Republic of The Gambia

Technology Needs Assessment – Phase II

Report III

TECHNOLOGY ACTION PLAN (TAP)

BY

1. Ms. Lallah Badgie	Ministry of Environment, Climate Change and Natural Resources
2. Mr. Benedic Leese Mendy	Department of Water Resources
3. Mr. Momodou Dumbuya	Ministry of Works and Transport
4. Mr. Amulaye Jarjusey	Ministry of Works and Transport
5. Mr. Bubu Pateh Jallow	National Consultant

TABLE OF CONTENTS

REPORT III - TECHNOLOGY ACTION PLAN

List of Acronyms

AFOLU:	Agriculture, Forestry and Land Use
ANR:	Agriculture and Natural Resources
BAC	Brikama Area Council
BCC	Banjul City Council
CA:	Conservation Agriculture
CADR:	Compound annual growth rate
CO2e	Carbon Dioxide Equivalent
CRR	Central River Region
CRS	Catholic Relief Services
DoA	Department of Agriculture

DWR	Department of Water Resources
ERC	Energy Resources Centre
FAO	United Nations Food and Agriculture Organization
GBA	Greater Banjul Area
GBOS	Gambia Bureau of Statistics
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagramme
GHG	Greenhouse Gas
GOTG	Government of The Gambia
HFO	Heavy Fuel Oil
IPP	Independent power producer
KMC	Kanifing Municipal Council
LDCF	Least Developed Countries Fund
LRR	Lower River Region
MECCNAR	Ministry of Environment Climate Change and Natural Resources
MoA	Ministry of Agriculture
MoFEA	Ministry of Finance and Economic Affairs
MoHSW	Ministry of Health and Social Welfare
MoLGL	Ministry of Local Government and Lands
MoTIE	Ministry of Trade, Industry and Employment
MW	Megawatt
NAPA	National Adaptation Programme of Actions
NARI	National Agricultural Research Institute
NAWEC	National Water and Electricity
NBR	North Bank Region
NCCP:	National Climate Change Policy
NDP:	National Development Plan
NIR	National Inventory Report
NTP	National Transport Policy
PURA	Public Utilities Regulatory Agency
REEEP	Renewable Energy and Energy Efficiency Programme
SDG	Sustainable Development Goal
SPCR:	Special Programme for Climate Resilience
TAP	Technology Action Plan
TEEC:	Total Final Energy Consumption
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework for Climate Change Convention
URR	Upper River Region
WAA	West African Aquaculture

CHAPTER 1: TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR THE AGRICULTURE SECTOR

1.1 TAP for the Agriculture Sector

1.1.1 Sector overview

Agriculture is the main driver of GDP growth, employs nearly half (46.4 %) of the working population and 80.7 % of the rural working population. The sector typically contributes up to 31% of national GDP although this has declined to 20% of GDP in 2016 (IHS 2016[1]). Furthermore, the poor are most likely to rely on agriculture for livelihood as 72% of the poor and 91% of the poor work as farmers. Agriculture, specifically groundnuts is the main source of foreign exchange for the Gambia-accounting for 30% while simultaneously meeting 50% of the national food requirements (CCA 2015). In addition, agro-industries constitute a significant component of Gambia's industries – which is another growth driver that contributes 15% to GDP.

The agriculture sector is characterized by subsistence-based rain-fed mixed-crop (mainly groundnuts, coarse grains, rice and cassava) farming, traditional livestock rearing, semi-commercial groundnut and horticultural production, small cotton and a large artisanal fisheries sub-sector. This type of farming system is carried out mainly by small-scale resource poor farmers who use labour-intensive traditional production practices on less than one-hectare average farm size plots (usually fragmented). The farming system, in general, results in low outputs and causes a gradual decline in soil fertility.

According to the Medium-term development plan (NDP, 2018-2021[2]) of The Gambia, key features of The Gambia's agriculture include:

- Predominantly, crop based with 85% of households while about 10% raise animals;
- Access to land is predominantly by inheritance with 92.4% of households' land acquired this way;
- Average holdings are 1.3ha (1.4ha for male but 0.8ha for female headed households)
- Only 4.5% of land parcels are irrigated indicating low technology application;
- Gender differences in crops grown; women mostly rice and vegetables while men focus more on cereal grains;
- Usage of fertilizers is common with 79.4% of households using it; 41.7% using inorganic fertilizers and 37.7% organic fertilizers.

Based on the 2010 National Inventory Report (GOTG/NIR, 2017[3]) of The Gambia, a total of about 2514GgCO2e was emitted from the Agriculture, Forestry and Land Use (AFOLU) category in The Gambia in 2010. From Figure 1 about 53% of the emissions came from Agricuture (Cropland and Livestock) sector.

[1] *2016 Independent Household Survey*
[2] *GoTG/NDP, (2017): Gambia National Development Plan, 2018-2021.*
[3] *GoTG/NIR, (2017): The 2010 National Inventory of Greenhouse Gas Emissions of The Gambia*

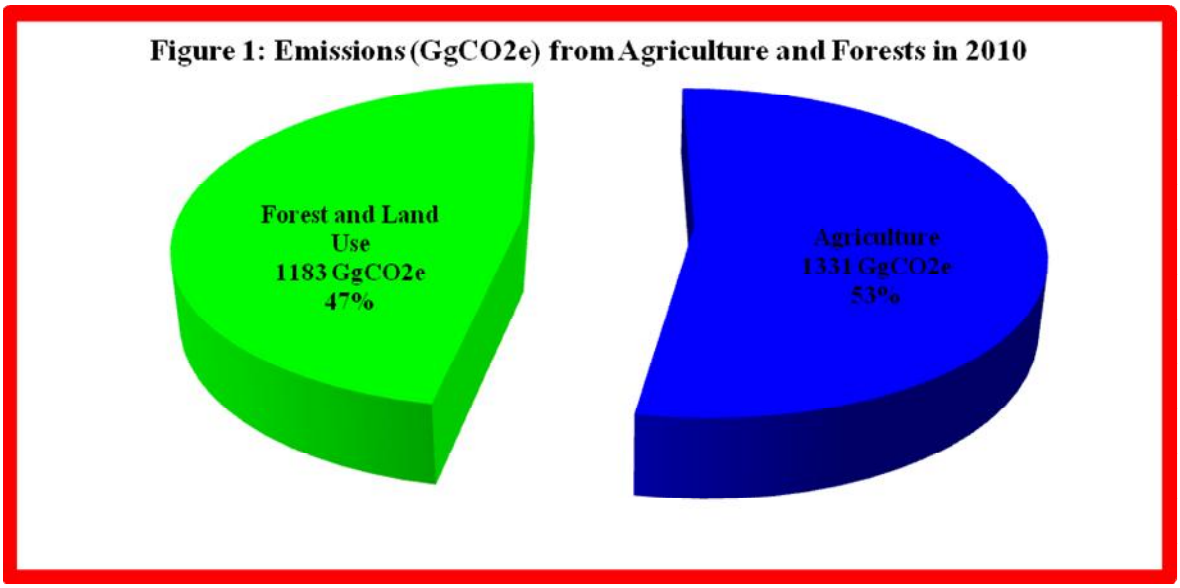
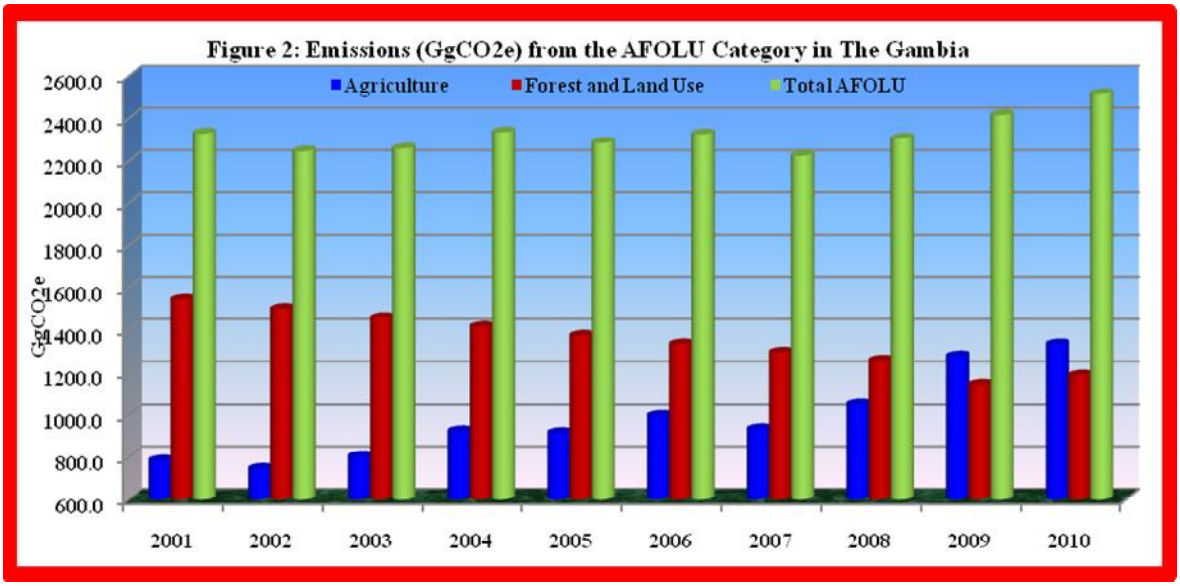


Figure 2 below shows an increasing trend in emissions from the Agriculture sector but a decreasing trend in emissions from Forest and Land Use Change. Of the sub-categories[4] of the Agriculture category, Rice cultivation (RC, 34%), Enteric Fermentation (EF, 29%) and Agricultural Soils (AS, 25%), are respectively, the biggest emitters in 2010.



The absence of a comprehensive Agriculture and Natural Resources (ANR) policy has resulted to incoherent and fragmented sub sectoral policies as well as weak linkages in the planning, coordination, and implementation of agricultural programs. Furthermore, it has been observed that budgetary allocations to agriculture did not match the strong policy declarations, thus rendering most of the sector objectives unrealistic.

[4] *EF=Enteric Fermentation, MM=Manure Management, RC=Rice Cultivation, AS=Agricultural Soils, SB=Burning Savanna and CRB=Burning of Crop Residues*

A weak policy environment limits private sector participation in agricultural financing especially in the provision of timely inputs, processing and adding value to farm produce and in marketing. The high cost of domestic borrowing, coupled with the ingrained risks in agriculture has contrived to make financing of agricultural investments less attractive. Presently only 4.8% of commercial bank loans are allocated to agriculture, demonstrating significant room for improvement. Government funding for the agriculture sector has not gone above 6% during the past five years. Not only was the level of allocations below the 10% NEPAD-recommended target, but the expenditure were skewed toward operating costs with just wages and allowances accounting for over 40% of expenditures.

Given the country's geo-physical characteristics, the soil resources in The Gambia are fragile, not renewable, and of relatively low fertility. The poor farming practices currently in use has not been helpful and resulted to consistently less than optimal yields and low agricultural productivity. The demand to achieve Zero Hunger will require land and labor efficiency through technology. The use of modern technology is weak in some cases and nonexistent in others.

