aquifer. Where there is high demand for groundwater, reflected by a density of boreholes or wells, then WRA will need to zone the aquifer and develop a water allocation balance for each zone. The application will then need to be checked against both the aquifer and zone water allocation balances.

7.2.4 Conditions of Permit and Authorization

The conditions of authorization should consider and include where appropriate:

- Controlling device;
- Measuring device;
- Data collection and submission;
- Airline (borehole);
- Water quality samples;
- Effluent treatment (EDCP);
- EIA;
- Riparian conservation;
- Soil and water conservation plan;
- Schedule of Inspections.

7.3 Water use thresholds in the Lamu sand dunes aquifer

- WRA has set thresholds for various water use categories, which are used to allocate/apportion water.
- The thresholds provide for minimum and maximum amount of water allocable per permit category per sub catchment.

The table below shows the Groundwater thresholds for the sand dunes aquifer.

PERMIT CLASSES	THRESHOLDS
A	<5 m ³ / day
B	≥5<20 m ³ /day
C	≥20<100 m ³ /day
D	≥100 m ³ /day

Table 7-1 Shella – Kipungani sand dunes Aquifer Water Use Thresholds

8 WAP IMPLEMENTATION PLAN

8.1 Compliance and Enforcement Plan

8.1.1 Compliance

In analyzing the water resource management problems, it is important to distinguish between water allocation and compliance/enforcement problems. For example, an aquifer may run dry, not because of any problem in the allocation of the resource, but rather because the water users fail to comply and WRA fails to enforce the conditions of the permits.

The purpose of a compliance plan is to bring the WAP into effect, to inform stakeholders and water users of the provisions in the WAP, and to progressively build better compliance to the water allocation framework. The effectiveness of the compliance plan will be measured by the extent to which the WAP is relevant to allocation decisions and compliance.

8.1.1.1 Approach

The WRA is committed to resolving competing claims for water use in ways that sustain the environment and socio-economic growth. While it is the responsibility of the applicant to fulfil all the conditions prescribed in their permit or water use authorization, the purpose of the WAP is to allocate water resources in such a way that allows for individual users to meet these requirements.

The Authority shall promote compliance by:

- Raising awareness of the benefits of complying with the rules and the potential consequences of not complying;
- Overcoming factors that promote non-compliance (e.g. permit conditions that are unattainable, delays in permit processing);
- Providing more punitive actions to non-compliance;
- Removing barriers to compliance.

There are many causes for non-compliance, including lack of awareness, poverty, apathy, or deliberate negligence. Each cause requires a different solution. Lack of

awareness can be addressed through appropriate communication and engagement. Permit fees are varied in accordance with the scale of the water user; category A applies specifically to social use of water resources, while a person with a category B, C or D permit should be able to afford their permit fees and water use charges. Reminders and prodding via phone calls, visits and/or letters can be employed to manage water users. Those that are deliberately non-compliant may be prosecuted with corresponding violation penalties.

The objective of the WAP and what it intends to achieve must be clearly spelt out at the beginning of the document.

The framework for a compliance plan has been developed as part of the implementation strategy of the WAP. The compliance plan set out actions that are required to achieve compliance, specify targets, deadlines and the responsible body for completing the action.

Various aspects should be considered, including:

- Assessment of the water resource monitoring network;
- Development of an adequate communication system;
- Conditions of authorizations;
- Monitoring water use;
- Monitoring period of abstraction restrictions;
- Financing the compliance plan.

8.1.1.2 Communication

There are two aspects relating to communication that should be considered:

1. Dissemination of the WAP;
2. Near real-time water resource status.

The WAP dissemination will involve the preparation of a brief summary document that sets out the key aspects of the WAP, focusing particularly on the aspects that touch on water users and the need for compliance.

The real-time water resource status is important to inform water users on the status of the aquifer at any given time, so that they can adjust their abstraction accordingly. In order to make this possible a number of steps can be taken, namely:

- Install “traffic light” water level indicators or public bill boards/notice boards in public places frequented by the water users;
- Inform WRUA and water users through SMS, social media or short radio advertisements when abstraction restrictions apply.

8.1.1.3 Building Compliance

This section presents various suggestions to build compliance around typical non-compliance issues. The following is recommended

1. Permits for new boreholes

New wells will be restricted to public water supply only. This is in a bid to ensure that the aquifer is not put under further stress. It is also easier to ensure compliance from public service providers including requirements for sewer network.