The low soil fertility levels are further exacerbated by the national overdependence on rainfall for agricultural production with low use of irrigation systems. Although the rainy season lasts for roughly 5 months in the year, only 6% of the arable land is irrigated. As a result, very little production takes place during the dry season. However even though the River Gambia emerges as a natural source for irrigation, various studies have shown that the maximum threshold for pump irrigation using river Gambia is at 6,000 ha. Stretching beyond this will correspondingly over stretch the salinity front which has negative implications for production. The sustainable use of the groundwater and innovative rainwater harvesting and utilization will consequently emerge as a viable option.

The Gambia National Agricultural Policy calls for the judicious and prudent utilization of land to satisfy competing requirements. Notwithstanding, poor land and water management has put farmers on a collusion path with pastoralists, ecologists, industrialists, and urbanization. Further exacerbating the land related challenges is that fact that almost all farmlands in rural Gambia are held under a customary land tenure system, which tends to discourage long term investment and limit women access to land.

A new agriculture and natural resources development policy is needed and must aim to increase farm productivity, diversify farm household production and marketing mix, ensure farmers get a fair price for their produce and are paid in cash, maximize value addition to agricultural commodities. The government's vision for the agriculture sector is to transform The Gambia into a major supplier of agricultural products to local and international markets by (a) increasing food security and boosting the income-generating capacity and the nutritional status of farmers, especially women and youths; (b) increasing and sustaining agricultural production and productivity; and (c) enhancing beneficiaries' productive capacity through supervision, coordination, regulation and advice.

1.1.2 Action Plan for Conservation Agriculture Technology

1.1.2.1 Introduction

Conservation agriculture (CA) is an agricultural system that aims at soil and water conservation, nutrient improvement and enhanced production. Conservative agriculture technologies are based on the principles of (a) minimal soil disturbance (zero-tillage), (b) maintenance of good soil cover (cover crops, residues and mulches), and (c) appropriate crop rotation or crop association depending on the availability of land. Zero tillage is a method of tilling a field in which the soil is disturbed as little as possible and it aims at making better use of agricultural resources through the integrated management of soil, water and biological inputs. Zero Tillage improves the soil, increases production and decreases the cost of production. It consists of improved agricultural packages including (a) crop residue from previous crop and crop rotation; (b) application of herbicide for control of emerging and non emerging weeds (pre- post emergence herbicides); (c) planting in rows and application of fertilizer in one operation by a special planter; and (d) starting agricultural operations after the soil has received 110 mm of rainfall.

Zero tillage, as a component of Conservative Agriculture, was applied in The Gambia on a relatively small scale in the 1980s and 1990s. This simple and cost-effective approach to increasing the climate resilience of agriculture is particularly well suited to low input rain-fed agricultural systems such as those in The Gambia. Zero tillage improves the productivity in rainfed and irrigated farming systems. A fundamental criterion related to coverage is that annual rainfall must exceed 600mm.

Due to increased human and animal population, and the reduction in productivity due to negative impacts of climate variability (which is now compounded by climate change), there is now the need to grow and produce more food in a shorter period. Agricultural mechanization was introduced which has negative impacts on the shallow and poor soils of The Gambia. Productivity continues to decline and there is need to go back to conservative agriculture which is recommended as a climate resilient agricultural technique because conservation of soil organic matter increases the fertility and water holding capacity of soils. The CA approach is compatible with the use of green manures to increase soil fertility. Intercropping, as a component of CA, involves planting two or more crops in close association, often focusing on nitrogen-fixing species. This approach can increase the climate resilience of agriculture by diversifying the risk of monoculture farming, as well as by increasing soil fertility through planting of nitrogen fixing crops.

Cost associated with establishment of one production unit using zero tillage equipment (tractor, 90HP+planter+ sprayer) is 31,600 USD. In field crops, the cost of implementing the technology is reduced to the cost of the seeder or planter (2,000 US$/yr) (MoE/URC/GEF, 2012). Application of conservative agriculture technologies shows that the cost of production is maintained as the inputs do not augment because soil fertility and water content are preserved. The major saving will be in terms of costs for tillage and land preparation for plantation.

Zero tillage improves the productivity in rain-fed and irrigated farming systems. There will be increase in farmers' incomes, increased food production and encouragement of private sector investments and thus new job opportunities in the production of agricultural crops. An overall yield stability, a reduction in cost of production, and increases in farmer's income are realized. Revenue increases of about 760$/ha/yr for cereal/legumes have been registered (MoE/URC/GEF, 2012). Under baseline conditions with the application of Conservation Agriculture, farmers need Tractor or Ox-drawn ploughs, seeders, seeds, inorganic fertilizers, herbicides and much more labour. With zero- or no-till diggers and hoes, seeds, organic fertilizers from crop residues, herbicides.

1.1.2.2 Ambition for the Conservation Agriculture TAP

The ambition sets the scale and context for the envisaged technology uptake and/or diffusion in the country/target area for the TAP (TEC/DTU[5]). The Gambia has a population of about 1,520,000 persons dependent on agriculture. With a population of 8 persons per House Hold (HH), there are 190,000HH engaged in agriculture. The ambition for the adoption of Conservation Agriculture is to engage 100,000HH in Conservation Agriculture. This represents 53% of the households engage in Agriculture. The targeted area for transfer and application of the zero tillage system is geographically large for The Gambia as rainfall is everywhere equal to or greater than 600mm.

1.1.2.3 Actions and Activities selected for inclusion in the Conservation Agriculture TAP

Economic and financial barriers include (a) high initial and application cost of zero tillage compared to conventional agriculture; (b) limited financial availability and capacity to adopt and promote conservation agriculture techniques and demonstration of field trials, and to support research, extension and crop insurance that encourages the application of conservation agriculture; (c) little valuation (price assignment) to the positive impacts of conservation agriculture techniques in relation to environmental damage and the services of ecosystem; (d) lack of access to financing because of not being able to provide collateral to support loan applications; (e) loan conditions are not favourable as repayment is within one season and risk of crop failure may result to defaulting and then followed by asset seizure; and (f) high interest rates by Commercial banks (23-27%);

Non-financial barriers to Conservation Agriculture include (a) weak implementation of existing legal and institutional frameworks and limited incentives that encourage the adoption and implementation of conservation agriculture; (b) farmer to extension worker ratio is too high because of the high attrition rate of staff, farmers are unfamiliar with all aspects of conservation agriculture technology, and government promotes other approaches over conservation agriculture; (c) farmers are more familiar with conventional agriculture to the extent that they view conservation agriculture as a downgrade to basic technology and general awareness of conservation agriculture is low; and (d) technically, crops with limited crop residues do not do well for conservation agriculture.

[5] *TEC/DTU, (2016): Enhancing Implementation of Technology Needs Assessments Guidance for Preparing a Technology Action Plan*

The economic and financial measures required to lift the barriers include (a) government subsidy provided to farmers to reduce initial and application costs of adoption of conservation agriculture;

- Sustainable financial flows establish to promote research, extension and crop insurance that encourages the application of conservation agriculture;
- Techniques and skills for valuation of the benefits of conservation agriculture are adopted and applied in relation to environmental damage and the services of ecosystem;
- Farmers receive higher income from conservation agriculture practices to enable provision of collateral to support loan applications
- Loan conditions are not favourable as repayment is within one season and risk of crop failure may result to defaulting and then followed by asset seizure
- Farmers deal with village level financial services that provide low interest rates of about 5%

Non-financial measures to remove barriers include:

- Policies and legal instruments under the agriculture sector are fully implemented to encourage adoption and implementation of conservation agriculture;
- Government provides adequate incentives that encourage the adoption and implementation of conservation agriculture;
- Government has provided capacities, skills and incentives to build a larger number of extension agents to improve the Farmer to extension worker ratio;
- Conservation agriculture is popularized and has become an acceptable technology to the farmers;
- Extension workers with greater and varied specialization are available;
- Crops with high crop residues are adopted to promote conservation agriculture;
- Information on conservation agriculture is generally available and widely disseminated to farmers;

The actions, activities and the narrative descriptions of each of the measures selected as actions to be included in the TAP are provided in the Overview Table below. These also serve as Project Ideas for further development into Projects as and when funds and funding sources are identified. The Table also provides the estimated cost of the TAP for Conservation Agriculture and the different stakeholders who will be involved in the coordination and implementation of the actions and activities. The Overview Tables also indicates the risks and monitoring requirements.

Table 1: Overview of Conservation Agriculture TAP										
Sector	**Agriculture**									
Sub-sector	**Crop Production**									
Technology	**Conservation Agriculture**									
Ambition	Out of 190,000HH engaged in agriculture, the ambition is to engage 100,000HH or 53% of the households in Conservation Agriculture. The geographical area is country and the rainfall everywhere supports Conservation Agriculture									
Benefits	Benefits include (a) minimum soil disturbance and maintenance of good soil cover; (b) integrated management of soil, water and biological inputs;									
Action	**Activities to be implemented**	**Objectives**	**Source of funding**	**Responsible parties**	**How should it be done**	**Beneficiaries**	**Time frame**	**Monitoring**	**Indicators of success**	**Cost USD**
1: Expand access to finance	**1.1**Introduction of financial incentives to overcome the economic barrier	–To enhance the uptake of CA –To encourage farmers to adopt the new technology	Existing funding programs in The Gambia: FAO, UNDP, MoFEA, MoA, DWR	MoFEA, MoA, DWR	• Introduce an initial land preparation scheme • Farmers experimenting new technology without scarifying profit • Engaging policy makers drafting agriculture legislation to prioritize finance incentives for CA	Farmers, private and public sectors	Long term	MoFEA ,MoA, DWR	• Risk of adaptation reduced • Financial incentives in agriculture legislation	50,000
	1.2 Increasing access to finance for farmers by providing loans/credit to farmers at lower rates of interest	–To provide affordable loans/credit to farmers with lower rates	Existing funding programs in The Gambia: FAO, UNDP, MoFEA, MoA, DWR	MoFEA, MoA, DWR	–Give loans/credit to farmers to buy enough seed for cover crop, fertilizers, herbicides	Farmers, private and public sectors	Long term	MoFEA ,MoA, DWR	–Farmers accessed financial resources Interest rates on loans lowered –Labour cost affordable	100,000
	1.3 Acquisition of heavy machinery and equipment	–To provide financial cost required for the purchase/ manufacturing of heavy machinery and equipment	Existing funding programs in The Gambia: FAO, UNDP, MoFEA, MoA, DWR	International and local experts, MoFEA, MoA, DWR	–Training local manufacturers Strengthen technical institutions like GTTI –Campaign for tax reduction on imported machinery/equipment	Local manufactures, private and public business sectors	Long term	MoFEA ,MoA, DWR, international organizations	–Capital cost available –Specific seed machinery available	200,000

2: Expand capacity building initiative and collaboration	**2.1** Conducting training sessions	–To build capacities and increase the experience of technicians in CA. –To promote awareness creation to both small and large scale farmers –Sensitize farmers to build confidence in the CA technology	Existing funding programs in The Gambia: FAO, UNDP, etc, etc	MECCNAR, MoA, DWR, NARI	–Review and assess the technical needs of farmers and extension workers –Develop plans and programs for training and capacity building –Organize regular workshops	Farmers ,extension workers,	Medium	MoA, DWR, NARI	–Assessment report produced –CA Plan and program developed	100,000
	2.2 Conduct experimental studies in research institutions and on farm.	–This will help to better understand the impact of CA on different crops in different farm lands within country. –Promote research in agricultural sector –Promote new climate change technologies	Existing funding programs in The Gambia: FAO, UNDP, etc, etc	MECCNAR, MoA, DWR, NARI	–Assess the required technical and advanced equipment need in the research institution –Provide sufficient financial support to purchase the required equipment –Facilitate good communication between the farmers and the researchers –Assess the quality of seeds	NARI Staff, Department of agriculture staff, extension workers	Long term	MoA, DWR, NARI	–Research results obtained Funds available	200,0000

1.1.3 Action Plan for Tidal Irrigation Technology

1.1.3.1 Introduction

The climate of The Gambia is uniform across the country due to its small size and relatively flat features, with a single rainfall season annually, which starts in June and ends in October. The rainfall in the country varies evenly from 1,100 mm in the south-west to 700 mm in the north and east. The rainfall is highly seasonal with all but 1% or 2% falling in the raining season.

The Gambia River rises in Guinea and passes through Guinea Bissau and Senegal before finally entering The Gambia for an approximately 500 km journey to the sea. The flow in the river is highly seasonal. The maximum flow occurs at the end of the rainy season in late September or early October with a flow of about 1,500 m^3/s. The minimum dry season flow is less than 4.5 m^3/s; both measurements taken at Gouloumbo in Senegal. Due to the large variation in river flow and the flat nature of the country's terrain, the Gambia River is tidal, and thus saline in the west and freshwater in the eastern half of its length. The position of the interface between the freshwater and saltwater varies with river flow. During the low flow period, the freshwater-saltwater interface, defined as the point at which the salinity is 10 ppt, is 250 km from the sea. Under high flow conditions, this interface is located 150 km from the sea.

The availability of tidal freshwater at high tide in the CRR and URR of The Gambia, enables the use of that zone as source of irrigation water supply, referred to as Tidal Irrigation. This technology is intended to supplement rain fed agriculture. Due to the use of this technology, a double cropping of rice is achieved annually in a country with seven months of dry season. The land along the Gambia River is relatively flat, and, since the river is tidal all through its length in The Gambia, tidal irrigation schemes become feasible. Tide heights vary from 3.5 m at the mouth of the river to 0.9 m at Basang, 310 km upstream. Special intake structures or canals are constructed with gates which, when opened at high tide, allowed tidal waters to enter irrigation channels leading to the farms. During high tide, the gates were opened from 3 to 24 hours, depending on the size of the area to be irrigated. In two rice-growing areas, at Jahally and Pacharr, tidal and pump irrigation are coordinated. Tidal heights of 1.3 and 1.0 exist in the Gambia River at Jahally and Pacharr, respectively. Tidal water is utilized to irrigate low lands nearer the banks of the river while water is pumped from the river to irrigate large areas of land at higher elevations.

1.1.3.2 Ambition for the Tidal Irrigation TAP

Through the year the eastern half of the length of the River Gambia is under the freshwater zone. Thus, in these areas tidal irrigation is possible for the whole year round and the ambition is to put this area under tidal irrigation. The height of tide in this area also varies and thus the cost of the infrastructure will vary becoming more expensive in the Upper River Region where the banks of the River are higher above the water at all times.

1.1.3.3 Actions and Activities selected for inclusion in the Tidal Irrigation TAP

Under the category of Economic and Financial Barriers, initial high cost of system installation is identified as the main barrier for adoption and penetration of tidal irrigation technology. This initial high cost includes high cost of importation of the kits, as these are not manufactured in The Gambia, and high cost of land preparation. The import duty attached to the importation is also high. Facilitation schemes for credit/loans to the famers are not friendly because of high interest rates. The interest rates applied also make the farmers unable to pay back the loans, leading to seizure of assets and increased poverty. High cost of operations and maintenance of the system also contributes to economic and financial barriers. This includes high cost of di-silting the canals and replacement of broken structures.

Non-financial Barriers include:

- Limited skills of farmers and extension agents in land development, and the repair and maintenance structures and facilities;
- Farmers and other individuals do not have access to lands for farming due to unfavourable land tenure system, land tenure system policy and land ownership
- Water scarcity due drop in river water levels as a consequence of climatic variation and change, siltation, and inappropriate design of canals;
- Tidal irrigation not applicable country wide due to salt intrusion

To lift these barriers and make Tidal Irrigation technology widely adopted by farmers some measures have been identified under the barrier analysis. The actions and activities to be undertaken are indicated in the Overview Table below.

To lift the economic and financial barriers that limit the uptake and expansion of Tidal Irrigation technology, suggested actions and activities put forward include (a) provision of financial incentives to overcome high cost associated with tidal irrigation; (b) improve access to finance through soft loans/credit at lower rates of interest and favourable payment terms; and (c) use of appropriate machinery and equipment. The activities to achieve these economic and financially related actions may include the use of domestic (e.g., the proposed National Climate Change Fund) and international funding sources, assignment of budget codes in the domestic budget based on innovation and transformational change of the activities, development of institutional and human capacities to produce local materials, and provision of incentives schemes for tax waivers and reduction on imported machinery/equipment.

Table 2: Overview of Tidal Irrigation TAP

Sector	**Agriculture**
Sub-sector	**Crop Production**
Technology	**Tidal Irrigation**
Ambition	**The Technology will be expanded to cover the eastern half of the total length of the River Gambia within the territory of The Gambia**
Benefits	**Double cropping of rice cultivation will be achieved annually under Tidal Irrigation. Once the intake structures and irrigation channels are appropriately constructed, the operation is relatively cost free. Maintenance work on the irrigation channels and clearing of weeds and brush from the channels and irrigated area can be done by the local farmers. No cultural inhibitions have been experienced and the technology provides for viable commercial farming in a poor rural area.**

Action	Activities to be implemented	Objectives	Source of funding	Responsible parties	How should it be done	Beneficiaries	Time frame	Monitoring	Indicators of success	Cost USD
Expand access to finance	**1.1** Introduction of financial incentives to overcome high cost associated with irrigation	–To support short term uptake of the technology by farmers –Financial motive farmers to replicate the project in all fresh water areas within the country. –To motive farmers and water User's Association	Existing funding programs in The Gambia; FAO, UNDP,UNEP Microfinance institution participating in the funding programme together with public funders, MoFEA	MECCNAR in collobration with MoA, DWR,	–Secure funding from domestic and international sources. Introduce a scheme on installation of irrigation systems. set –Assigned budget incentives for Water User's Association –Assigned budget for micro irrigation scheme and develop structures to implement the scheme. –Farmers to pay Water User's Association in cash or kind at the end of every production season.	Farmers, Water User's Association, Extension workers	Long term	MoA, DWR, Department of Agriculture		100,000
	1.2 Increasing access to finance for farmers by providing loans/credit to farmers at lower rates of interest	To provide affordable loans/credit to farmers with lower rates	Existing funding programs in The Gambia: FAO, UNDP, MoFEA, MoA, DWR	MoFEA, MoA, DWR	Give affordable loans/credit to farmers	Farmers, private and public sectors	Long term	MoFEA ,MoA, DWR	–Farmers accessed financial resources Interest rates on loans lowered –Labor cost affordable	100,000
	1.3 Acquisition of heavy machinery and equipment	To provide financial cost required for the purchase/ manufacturing of heavy machinery and equipment	Existing funding programs in The Gambia: FAO, UNDP, MoFEA, MoA, DWR	International and local experts, MoFEA, MoA, DWR	–Training local manufacturers Strengthen technical institutions like GTTI –Campaign for tax reduction on imported machinery/equipment	Local manufactures , private and public business sectors	Long term	MoFEA ,MoA, DWR, international organizations	–Capital cost available –Gates spare parts available	200,000
Expand	**2.1**Training and	–Improved skilled	Existing	Internationa	–Develop plans and programs	Farmers,	Long term	MoA,	Training	150,000

capacity building initiative and collaboration	capacity building programmes on tidal irrigation techniques	personnel for the installation ,operation and maintenance of the technology –Train farmers on how to repair their gates –Train GTTI Student to make spare parts –Enhance skills of Water Users Association To improve farmers behavior and perception to Tidal Irrigation –To train local people to construct tidal canals, gates and perimeter dykes –To proper design tidal areas for rainy season, dry season and both rainy and dry seasons	funding programs, GCF, International adaptation training windows	l and national experts, MoA, Department of agriculture engineering unit,	training for capacity building installation and operation and maintenance –Review and assess needs of existing technical staff and farmers	extension Workers , water User Association , Agriculture engineers		Department of agriculture engineering unit	programs and capacity building conducted Sensitization via media advertised, aired, broadcasted	
	2.2 Strengthening institutions in terms of human resources and technical expertise	–Improved limited human resource capacities –Promote the development and management Implement the programs and activities for the technology	Existing funding programs available in The Gambia, Government, MoA, stakeholders, Department of Agriculture	Internationa l and national experts Department of Agriculture , MoA,	–Assess the required resources of the institutions –Train local engineers to construct tidal canals, perimeter dyke. –Train engineers to de-silt tidal canals –Design and conduct training programs on irrigation and water management –Build capacities of irrigation experts and professionals in the institutions –Create units in the institutions to be responsible of the planning, approval, administration, technical support, implementation,	NARI, GTTI, NEA,DWR, MECCNAR	Medium term	Department of Agriculture, MoHERST, MoFEA, MoA	Human labour increased Design and training program available Institutions equipped with required equipment and capacities	250,000

					monitoring and evaluation					
	2.3 Strengthening technical tertiary institution	–To engage students in this institution to build component or spare parts in order to overcome shortage and also reduce importation. –Farmers to immediately replace their gates when necessary	Funding programs available in The Gambia, , MoA, stakeholders, Department of Agriculture	International and national experts MECCNAR in collaboration with MoA, DWR, NEA	–Assess the requirements needed in the institution –Equip the institution with the required equipment for the students. –Design and teach courses related to irrigation method. –Conducted hands-on practical sessions for the student design and build spare parts needed. –Arrange field works for students on tidal areas	GTTI, NTA, other technical institution	Long term	MoA, Department of agriculture engineering unit,	–Equipment required available. –Students started learning courses related to irrigation –Spare parts constructed	150,000
	2.4 Introduction of Water User Association concept and Agricultural Science within Basic and Secondary Education and Higher Education	In order to obtained enough qualified technicians in Water User Association and Agricultural related fields	Funding programs available in The Gambia, , MoA, stakeholders, Department of Agriculture	International and national experts MoBSE, MoHEREST	–Engage Government and Stakeholders to incorporate Water User Association concept in all levels of Gambia Education Curricula –Water User Association concept and Agricultural related courses to be a requirement for all students	Water User Association, Agriculture extension workers, farmers	Long term	DWR, MoA, MoBSE, MoHEREST	–Water User Association concept incorporated in the education curricula –Student attending courses related to Water User Association and agricultural related fields	100,000
	2.5 Awareness campaign	To increase awareness/information on Tidal Irrigation Technology and Water User Association. Sensitize farmers on the impact of climate change on irrigation systems	Funding programs available in The Gambia, , MoA, stakeholders, Department of Agriculture,	International and national experts, MoICI, DWR, MoA,	–By organizing workshops –Through media programs	Farmers , Water User Association, Agriculture extension workers	Medium term	MoICI, DWR, MoA	–Workshops organized successfully –Demand for Water User Association	100,000

1.1.4 Action Plan for Aquaculture and Fish Farming Technology

1.1.4.1 Introduction to Aquaculture and Fish Farming Technology

Aquaculture is the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants and involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish. Mariculture refers to aquaculture practiced in marine environments. Particular kinds of aquaculture include fish farming, shrimp farming, oyster farming, algaculture (such as seaweed farming), and the cultivation of ornamental fish. The farming of fish is the most common form of aquaculture. It involves raising fish commercially in tanks, ponds or ocean enclosures, usually for food. Fish species raised by fish farms include salmon, tilapia and catfish.