2. Specify the minimum distances between wells.
3. Specify the abstraction limit
4. New tariff regime
5. Existing wells (Permitted)
 - In existing wells, a requirement for installation of smart meters (type approved by WRA) and configured to transmit data to WRA servers will be put in place.
 - There will also be enforcement of permitted abstraction volumes.
 - In overdrawn sub catchments, permitted volumes will be varied downwards where the density of boreholes is very high and usage is high.

6. Existing wells (Illegal)

- Application for permit as per the Water Resources Regulations (will require the wells to be capped until permit issued);
- Suspension /deregistration of drillers/constructors and consultants involved in the development of illegal wells;
- Surcharging of owner for water used illegally;
- Installation of smart meters (type approved by WRA) and configured to transmit data to WRA servers;
- Enforcement of permitted abstraction volumes;
- Requirement for water recycling/reuse/reduce strategies before legalization is allowed;

7. Drillers and Water Resources Professionals

- Drillers participating in illegal drilling to be sanctioned through suspension/deregistration;
- Enforcement of requirement for notification of mobilization to site and a requirement of the driller and hydrogeologist be notified to WRA for every project
- Checking that the well/borehole completion records are duly filled in by licensed water resources professionals(hydrogeologists) and drilling contractors

8.1.1.4 Category A Users

Category A water use is intended to cover those activities that have minimal impact, such as non-motorized shallow wells, low volume and/or low risk pans, etc. Category A applications thus do not require resource-intensive work or a detailed level of scrutiny from the WRA.

The application and approval process has been deliberately designed to be quick, cheap and free of complications. Despite this many water users fail to register their water use

through the Category A authorization process. Various issues can be addressed to improve compliance:

- Despite the lack of revenue to WRA associated with Category A users, WRA needs to promote this option through the WRUAs to register the hand dug wells
- WRA to review the Category A threshold to comply with small scale subsistence / livelihood water use.

8.1.1.5 Meters

Devices to measure water abstraction are a crucial component to water resource monitoring and enforcement. It is therefore important to ensure that water users are compliant with the requirement for such meters.

The WRM Rules state that every water user, whether for water abstraction or effluent discharge, is required to have a controlling device and measuring device installed for accurate measurement of water abstracted, obstructed or diverted and for effluent discharged. The Rules further specify the type of measuring device, location, and calibration requirements. In addition, airlines are required to be installed in wells/boreholes to allow for the measurement of water levels.

Water users will be required to install smart master meters approved by the Authority for ease of monitoring water abstraction.

8.1.2 ENFORCEMENT PLAN

WRA has the overall responsibility to oversee enforcement and compliance to all the water regulations.

The enforcement plan set out:

- Mechanisms for reporting and investigating infringements to the WAP;
- Appropriate action to be taken against violators;
- Penalties for and restrictions on violators;

One option is to empower the WRUAs to monitor compliance to the WAP and report violators to WRA. WRUAs, being locally based, can identify and document violations

as they occur, issue warnings and escalate the case to WRA where non-compliance persists. In order to do this the WRUAs need to be given a clear mandate, need to be incentivized, and need to address the resource requirements. When violation cases are reported to WRA it is imperative that WRA takes action which may comprise of confiscation of equipment, closing of control gates, sealing off boreholes/wells and ultimately prosecuting persistent violators.

Special management units to sections of aquifers can be encouraged to be formed for example resident associations to monitor, report and ensure policing of groundwater abstraction in their area of use.

In the context of human capacity and financial constraints for enforcement by the WRA, the authority can take on the approach of focusing enforcement action by regularly monitoring a number of suspected violating users for compliance, and delegate the enforcement of smaller scale user violation monitoring to WRUAs.

8.1.2.1 Reporting and Investigating Violations

Violations to WAP conditions can be reported by individuals, organizations, or WRUAs.

The enforcement plan sets out to whom violations should be reported to and who is responsible for investigating the claims. A procedure for report investigation will be established and a time limit for responding to a violation report defined. These procedures may vary depending on the severity of the reported violation. However, the plan will be established with consideration of the limited human and financial resources available.