Aquaculture development was introduced in the world mainly to minimize over-fishing of the fish stocks from the wild in order to preserve abundant fish resources for the future generations and to play a leading role in food security, generate revenue and employment particularly at the rural communities. Due to the protein contents, the demand for fish and fishery products continues increasing.

Economically, aquaculture products fill a distinctive niche in the market, that of the high value, high quality seafood product (e.g. smoked salmon, fresh oysters). These products will complement, rather than compete with, the supply from wild fisheries in the marketplace. In the short-to medium-term, it should be recognized though that the main factors which will determine the development of aquaculture is the ability to develop markets, although environmental restrictions and disease may constrain developments for some species.

A decrease in fish stocks is projected under climate change and the relative contribution of aquaculture is likely to increase due to the decline of wild stocks and the imposition of tighter fishing regulations. The social and economic impacts of aquaculture include increase in fish supplies, reduction in fish price, export earnings, creation of employment and improved infrastructure in rural areas. Aquaculture can be a focus for rural development and stabilization, and a source of employment opportunities in depressed rural economies. Aquaculture can generate significant social and economic benefits at a regional level. The creation of employment opportunities in less fortunate rural areas is often cited as one of the most important reasons why local and national governments have been willing to encourage the development of aquaculture.

The three most obvious benefits have been a noticeable decrease in the price of some species, an increase in consumer surplus for this produce and the creation of new products. Environmental benefits include avoidance of water quality degradation, avoidance of biodiversity losses and the avoided use of chemicals for disease management. Disadvantages of aquaculture include conflict over resource usage, creation of a resource sink, disruption of social structure, and loss of traditional occupations. A continuous fall in market price, associated with oversupply problem may ultimately threaten the viability of the industry itself.

In The Gambia, per capita consumption of fish at the urban communities outstrips that of the rural communities. People in the latter also find it difficult for fish to be readily available and affordable. Unemployment rate has ever been high. Government of The Gambia found it prudent to introduce aquaculture as an alternative to capture fisheries and by way of alleviating poverty and facilitating the improvement of the nutritional standards of the population. Today, aquaculture is the latest fisheries sub-sector in The Gambia after Artisanal and Industrial fisheries sub-sectors. The first aquaculture project was introduced at Bansang, CRR, through the cooperation of The Gambia Government, the CRS and the American Peace Corps. Tree types of aquaculture are practice in The Gambia: borehole aquaculture, irrigation aquaculture and tidal aquaculture. The only state owned hatchery is at the Aquaculture site in Sapu. There is another private shrimp hatchery in Pirang owned by the West African Aquaculture (WAA) which is engaged in aquaculture for shrimps on a commercial scale. About 100 hectares from their 550 hectare land have been used for construction of ten (10) ponds and less than 100 tonnes of shrimps was produced. The hatchery is producing 2.5 million post larvae (PL). The production cycle is 6 months from April – November (Fisheries and Aquaculture Strategy Action Plan 2017 – 2021). Aquaculture is steadily increasing from few trial ponds in 1979 to about 98 small-scale fish ponds in 2016. In The Gambia, Aquaculture ponds are owned by the Government, communities, private individuals and schools (Dibba B, May 2016[6]).

This report concentrates only on tidal aquaculture practice in The Gambia. This technology is selected because it is more reasonable in terms of cost compared to the other two types. During the TNA identification on sector areas meeting held at the Department of Water Resources, The Gambia on 15th May, 2018, Aquaculture was selected as priority sector—due to its vulnerability to climate change tendencies. The focus was mainly centered on barriers affecting the sub-sector. Existing barriers have been creating obstacles and affect the transfer and diffusion of prioritized adaptation technologies. This report is based on the existing Aquaculture projects in The Gambian. It is prepared through observations, literature review, interviews and discussions. The Fisheries Act, 2007 and the Fisheries and Aquaculture Policy (2018 – 2022) aim to outline the analysis of existing barriers and enabling framework for prioritized technologies in the aquaculture sector.

1.1.4.2 Ambition for the Aquaculture and Fish Farming TAP

In The Gambia, aquaculture is applicable in every part of the country, whether in fresh water zone in CRR and URR or in the saltwater zone in LRR, NBR, WCR and Greater Banjul Area (GBA). This assessment targets 1000 ponds per District/Ward each measuring 500m^2. The interventions will involve research on physical, chemical and biological properties of aquaculture for maximum production through adoption of better land management practices. The LHDP under the Ministry of Agriculture has transferred technology to Rural Fish Farmers to improve and diversify production, nutrition and increase revenue through integration of poultry into fish farming technology.

[6] *Dibba, 2016: Aquaculture Sector Review*

1.1.4.3 Actions and Activities selected for inclusion in the Aquaculture and Fish Farming TAP

Barriers related to technology implementation have been identified in two categories (a) Economic/financial and non-financial barriers. Financial barriers include high cost of aquaculture operations (pond construction); lack of loans to communities to invest; inadequate potential and risky investments in aquaculture; poor and inadequate access to markets for fish; inaccessible energy; inadequate process feeds; expensive costs of imported seeds; low level investments resulting to less economic and financial benefits; inadequate funds to prevent intruders consuming the fish species in the ponds; and lack of foreign investments. Non-financial barriers include inadequate access to and availability of information and capacity; socio-cultural issues; technical and technological barriers; and legal and institutional barriers.

Actions are needed to lift these barriers and make aquaculture and fish farming technology accessible to majority of communities in all the districts and wards. Some of these actions and activities are included in the following Overview Table of the TAP.

Table 3: Overview of Aquaculture and Fish Farming TAP

Sector	**Agriculture**
Sub-sector	**Crop Production**
Technology	**Aquaculture and Fish Farming Technology**
Ambition	**The Technology will be expanded to cover the eastern half of the total length of the River Gambia within the territory of The Gambia**
Benefits	**Double cropping of rice cultivation will be achieved annually under Tidal Irrigation. Once the intake structures and irrigation channels are appropriately constructed, the operation is relatively cost free. Maintenance work on the irrigation channels and clearing of weeds and brush from the channels and irrigated area can be done by the local farmers. No cultural inhibitions have been experienced and the technology provides for viable commercial farming in a poor rural area.**

Action	Activities to be implemented	Objectives	Source of funding	Responsible parties	How should it be done	Beneficiaries	Time frame	Monitoring	Indicators of success	Cost USD
Improve community investment and ownership of aquaculture and fish farming facilities	Facilitate partnerships and communal operations for cost reduction and cost effectiveness;	Promote wide application of technology	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoF, MoFEA, MoA,	New set of package to support local farmers during application of Aquaculture and Fish Farming	Farmers, Fish User's Association and private sector	Short-term/ Long-term	MoFEA ,MoA, MoF, international organizations		75,000
	Facilitate access to finance through low interest loans to communities to invest;	Create access to financial sources	FAO, UNDP, MoF, MoA, MoFEA and other international funds	Ministry of Fishery (MoF), MoFEA DWR, MOA, international and national experts	Easy access to funds created for Farmers	Farmers, public and private sector	long-term	MoA, DWR, Ministry of Fishery	–Farmers accessed financial resources Interest rates on loans lowered –Labor cost affordable	85,000
	Improve access to markets for fish and fish products from aquaculture and fish farms;	Assist farmers in the quick buying and selling of fish and fish products	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoF, MoFEA, MoA,	Easy access to markets and fishing sites	Farmers and Fish User's	Short-term	MoA, MoFEA, Ministry of Fishery	- Affordable, quick and low transportation charges –Profit and encouragement to farmers	115,000
	Encourage local production of seed and feeds to reduce costs of importation	To provide financial cost required for the purchase/ manufacturing of seed and feeds	FAO, UNDP, MoF, MOA, private sector, and other international funds	Ministry of Fishery (MoF), MoFEA DWR, MOA, international and national experts	–Training local manufacturers Strengthen technical institutions like GTTI –Campaign for tariff on imported products	Local manufactures, private and public business sectors	Long term	MoFEA ,MoA, MoF, international organizations	–Capital cost available –Local production of feeds available to reduce costs	150,000
Capacity building of communities;	training and sensitization of communities on aquaculture, fish farming and maintenance of ecosystems to support aquaculture;	Increase capacities	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoA, MoF, DWR, NGOs	–Develop plans and programs training for capacity building installation and operation and maintenance –Review and assess needs of existing technical staff and farmers	Farmers, extension Workers , Fish User Association , MoF, MoA	Long term	MoA, MoF	Training programs and capacity building conducted Sensitization via media advertised, aired, broadcasted	75,000
	upgrade and/or	–Improved limited human	FAO, UNDP,	International	–Assess the required resources of the	Farmers,	Medium term	MoF, MoHERST,	Human labour	420,000

	establish aquaculture and fish farming institutions	resource capacities –Promote the development and management Implement the programs and activities for the technology	MoF, MOA, private sector, and other international funds	and national experts, MoF, MoA, MoFEA	institutions –Train local engineers to construct and maintain fish ponds and its products –Train engineers of the day to day management of finger-lings –Design and conduct training programs on Aquaculture and Fish Farming –Build capacities of Aquaculture experts and professionals in the institutions –Create units in the institutions to be responsible of the planning, approval, administration, technical support, implementation, monitoring and evaluation	GTTI, MoF, DWR, MoA, UTG, NGOs and other technical institutions		MoFEA, MoA	increased Design and training program available Institutions equipped with required equipment and capacities	
Improve socio-cultural acceptance of aquaculture and fish farming;	societal set-ups,	Raise awareness level	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoF, MoICI, DWR, MoA, NGOs	–By organizing workshops –Through media programs	Farmers, NGOs, Agriculture extension workers	Medium term	MoICI, MoF, MoA	–Workshops organized successfully –Demand for Fish User Association	50,000
	encourage partnerships;	Access to information	Funding programs available in The Gambia, , MoA, MoF, stakeholders, Private sector	MoF, MoICI, MoA, Public and Private sector	–By organizing meetings and workshops –Through media programs -Other effective communication means	MoF, MoA, Local manufactures, private and public sectors	Medium term	MoICI, MoF, MoA	–Meetings and Workshops organized successfully –Strategic communication means	15,000
	encourage aquaculture farmers to produce commercially and beyond family consumption;	To increase awareness/information on the benefits of Aquaculture and Fish Farming.. Sensitize communities on the impact of climate change and over-fishing	Funding programs available in The Gambia, , MoA, MoF, stakeholders, Private sector	MoF, MoICI, MoA, Public and Private sector	–By organizing workshops and meetings with farmers and communities –Through media programs	Farmers , Fish User Association, Agriculture extension workers	Medium term	MoICI, MoF, MoA	–Meetings and Workshops organized successfully –Demand for Fiah User Association	50,000
	encourage youths to stay within the community to enhance availability of labour force;	Sensitize youths on the benefits of Aquaculture and Fish Farming.	Funding programs available in The Gambia, , MoA, MoF, stakeholders, Private sector	MoF, MoICI, MoA, NGOs	–By organizing workshops and meetings with youths and communities	NGOs-youths, Farmers and communities	Medium term	MoICI, MoF, MoA	–Meetings and Workshops organized successfully	20,000
	promote gender responsiveness and empowerment of	Sensitize regarding the involvement of women on the benefits of	Funding programs available in The	MoF, MoICI, MoA, NGOs	–By organizing workshops and meetings with communities	NGOs-women, Farmers and communities	Medium term	MoICI, MoF, MoA	–Meetings and Workshops organized	10,000

	women;	Aquaculture and Fish Farming.	Gambia, , MoA, MoF, stakeholders, Private sector						successfully	
	discourage expansion of settlements into lands suitable for aquaculture and fish farming);	To increase awareness/information on the benefits of Aquaculture and Fish Farming.	Funding programs available in The Gambia, , MoA, MoF, stakeholders, Private sector	MoF, MoICI, MoA, NGOs	–By organizing workshops and meetings with communities –Through media programs	NGOs, Farmers, Public and Private sector	Medium term	MoICI, MoF, MoA	–Meetings and Workshops organized successfully –Demand land suitable for aquaculture and fish farming	50,000
Strengthen technical and technological capacity of communities and extension agents	adopt, promote and utilize traditional methods;	In order to obtained enough qualified farmers and extension agents in aquaculture and fish farming	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoA, MoF, DWR, NGOs	–Engage Government and Stakeholders to incorporate traditional methods. – Design and teach courses related to modern and traditional method.	Farmers, extension Workers , Fish User Association ,	Long term	MoA, MoF	Training programs and capacity building conducted Sensitization via media advertised, aired, broadcasted	25,000
	improve efficiency, methods and technologies for production and utilization of seed, feed, and fingerlings for aquaculture and fish farming;	Increase capacities	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoA, MoF, DWR, NGOs	–Develop plans and programs training for capacity building –Review and assess needs of existing technical staff and farmers	Farmers, extension Workers , Fish User Association , MoF, MoA	Long term	MoA, MoF	Training programs and capacity building conducted	25,000
	increase the number and quality of technical and extension agents to enable site selection and design of ponds;	Increase capacities	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoA, MoF, DWR,	–Develop plans and programs training for capacity building –Review and assess needs of existing technical staff and extension agents	Extension Workers, MoF, MoA	Medium term	MoA, MoF	Training programs and capacity building conducted	25,000
	determination of the different sex, stages and the sock size in a pond; mortality rate in a stock; disease outbreaks;	Strengthen technical and technological capacities	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoA, MoF, DWR,	–Develop plans and programs training for capacity building –Review and assess needs of existing technical staff, farmers and extension agents	Extension Workers ,MoF, MoA, Farmers	Medium term	MoA, MoF	Training programs and capacity building conducted	25,000
	strengthen laboratory and qualified technicians for testing biological and water samples among others;	Strengthen technical and technological capacities	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoA, MoF, DWR,	– Strengthen technical and technological capacities of workers –Develop and strengthen laboratory for testing	Extension Workers ,MoF, MoA, Farmers	Medium term	MoA, MoF	Training programs and capacity building conducted A full equipment and operational laboratory	250,000
	improve the availability of logistics and	-Increased accessibility for farmers to ease	FAO, UNDP, MoF, MOA,	MoA, MoF,	–Provision of logistics support and incentives	Extension Workers ,MoF,	Medium term	MoA, MoF	Logistics support and incentives	100,000

	incentives to maintain high level trained personnel at the community level where aquaculture and fish farming are implemented;	movement -Improved incentives to maintain high level trained personnel	private sector, and other international funds	DWR,		MoA, Farmers			would successfully boost the sector	
	Improve financial availability and flow to fund research and development from Government and development partners;	–Improved limited human resource capacities –Promote the development and management Implement the programs and activities for the technology	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoF, MoA, Public and Private sector	–Assess the required resources of the institutions –Train local engineers and technicians –Design and conduct training programs on aquaculture and fish farming –Build capacities of aquaculture and fish farming experts and professionals in the institutions –Create units in the institutions to be responsible of the planning, approval, administration, technical support, implementation, monitoring and evaluation	MoF, GTTI, MoA, ,DWR, and other tertiary institutions	Medium term	MoA, MoF ,MoHERST, MoFEA	Human labour increased Design and training program available Institutions equipped with required equipment and capacities	100,000
Strengthen the legal, policy and institutional mechanisms for aquaculture and fish farming	Improve access to energy;	- Increase energy supply and quality for aquaculture and fish farming sites and markets	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoF, MoA,	- Design and build energy system or facilities created for farmers	Farmers, extension Workers , and public	Long term	MoA, MoF	Access to efficient energy supply. Improved quality services.	80,000
	Strengthen road and communication infrastructure to, at and from aquaculture facilities;	Ease movement to, at and from a aquaculture facilities with less time, thereby reducing cost	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoF, MoA,	Design and construct road infrastructure created for farmers	Farmers, extension Workers , and public	Long term	MoA, MoF	Quick access to aquaculture facilities	100,000
	Fully Integrate aquaculture and fish farming in the Fisheries Act and Policy for effective enforcement	Promote application of technology	FAO, UNDP, MoF, MOA, private sector, and other international funds	MoF, MoA, IDWR, NGOs, MOICI and National Assembly	- Developed/ implemented supportive policies for technology deployment	Extension Workers ,MoF, MoA, Farmers, Public and Private sector	Long term	MoA, MoF, DWR, National Assembly	Workshops and meetings successfully conducted. Updated fisheries Act and Policy	100,000

CHAPTER 2: TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR THE COASTAL RESOURCES

2.1 TAP for the Coastal Resources Sector

2.1.1 Sector overview

The Gambia's coastal zone consists of 80 km of open ocean coast and approximately 200 km of sheltered coast within the tidal reaches of the River Gambia[7]. The coastal zone of The Gambia is the home to the majority of the population which continues to increase and is being reinforced by rural-urban migration. These populations, their settlements and livelihoods are exposed to sea-level rise and heavy precipitation events.

This coastal area is vulnerable to climate change impacts from rising sea levels, potential changes to precipitation patterns and potential increases to wet season rain storm intensity. Generally accepted impacts include (a) tidal flooding of low-lying areas along the open coast and up the river, with loss of important urban areas, port infrastructure, roads, fish landing sites, farmland, forestry and significant natural habitats; (b) saline intrusion into fresh water aquifers; and (c) shoreline erosion of the open coast with loss or damage to urban areas, roads, fish landing sites, historic and cultural sites and tourism assets. Exposure to flooding (both coastal and inland following heavy precipitation) and storm damage is high in the informal housing in the Banjul and Bacau, and the Ebon Town, Jeshwang, Tallinding Kunjang and Fagikunda settlements where housing tends to be of poor quality and is easily damaged or destroyed.

At a national level the greatest predicted impact of climate change will be the effective loss of the capital city, Banjul and the surrounding ecological systems (Figure 2.1a,b). Much of the residential area of the city is extremely low lying and already at risk from tidal flooding; this situation will be exacerbated by expected sea level rise, putting most of the city and the access highway at risk of flooding. Ongoing shoreline erosion along the north shore of the city will soon impact on the government and commercial areas of the city and the immediate shoreline areas (Figure 2.2).

[7] *AGRER Consulting Services, (2017): Strategic Programme for Climate Resilience (SPCR), Volume I: Main Report*

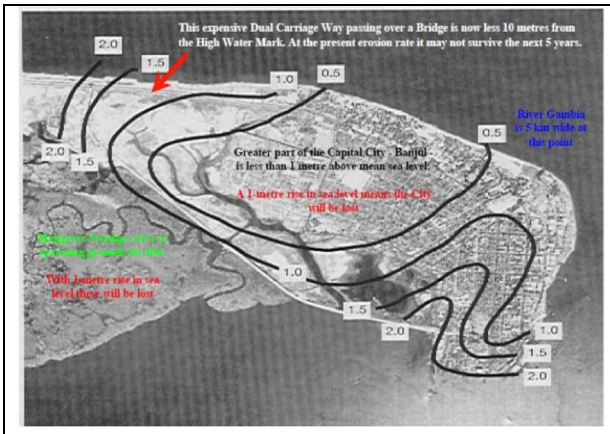


Figure 3: The low altitude of the City of Banjul makes it one of the most vulnerable to coastal erosion and other climate change threats.

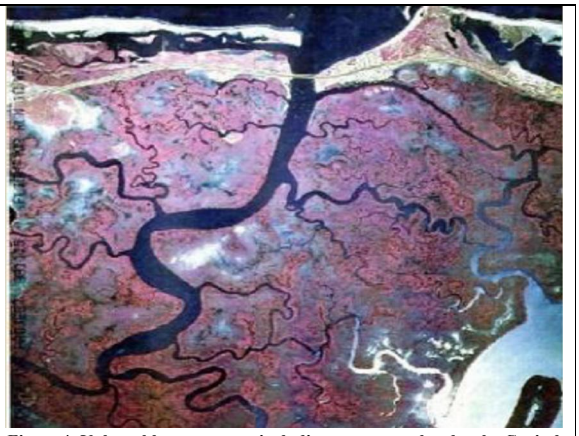


Figure 4: Vulnerable ecosystems, including mangroves border the Capital City of Banjul.

Figure 5: Shoreline erosion affecting residential, commercial and tourist assets along the coastal zone

In efforts to address the ongoing and potential challenges posed by climate change along the coastal zone of The Gambia, the Government of The Gambia secured funding from th Islamic Development Bank. This 2003 beach nourishment of the shoreline was intended to have a maximum 25 year design life to provide time for planning a robust and permanent solution to the coastal threat. Observations of the beach suggest that the remaining life of the nourishment is likely to be less than 10 years, after which the buildings and roads along the shore will be under direct attack by waves. Any solution for the capital city and other very sensitive areas of the coastal zone must not only allow for the existing and future tidal flood and erosion risks but must also recognize the need for sustainability of the management of the sand on the beaches and the estuary of the River Gambia including the substantial improvement of surface drainage, waste management, transport, water supply, power, sanitation, public spaces, etc. to provide for a healthy and efficient urban environment.

Beyond the city of Banjul and its immediate environs, there is a widespread issue of ongoing coastal erosion that is predicted to increase in the future. Fish landing sites, high value residential/diplomatic properties, cultural sites and tourism assets are at risk. This risk has been recognized for over twenty years and there has been a longstanding theoretical presumption in principle against development of significant structures within 150 m of the shoreline to allow a

buffer zone for erosion. Unfortunately this presumption has never been enshrined in policy, and inappropriate construction continues, particularly in the tourism development zones along the open coast, and within the government district of Banjul.