Reporting violations will be done in such a manner that the authority can easily follow up on such a claim. The report should include the following information:

- Name of the reporter;
- Contact details of the reporter (address, telephone number, and email address);
- Water body;
- Nature, location, date and time of violation;

- Name and contact details (if available) of violator.

8.1.2.2 Taking Appropriate Action

Verbal and written warnings as well as corrective action imposed by WRUAs and the WRA are available as enforcement tactics. The appropriate action to take against a violation will depend on the severity of the violation.

A “name and shame” approach that publicizes permit compliance information can be successfully adopted although in the final analysis it is usually prosecution of individual cases that can demonstrate the commitment by WRA to enforcement.

8.1.2.3 Violation Penalties

The WRR 2021 define penalties for permit violations.

Options for penalties may include:

- Financial penalties;
- Restrictions on water use;
- Imposed community service obligations.

These will be presented in the WAP

8.2 M&E Framework

Monitoring and evaluation are key components for successful WAP implementation and contribute towards the WAP review. Monitoring should be an ongoing task to achieve sustainable water resource management; ensuring that abstraction limits are adhered to, permit conditions are upheld, Reserve conditions are maintained, and that water quality standards are met.

8.2.1 Key Indicators for WAP Compliance

Table 8- presents a number of key indicators that will form part of the M&E plan. These are intended to monitor the progress towards achieving the predefined targets.

Table 8-1 : Key Indicators to Monitor WAP Compliance

Indicator	Means of Verification	Frequency	Responsibility
Over abstraction that is not supported by a valid permit	Meter reading data (abstraction data), PDB, Inspections	Continuous	WRA
Abstraction without valid permits.	PDB Reports, and inspection reports	Continuous	WRA
Abstraction without measuring devices	Inspections	Continuous	WRA
Discharging and disposing waste into the environment against prescribed standards	Inspections	Continuous	WRA

8.2.2 WAP Evaluation Process

An evaluation exercise provides an opportunity to reflect on progress towards meeting predefined objectives and outcomes. It is proposed that a mid-term evaluation exercise is conducted approximately 2.5 – 3 years after the WAP is developed to establish whether there is adequate information to gauge progress, to identify constraints to WAP implementation and to modify the implementation plan accordingly.

It is advisable to use participatory methodologies during the evaluation exercise to ensure that the key stakeholders are provided with an opportunity to reflect on the constraints and successes of the WAP implementation plan. In addition, the findings and recommendations emerging from the exercise are developed by the key stakeholders themselves.

An evaluation of the WAP at the end of the WAP term would be a component of the WAP review process which is discussed in Section **Error! Reference source not found..**

8.2.3 ROLES AND RESPONSIBILITIES

The roles and responsibilities of different stakeholders for WAP implementation are clearly set out in the WAP. Table 8- provides suggested responsibilities

Table 8-2 : Stakeholder Roles and Responsibilities

Stakeholder	Role	Responsibility
WRA	National government agency responsible for regulation of use and management of water resource	• Publish and disseminate WAP; • Enforce conditions of WAP; • Prosecute permit violators; • Facilitate WAP implementation; • Facilitate WAP evaluation after 3 years. • Monitor water resource status • Implement system of communication to WRUAs and water users regarding flow status
WRUA	Cooperative management of water resources and a forum for conflict resolution	• Communicate terms of WAP to water users and other stakeholders; • Enforce conditions of WAP; • Investigate permit violations, complete follow-up inspections, issue warnings regarding non-compliance. • Support planning and implementation of common self- regulating intakes • Implement system of communication to water users regarding flow status

County Government	Devolved government functions and services	• Support WAP compliance • Ensure County Government projects comply with WAP
Water Users	Utilize water resources in a responsible and legal manner	• Comply with conditions of permits and WAP. • Install abstraction meters and remit data
Water Service Providers	Provide efficient, reliable and affordable water services	• Comply with conditions of WAP • Develop storage to build water security • Facilitate WAP implementation
Environmental NGOs	Advocate for policy and practice that supports environmental conservation	• Monitor WAP compliance • Report cases of non-compliance • Monitor cases of Reserve violations
Research institutions	Promote understanding and improvements in water allocation and use	• Support acquisition and sharing of data relevant to WAP
GOK Ministries and agencies	Policy, regulation and national government services	• Facilitate WAP implementation and compliance

8.3 Special Studies

8.4 WAP Review Process

Revisions to the WAP are expected given changes in the human and natural environment and emerging information on the availability and use of the water resources. This first WAP (2024 – 2029) will be reviewed after five years with the subsequent WAPs reviewed after a 5-year period.