Almost all the supply of drinking water for the country, and much of the agricultural water supply is taken from the underlying aquifers. Abstraction near the coast has resulted in saline intrusion, reducing water quality and making some bore holes unviable. Population growth in the coastal zone and potential changing climatic conditions are expected to put increasing pressure on the water resource with lowering water tables and higher saline intrusion.

2.1.2 Action Plan for Sustainable Sand Management Technology

2.1.2.1 Introduction to Sustainable Sand Management Technology

Sustainable sand management is a combination of structural measures and technologies together with non-structural alternatives. Typical structural combination is beach stabilization structures (Groins or detached breakwaters) and beach nourishment. Beach fill on a regular basis must also supplement this combination. Together, their life-cycle costs and environmental impact may be less than if selectively and separately implemented. The combination mitigates downdrift impacts and/or increases the fill life of the nourished beach. Construction of the beach stabilization structures without fill is likely to damage adjacent beaches. Sustainable sand management reduces downdrift impacts by slowing the loss of placed sand. Beach rebuilding is sustainable as sand is being moved from where it has been deposited, to where it has been eroded from.

Beach nourishment is the process of dumping or pumping sand from elsewhere onto an eroding shoreline to create a new beach or to widen the existing beach. It is a process by which sediment (usually sand) lost through long shore or erosion is replaced from sources outside of the eroding beach. A wider beach can reduce storm damage to coastal structures by dissipating energy across the surf zone, protecting upland structures and infrastructure from storm surges, tsunamis and unusually high tides.8Beach nourishment is typically a repetitive process, since it does not remove the physical forces that cause erosion, but simply mitigates their effects. Sediment texture (grain size and sorting) is critical for success of beach nourishment. Sand fill must be compatible with native beach sand. In some cases, beaches have been nourished using finer or coarser sand than the original. Thermo-luminescence monitoring reveals that storms can erode such beaches far more quickly than the natural beach.

To control the amount of sand moving alongshore, it is good coastal engineering practice to combine beach nourishment with groin construction to permit sand to immediately begin to bypass the groin field. To minimize downdrift impacts, beach nourishment and groin construction should be concurrent. Construction of the first groin should be at the downdrift end of the project. Net drift will combine with the artificial beach nourishment to fill and stabilize the first compartment. The second groin is then constructed and the process is repeated. At the end of the sediment cell, a terminal groin can be used to anchor the beach and limit the movement of

sand. Gradually working updrift, the groin field construction is completed. This process together with tapering the ends will help to minimize the impact to adjacent, downdrift beaches.

Sustainable sand management is one of a comprehensive approach to advance sustainable soft and hard coastal engineering measures at strategic locations of the coastal zone of The Gambia that is vulnerable to rising sea levels and coastal erosion. Sustainable sand management, including beach nourishment is a well recognized in The Gambia and deemed to have made positive impacts in the beach restoration system. Beach nourishment or replenishment is one of the most popular soft engineering techniques of coastal defense management schemes. This involves importing alien sand off the beach and piling it on top of the existing sand. The imported sand must be of a similar quality to the existing beach material so it can integrate with the natural processes occurring there, without causing any adverse effects. Beach nourishment can be used alongside the groyne schemes. The scheme requires constant maintenance.

In 2003 and 2004, beach nourishment was used around the Greater Banjul area to reclaim significant areas lost to erosion. About 1,400,000m³ of offshore dredged sand was used along a stretch of approximately 3 km to protect the capital city, cemeteries and the main Highway linking the Capital city of Banjul to the rest of the country. The beach nourishment at Kololi (Senegambia and Kairaba Beach Hotels, Figure 23b) was done with about 106m³ of offshore dredged sand. The nourished beach at this site decreases at a rate of 2m annually due to increased wave energy (GoTG/GEF/UNDP, 2012).

Where the nourishment is accompanied by well designed shoreline stabilization schemes it has helped stabilize the coastal zone severely threatened by coastal erosion in the long term. This is the case at the Cape Point in Bakau. However, where the shoreline stabilization schemes are absent the nourishment measure has serious shortcomings and has actually led to more coastal erosion. This is the case at the Kairaba and Senegambia hotel areas in Kololi. These short comings of the 2003/2004 beach nourishment project are being corrected under the GoTG/GEF/UNDP LDCF NAPA project using the proper engineering design with 50-year design standard to further ensure sustained benefits to future generations. The element of sustainable sand recharge involved with the scheme will also bring much needed recreational, aesthetic and touristic benefits.

2.1.2.2 Ambition for the Sustainable Sand Management TAP

The Gambia's coastal zone consists of 80 km of open ocean coast and approximately 200 km of sheltered coast within the tidal reaches of the River Gambia. The ambitious target for the direct application of sustainable sand management technology is 69 kilometers of the open coast and the indirect application to 200 kilometers of sheltered coast. All the settlements and communities within 20Kms of the shoreline must benefit from the application of the technology. Applications of sustainable sand management in the open coast will protect the expensive tourism and private structures (hotels, resorts and residential villas) on the coastline. Fish landing sites, high value residential / diplomatic properties, cultural sites and tourism assets are at risk. Applications of the technology in the sheltered coast will support wetland agriculture and aquifer recharge,

maintain a minimum flow above the natural dry season rates; and regulate the influence of the natural habitat of the fresh and brackish water sections of the river, which traverses a very extensive low lying agricultural basin, with impacts on artisanal fisheries and river margin vegetation.

2.1.2.3 Actions and Activities selected for inclusion in the Sustainable Sand Management TAP

The Overview Table of the Sustainable Sand Management TAP shows the actions, activities and other information that can serve to enable effective adoption and acceptance of Sustainable Sand Management as a viable technology for coastal zone management at a lower cost and technical effectiveness.

Table 4: Overview of Sustainable Sand Management Technology Action Plan										
Sector	**Coastal Resources**									
Sub-sector	**Coastal Zone Management**									
Technology	**Sustainable Sand Management**									
Ambition	**The Technology will manage the existing sandy beaches along the 69-kilometre stretch of the open shoreline and the 200km sheltered part of the Coastal Zone of The Gambia. All the settlements and communities within 20Kms of the shoreline are beneficiaries.**									
Benefits	**The implementation of the sustainable sand management technologies will enable the retention of the natural appearance of the beach, the recreational beach is widened, and the structures behind the beach are protected as long as the added sand remains. The Tourism industry of The Gambia will continue to flourish as Tourists are attracted to the country because of the available of the sun and sand.**									
Action	**Activities to be implemented**	**Objectives**	**Source of funding**	**Responsible parties**	**How should it be done**	**Beneficiaries**	**Time frame**	**Monitoring**	**Indicators of success**	**Cost USD**
Encourage and facilitate activities to lift the economic and financial barriers for the adoption of Sustainable Sand Management Technology	Provide Government subsidies and tax waivers to imported equipment and materials to be used in sustainable management of the sand;	To improve access toequipment and materials to be used	GEF, UNEP, UNDP	NEA, MECCNAR, DWR, MoFEA	–Tax exemption within ECOWAS Member Sates –Tax reduction on the important of equipment and materials used in sustainable sand management	Farmers, government and business owners	Long term	MoFEA, NEA	Reduction of tax on importation of equipment and materials	10,000
	Impress on the business and private owners of hotels, resorts and residential assets on the coastline to contribute financially to the management of the sandy beaches adjacent to the structures;	To support Government insufficient coastal zone management budget	GEF, UNEP, UNDP	NEA, MECCNAR, DWR, MoFEA	Sensitizing them on the importance of their contribution towards coastal management projects for the sake of their businesses.	business and private owners of hotels, resorts and residential asset, fruit sellers	Long term	NEA, MECCANR	Business owners contributing financially to support government budget	20,000
	Review the tax system related to waterfront property on the coastal zone of The Gambia with a view to generate greater income necessary for the sustainable management of the coastal zone;	To protect the existing and new water front developments from the coast	GEF, UNEP, UNDP	GEF, UNEP, UNDP	–To formulate, review policies and regulations relating to waterfront property	business and private owners of hotels, resorts and residential asset, fruit sellers	Short term	NEA, MECCANR	Policies and regulations reviewed	100,000
Institutional, Policy and Regulatory actions	Update the relevant sectoral policies and regulations to manage the coastal zone and the inadequate implementation of existing policies and regulations related to environment and natural resources management including the coastal zone;	To fully implement policies and regulation	GEF, UNEP, UNDP	MoJ, NEA, MECCNAR,	–Amend relevant policies and regulations –Enforce the implementation of the relevant policies and regulations	Law makers, policy makers, NEA, MECCNAR	Short term	MoJ, NEA, MECCNAR,	Good and adequate policies and regulations for coastal zone	
	Develop and operationalize policies and regulations on sustainable sand management;	Is to come up with policy framework for laws and regulations	GEF, UNEP, UNDP	MoJ, NEA, MECCNAR,	Develop operational policies and regulations	NEA, MoJ, MECCNAR	Long term	NEA, MECCANR	Develop policies and regulations implemented	100,000

		on sustainable sand management								
	Develop and operationalize policies and regulations against inappropriate construction of immovable hard structures on the beach, particularly in the tourism development zones;	To discourage inappropriate constructions of structures along coast line	GEF, UNEP, UNDP	MoJ, NEA, MECCNAR, DWR	–Create and enforce laws on the illegal construction on coastal zone. –Enactment of policies and regulations against inappropriate constructions of structures	Business and private hotel owners, settlements around the coast	Medium term	MoJ, NEA, MECCANR	N inappropriate constructions of structures along coast line	50,000
	Apply the recommended precautionary policy principle against development of significant structures within 150 m of the shoreline to allow a buffer zone for erosion;	To take measure to avoid erosion on developed structures	GEF, UNEP, UNDP	MoJ, NEA, MECCNAR, DWR	–Develop precautionary policies –Following recommended coastal development plans	Policy makers, coastal engineers, NEA MoTWI	Long term	NEA, MECCNAR	Precautionary policies in place.	70,000
	Regulate abstraction of sand on the coastal zone; Disallow projects that use coarser grain sand instead the natural fine sand originally found on the beaches of The Gambia.	Stop illegal sand mining.	GEF, UNEP, UNDP	MoJ, NEA, MECCNAR,	Banning illegal sand mining –Dispatch security officers along coast –Conduct awareness campaign on effect of illegal mining along the coast	Communities along coastal zone, business and private hotel owners along the coast	Medium term	NEA, MECCNAR	Coastal zone free from illegal sand mining	50,000
	Facilitate the institutions and organizations to effective exercise their mandates collaboratively and efficiently for effective management of the coastal resources.	Effective coordination of institutions and organizations for proper management of coastal resource	GEF, UNEP, UNDP	NEA, MECCNAR, DWR	–Engaging different institutions and organizations to collaborate effectively on their mandates on coastal management –Collaborate on their different activities regarding coastal management	Stakeholders, NEA, MECCNAR, MoTWI	Medium term	NEA, MECCNAR	institutions and organizations collaborate effectively	100,000
Technical actions to stabilize sand on the shoreline	In the process of establishment of the technology, provide a physically and technically perfect match between avoidance of damage and destruction of marine life, disturbance of the original beach and production of an alternative that serves to adapt to climate	Find ways to protect marine life, maintain our beautiful beaches	GEF, UNEP, UNDP	NEA, MoTWI, MECCNAR, DWR	Put in place proper sand mining on the coast.	Communities along coastal zone, business and private hotel owners along the coast	Long term	NEA, MECCNAR	Marine life and beaches protected	90,000

	change									
	Construct well designed shoreline stabilization schemes that help stabilize the movement of sand on the coastal zone;	To control the movement of sand on the coastal zone	GEF, UNEP, UNDP	NEA, MECCNAR, DWR	–Develop appropriate shoreline stabilization methods. –Make recommendations regarding rules and regulations on shoreline stabilization schemes	Communities along coastal zone, business and private hotel owners along the coast, stakeholders	Long term	NEA, MECCNAR	shoreline stabilization schemesdesigned	60,000
	All elements of sustainable sand recharge and management must involve the much needed recreational, aesthetic and touristic benefits:	Is to promote tourism and recreation	GEF, UNEP, UNDP	NEA, MECCNAR, DWR	NEA, MECCNAR, MoTC	MoTC, GTBoard	Medium term	NEA, MECCNAR,	Tourism, recreational involed	80,000
	Conduct regular monitoring and maintenance of identified defects and damages, and re-nourish the beach as and when found necessary;	To make sure the beach is nourished and attractive always	GEF, UNEP, UNDP	NEA, MECCNAR, DWR	–Regular monitoring of the beach. –Taking immediate measures on the required maintenance	Communities along coastal zone, business and private hotel owners along the coast, stakeholders	Long term	NEA, MECCNAR	Monitoring and maintenance scheme in placed	150,000
	Facilitate the return and recruitment of faunal and floral species that were lost due to reduced beach area and loss of ecosystems;	To regain lossfaunal and floral species.	GEF, UNEP, UNDP	NEA, MECCNAR, DWR, MoA	To avoid beach sand mining that destruct habitat.	Beach sand miners	Long term	NEA, MECCNAR, MoA	of faunal and floral Returned	100,000

2.1.3 Action Plan for Breakwater System Technology

2.1.3.1 Introduction to Breakwater System Technology

Breakwaters are segmented, shore parallel structures built along the upper beach at approximately high water mark. They are normally built of rock, but can be formed of concrete armor units. Enormous concrete blocks and natural boulders are sunk offshore to alter wave direction and to filter the energy of waves and tides. These are offshore breakwaters facilitating the breaking of the waves further offshore and therefore reduce their erosive power. The waves break further offshore and therefore reduce their erosive power. This leads to wider beaches, which absorb the reduced wave energy, protecting infrastructure and property behind.

The Dolos which was invented by a South African engineer in East London has replaced the use of enormous concrete blocks because the dolos is much more resistant to wave action and requires less concrete to produce a superior result. Breakwater is designed to dissipate the force of incoming waves by allowing water to flow around rather than against it and to reduce displacement by allowing a random distribution of tetrapods to mutually interlock.

Costs for breakwater systems depend on structure dimensions and spacing. They can be heavily influenced by the availability of suitable rock (or other material), transport and the costs of any recycling or nourishment. Rock structures can be assumed to have an unlimited life with respect to economic assessments.

Breakwater systems have high impacts on shoreline processes, intertidal habitats and landscape systems, and may be unacceptable in environmentally sensitive areas. Erosion in the lee of the gaps may well continue for several years after construction while a new beach plan shape develops. On frontages affected by long-shore transport the breakwaters may reduce drift rates, resulting in the erosion of downdrift stretches of coast, but helping to stabilize the updrift shore.

2.1.3.2 Ambition for the Breakwater System TAP

Breakwater systems are not effective in handling heavy storms and they are difficult to install. The structure must be visible and be properly spaced to protect swimmers and fishing boats during operations. The coastline of The Gambia is sandy and dynamic and the need to stabilize the sand is eminent. Shoreline stabilization techniques have been tested in various segments of the open coast but Breakwater systems seem to satisfy the dynamic conditions of the coastline. It is proposed to construct breakwater systems along the 69km land stretch of the open coast.

2.1.3.3 Actions and Activities selected for inclusion in the Breakwater System TAP

One of the main activities in the Technology Needs Assessment process is identifying barriers in order to get the chosen technologies transferred, diffused and up-taken in a successful, replicable manner. Existing barriers do challenge this objective of transferring, diffusing and up-taking the technologies.

Table 5: Overview of Breakwater System Technology Action Plan

Sector	**Coastal Resources**									
Sub-sector	**Coastal Zone Management**									
Technology	**Breakwater System Technology**									
Ambition	**Install Breakwater System Technology along the 69km land stretch of the Open coastal zone of The Gambia**									
Benefits										
Action	**Activities to be implemented**	**Objectives**	**Source of funding**	**Responsible parties**	**How should it be done**	**Beneficiaries**	**Time frame**	**Monitoring**	**Indicators of success**	**Cost USD**
Provision of Financial Contribution and Incentives	Encourage hotels or other private bodies to contribute to the cost of establishment of the breakwater systems	Funding to strengthen the coast of The Gambia where many hotels are located with breakwater systems	FAO, UNDP, MoFEA, GEF, GCF and other international funds	NEA, MECCNAR, DWR, public and private sector	–Seeking for required funding for the implementation of the technology from Government and its development partners –Encourage local production of heavy machinery –Facilitate easy ferrying of imported boulders Reduce high duty tax levies	Business and homes near the coast, tourist development areas, cultural sites	Medium term	NEA, MECCNAR	Availability of funds Heavy machinery locally manufactured Duty tax reduce Easy ferrying of boulders from Dakar to Banjul	1,000,000
Policy, regulations and strategic planning	Develop and operationalize a comprehensive policy for coastal zone management	Working mechanism for comprehensive management of coastal zones	FAO, UNDP, MoF, MOA, private sector, and other international funds	NEA, MECCNAR, DWR,	–Develop plans and programs on coastal zone management –Review and assess needs of existing technical staff and stakeholders	NEA, MECCNAR, DWR, public and private sector	Medium term	MoA, MoF	Training programs and capacity building conducted	80,000
	Avoid overlapping legislation for different agencies aspects of coastal zone management	-Enabling framework for technology transfer and diffusion	FAO, UNDP, MoFEA, GEF, GCF and other international funds	NEA, MECCNAR, DWR, public and private sector	-Create enabling framework for different agencies on coastal zone management	NEA, MECCNAR, DWR, public and private	Long term			50,000
	Cultivate and maintain high level of political buy-in for sustainability	National institutions and relevant stakeholders actively participate in coastal zone management and sustainability	FAO, UNDP, MoFEA, GEF, GCF and other international funds	NEA, MECCNAR, DWR,	-Strengthen of national institutions and stakeholders	NEA, MECCNAR, DWR, public sector, NGOs	Long term			50,000
	Implement policy for Integrated Coastal Zone Management	Working mechanism for the implementation and management of coastal zones	FAO, UNDP, MoFEA, GEF, GCF and other international funds	NEA, MECCNAR, DWR, public sector, NGOs	-Develop and execute policy for Coastal Zone Management	NEA, MECCNAR, DWR, public sector, NGOs	Long term			80,000
	Support the enforcement of existing legal framework, and laws and regulations,	-Awareness level on advantages of new technology increase by 50%	FAO, UNDP, MoFEA, GEF, GCF and other international funds	NEA, MECCNAR, DWR, public and private, NGOs	-Raise awareness/information to support the enforcement of existing legal framework	NEA, MECCNAR, DWR, public sector, NGOs	Long term			80,000
Support to research and development	Conduct studies to determine materials to use as alternative to concrete and cement in	To modify or improve the technology to respond to the emerging demands	FAO, UNDP, MoFEA, GEF, GCF and other	NEA, MECCNAR, DWR, MoTWI	-Feasibility studies of construction materials of breakwater systems	NEA, MECCNAR, DWR, MoTWI			Users expressing their needs for technology	200,000

	construction of breakwater systems		international funds						modification and getting satisfaction with the modified or new products.	
Sensitization, Information and awareness raising	Conduct sensitization, information and awareness campaign on the problem of sea level rise, erosion and the various methods of assessing and controlling the impacts	To create awareness to all stakeholders and public sector on the adaptation and diffusion of the coastal technology	FAO, UNDP, MoFEA, GEF, GCF	MECCNAR, NEA,MoTC, GTBoard	Conduct awareness workshops on: the impact of climate change on coastal araes, the benefits of breakwater systems, Benefits of keeping our beaches safe and attractive	Tourist hotel owners, Business and homes near the coast, tourist development areas, cultural sites	Long term	MECCNAR, NEA,	Workshops successfully conducted.	60,000
Institutional Strengthening and capacity building	Strengthen inter-agency coordination for coastal zone management	To identify strategies in order to improve the collaborations	FAO, UNDP, MoFEA, GEF, GCF,	NEA, MECCNAR, DWR, MoTWI	NEA together –with MECCNAR to come up with project proposals in collaboration with MoTC on activities in the coast –Implementation of collaborative activities on breakwater systems in coastal areas	NEA, MECCNAR, DWR, MoTWI	Medium term	NEA, MECCNAR,	–Funding available for propose projects –Collaborations amongst relevant stakeholders	2,000,000
	Raise awareness of coastal zone management and technology among policy makers and key stakeholders	To build capacities in institutions	FAO, UNDP, MoFEA, GEF, GCF,	International and national experts , MECCNAR, DWR,	–Train local policy makers and key stakeholders. Trained and sensitizing on environmental protection –Coordinate and organize research activities on coastal erosion.	NEA, MECCNAR, public and private sector	Medium term	MECCNAR	Infrastructure facilities available	60,000
	Provide support for research and capacity building within local institutions in coastal engineering	–To engage students in this institution to build component or spare parts in order to overcome shortage and also reduce importation. –Farmers to immediately replace their gates when necessary	Funding programs available in The Gambia, , MoA, stakeholders, Department of Agriculture	International and national experts MECCNAR in collaboration with MoA, DWR, NEA	–Assess the requirements needed in the institution –Improve infrastructures and include research actives on both institutions and higher academic institutions –Design and teach courses related to breakwater systems. –Arrange field works for students on breakwater systems	GTTI, NTA, other technical institution	Long term	MoA, Department of agriculture engineering unit,	–Equipment required available. –Students started learning courses related to irrigation –Spare parts constructed	400,000
	Harmonize institutional roles and mandates for smooth operation in the coastal zone	coordination of institutions running the affairs of coastal zone	Funding programs available in The Gambia, , MoA, stakeholders, Department of Agriculture	International and national experts MECCNAR in collaboration with MoA, DWR, NEA	–Assess the requirements needed in the institution -Create a running demarcation to institutions running the of coastal management -Synergize institutions	NEA, MECCNAR, public and private sector	Long term			50,000
	Avoid slow bureaucratic process	Strengthen the bureaucratic process more	Funding programs	International and national	-Develop the human resources required for coastal zone	NEA, MECCNAR,	Long term			20,000

		effectively and quick	available in The Gambia, , MoA, stakeholders, Department of Agriculture	experts MECCNAR in collaboration with MoA, DWR, NEA	management -Raise awareness/information of the benefit to response to climate change and environmental hazards quickly	public and private sector				
	Strengthen inter-agency coordination	Raise awareness of the role of different stakeholders and inter-agency	Funding programs available in The Gambia, , MoA, stakeholders, Department of Agriculture	International and national experts MECCNAR in collaboration with MoA, DWR, NEA	-Increased capacities and awareness of the role of each agency	NEA, MECCNAR, public and private sector	Long term			80,000

2.1.4 Action Plan for Groyne System Technology

2.1.4.1 Introduction to Groyne System Technology

Groynes are wooden structure but can also be made of concrete and/or rock barriers or walls perpendicular to the sea. Beach material builds up on the updrift side, where littoral drift is predominantly in one direction, creating a wider and a more plentiful beach, therefore enhancing the protection for the coast because the sand material filters and absorbs the wave energy. However, there is a corresponding loss of beach material on the downdrift side, requiring that another groyne to be built there.