It is important to recognise that the custodian of the WAP is WRA. Therefore, proposed changes to the WAP must be channelled through WRA.

These processes will include the following:

8.4.1 Incremental Changes to WAP

Proposals for changes to the WAP can be initiated by an individual water user, WRUA and WRA. The proposal must be submitted in writing to WRA, stating the following:

- a. What part of the WAP requires amendment;
- b. A discussion on the alternative options, providing supporting details;
- c. A recommendation regarding which alternative is considered preferable.

On receiving a proposal for amendment, WRA will review the proposal within 30 days and will send the proposal with comments to the WRUAs within AMU Island within 90 days of receiving the proposal. WRA will propose one of the three courses of action:

- i. The proposal is not supported by WRA and it does not recommend further action on the proposal;
- ii. The proposal has merit and WRA recognises the need to act quickly and therefore invites the WRUAs to a meeting to discuss the same within 90 days of receiving the proposal;
- iii. The proposal has merit but WRA recommends deferring discussion until a number of issues have accumulated or placing the issue in the agenda of WRUAs meetings.

If WRA and the WRUAs agree on the provisions within the WAP that require amendment, then the WAP will be amended accordingly. WRA would then place an advertisement in the newspaper and/or prominently display in public places within the sub-basin, to ensure widespread notification of the changes to the WAP.

8.4.2 Evaluation and Review of WAP

At the end of the current WAP, WRA in collaboration with WRUAs, will commission a detailed evaluation of the WAP covering aspects of:

- i. Objectives and indicators;
- ii. Conditions;
- iii. Compliance;

- iv. Enforcement;
- v. WAP monitoring and review process.

The evaluation would form a basis for detailed and if necessary, substantial revisions to the WAP.

8.4.3 Preparations for Revising WAP

The WAP will require amendment as additional information becomes available. However, WRA, the WRUAs, the water users and other stakeholders have a responsibility to see that additional information is collected and made available to the WAP review process.

8.5 Implementation Budget & Financing

The WAP is a framework for decision making requiring long term financing. It will require all the institutions and stakeholders involved to have sufficient financial resources to cover their own activities and responsibilities. The institutions need to examine their responsibilities and budget accordingly.

9 RECOMMENDATIONS FOR WATER ALLOCATION PLAN IMPLEMENTATION

Permitting to undertake construction of new wells will be prioritized to water service providers for public services against private/ individual entities but nothing should stop the WRA from authorizing drilling for any other uses where necessary.

1. Well construction will be allowed upon establishment that there will be no interference with the nearby existing wells.
2. The physical/Chemical characteristic will determine the ultimate use of the water in compliance to the human health safety measures.
3. Lock ups to abstraction will be imposed in areas of over abstraction /deficit.
4. No permits to be issued in areas with poor water quality
5. Establishment of more groundwater monitoring wells should be done to monitor the aquifers.
6. Consideration of conjunctive use of water resources – both surface and Groundwater to reduce over reliance on groundwater. The need to emphasise rainwater harvesting.

Recommendations for Aquifer management plan

- i. The management of the recharge zone (sand dunes) should stress the importance of retaining and improving natural recharge characteristics and minimising inappropriate land conversion;
 - ii. Conversely, areas suffering from significant depletion could be managed in a more restrictive fashion, including reducing authorised abstraction or *moratoria* on new BH construction.
2. Management “rules” will likely range from restrictive to truly laissez faire, and should encourage the dynamism and investment capacities of the private sector while at the same time putting in place sensible controls on inappropriate groundwater use. These controls and their objectives must be widely publicised.
 3. Despite the difficulties associated with ensuring this, broad stakeholder/public participation should be part of the GCA/AMP development process.

4. The GCA/AMP may consider any or all of the following demographic characteristics when considering which areas require controls or encouragement; population densities and projected growth rates; abstraction intensities and absolute borehole numbers.
5. It is self-evident that Government and political support for any GCA/AMP process is more than merely desirable, and we acknowledge that this may prove the principal stumbling block to such a process.

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