Groynes are extremely cost-effective coastal defense measures, requiring little maintenance, and are one of the most common coastal defense structures. Groynes are common in The Gambia and have done well in the past. Lack of wood for their construction has limited their use but this can be overcome with the use of concrete, which is relatively more expensive.

Groynes are cross-shore structures designed to reduce long-shore transport on open beaches or to deflect near-shore currents within an estuary. On an open beach they are normally built as a series to influence a long section of shoreline that has been nourished or is managed by recycling. They trap beach material and cause the beach orientation to change relative to the dominant wave directions. Sand is carried in temporary suspension during higher energy wave or current conditions and will therefore tend to be carried over or around any cross-shore structures. They mainly influence bedload transport and are most effective on shingle or gravel beaches. Groynes can also be used successfully in estuaries to alter nearshore tidal flow patterns. In an estuary they may be single structures.

Rock is often favoured as the construction material, but timber or gabions can be used for temporary structures of varying life expectancies (timber: 10-25 years, gabions: 1-5 years). Groynes are often used in combination with revetments to provide a high level of erosion protection. Groynes along a duned beach must have at least a short “T” section of revetment at their landward end to prevent outflanking during storm events. The revetment will be less obtrusive if it is normally buried by the fore-dunes. Beach recycling nourishment is normally required to maximize the effectiveness of groynes. On their own, they will cause down-drift erosion as beach material is held within the groyne bays[8].

2.1.4.2 Ambition for the Groyne System TAP

Both timber and rock groynes have performed very well in The Gambia. As a general rule, groynes should not be built on an open beach unless construction is accompanied by a commitment to regular recycling or nourishment. Without this commitment the groynes are likely to cause down-drift erosion as the upper beach becomes starved of sediment. Hence, groynes should be constructed in the sheltered coasts of The Gambia from Cape Point to Banjul and beyond.

[8] *Summary 12: GROYNES - A guide to managing coastal erosion in beach/dune systems: www.snh.org.uk/publications/on-line/.../erosion/appendix_1.12.shtml*

2.1.4.3 Actions and Activities selected for inclusion in the Groyne System TAP

The following Table indicates the barriers that affect the popularization and penetration of groyne systems as coastal management technology under a changing climate. Actions and activities to lift these barriers are provided in the Overview Table of the Groyne System TAP.

Table 6: Barriers to popularization of the Groyne System Technology	
Category	Barrier
Financial and economic	• High cost of investment capital • High inflation rate and high price fluctuations • High import duties • Lack of funds for costal management plan if any • High maintenance cost
Technical	• Inadequate technical standards and institutions • Inadequate expertise • Inadequate technology know-how • Uncertainties about the scale of sea-level rise
Information and awareness	• Inadequate technical information • Low literacy on coastal engineering • Limited public awareness
Socio-cultural	• Property right • Spiritual beliefs
Political	• Instability • Corruption by government officials
Human skills	• Limited skills coastal engineering • Limited skills in research and new tools development
Environmental	• Inadequate understanding of sea-level rise • Inadequate knowledge of other climate change impact • The land condition
Policy	Government laws and regulations

Table 7: Overview of Groyne System Technology Action Plan

Sector	**Coastal Resources**
Sub-sector	**Coastal Zone Management**
Technology	**Groyne System Technology**
Ambition	
Benefits	

Action	Activities to be implemented	Objectives	Source of funding	Responsible parties	How should it be done	Beneficiaries	Time frame	Monitoring	Indicators of success	Cost USD
Expand access to finance	**1.1** Acquisition of materials/equipment	To improve the uptake of the Groyne technology	FAO, UNDP, MoFEA, GEF, GCF	NEA, MECCNAR, DWR, international and national experts	–Seeking for required funding for the implementation of the technology from Government and its development partners –Encourage local production of heavy machinery –Facilitate easy ferrying of imported boulders Reduce high duty tax levies	Business and homes near the coast, tourist development areas, cultural sites	Medium term	NEA	Availability of funds Heavy machinery locally manufactured Duty tax reduce Easy ferrying of boulders from Dakar to Banjul	200,000
	1.2 Introduction of finance incentives	To compensate the affected business and homes due to the adoption and implementation of the Groynes	FAO, UNDP, MoFEA, GEF, GCF	NEA, MECCNAR, DWR, international and national experts	Give financial support to affected parties Allocation of lands for their new establishment and settlement by Government	Business and homes near the coast, tourist development areas, cultural sites	Short term	NEA	Affected parties supported in both cash and kind.	100,000
Expand capacity building initiative and collaboration	**2.1** Strengthening the collaboration between, and relevant stakeholders	To identify strategies in order to improve the collaborations	FAO, UNDP, MoFEA, GEF, GCF,	NEA, MECCNAR, DWR,MoTWI	NEA together –with MECCNAR to come up with project proposals in collaboration with MoTC on activities in the coast –Implementation of collaborative activities on Groynes in coastal areas	MoTC, DWR	Medium term	NEA, MECCNAR,	–Funding available for propose projects –Collaborations amongst relevant stakeholders	50,000
	2.2 Strengthening infrastructure/institutions	To build capacities in institutions	FAO, UNDP, MoFEA, GEF, GCF,	International and national experts , MECCNAR, DWR,	–Improve infrastructures and include research actives on both institutions and higher academic institutions –Train local Coastal Engineers Trained and sensitizing on environmental protection –Coordinate and organize research activities on coastal erosion.	NEA, MoTWI, MoHERST	Medium term	MECCNAR	Infrastructure facilities available	100,000
	2.3 Conduct awareness workshop programmes	To create awareness to all stakeholders and public sector on the adaptation and diffusion of the coastal technology	FAO, UNDP, MoFEA, GEF, GCF	MECCNAR, NEA,MoTC, GTBoard	Conduct awareness workshops on: the impact of climate change on coastal araes, the benefits of Goynes, Benefits of keeping our beaches safe and attractive	Tourist hotel owners, Business and homes near the coast, tourist development areas, cultural sites	Long term	MECCNAR, NEA,	Workshops successfully conducted.	50,000

CHAPTER 3: TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR THE WATER RESOURCES SECTOR

3.1 TAP for the Water Resources Sector

3.1.1 Sector overview

Water resources in The Gambia include surface and groundwater systems. Much of The Gambia is low-lying in flood-prone areas. It is projected that increased PET as a result of future climate change, combined with construction of dams in upper Gambia River, will result in reduced freshwater recharge downstream, causing hyper salinity in mangrove and other wetlands along the river's estuary and coastal zone. Hypersalinity in rice growing swamp areas could negatively impact the food production and livelihoods associated with rice production.Using information on the maximum expected increase in open water evaporation, in conjunction with the mean ratio of actual to potential evapotranspiration at Sambangalou and Gouloumbo, one may deduce a 3% reduction in groundwater recharge, by the year 2075.

As a direct consequence of sea level rise, peak flows are expected to decrease in magnitude and occur later than under present sea level. Under projected sea level rise, the saline front (salt concentration = 1g/l) is expected to migrate landward/upstream of its present upper limit around Kuntaur (254 km). Ocean-wards, the duration of salt-water transgression will be increased, but the perennial nature of the freshwater flow regime will be enhanced the further one moves in the direction of the river's headwaters. Under the projected rise in mean sea level, it is observed that maximum saline intrusion length increases by a mere 40 m/year.

The coastal communities, their settlements and livelihoods are exposed to sea-level rise, heavy precipitation events and serious health risks associated with flooding, as flooding often contaminates drinking water supplies and create conditions conducive to pathogens. Reduced rainfall and thus reduced recharge of the groundwater and surface water resources result into intrusion of saltwater into water sources, particularly on the Kombo Peninsular. Some of the water points have been abandoned; in some areas it has become expensive to sink water points as one has to dig deeper and maintain a deeper water column in the water points to allow availability of water for the whole year.

Increase strength and severity in windstorms and flash floods have been observed and they cause the most damage to property in The Gambia. Each year these hazards result in significant infrastructure damage, injuries and fatalities, and loss and damage to agricultural crops. Climate-related illnesses such as malaria which peaks in the rainy season (July-October) and diarrhoeal diseases which increase during the monsoons due to inadequate water handling practices and environmental sanitation exacerbated by uncontrolled runoff and flooding, are likely to be impacted by climate variability. The flooding also increases exposure to malaria and other waterborne and water contact diseases, which can quickly affect many people due to population density.

3.1.2 Action Plan for Water Conservation Technology

3.1.2.1 Introduction to Water Conservation Technology

Improvement of freshwater availability can be achieved through reduction in water losses, decrease in water demand and effective management of water supply systems using Village Water Committees (VWCs). Water losses in community water supply systems can occur during storage, transmission, or delivery through evaporation, leakage (often due to aging infrastructure), or improper, illegal, or uncontrolled use. The losses are substantial, and they are likely to increase with rising temperatures.

Technicians repairing a leakage which is common in many parts of the Greater Banjul Area (GBA) and cause a lot of losses to NAWEC

A major source of water loss is aging infrastructure (see above picture), which is costly to repair or replace. Leak detection and repair can also be costly, depending on the size of the system. Cost assessments should be made to evaluate the economic losses from leakages versus the resources required to reduce the water losses. Covering or lining storage facilities to reduce evaporation is most cost-effective for small facilities. Lining canals is efficient but expensive, although costs vary from concrete linings, the most expensive option, to collimation, the least expensive. In fact, this method is rarely used, despite the significant reduction in water losses that it can achieve, because of the expense involved. While water is typically undervalued, climate change will affect the availability of water, thereby increasing its value and the economic benefit of strategies for reducing water losses. The market for water loss reduction depends on the costs of water and the distribution of incentives for addressing losses.

Water loss reduction is a suitable approach in almost any environment, but especially in locations with impervious soils that are facing water shortages. It is also an important technology to consider in areas with aging water distribution infrastructure. Water loses can be reduced during distribution by implementing an active leak detection program; identifying illegal taps and connections; installing or calibrating water meters; reducing main breaks by rehabilitating and replacing water mains; and developing an “asset management” strategy for maintaining and improving existing infrastructure.

3.1.2.2 Ambition for the Water Conservation TAP

Water loss reduction measures and technologies to improve freshwater availability can be implemented at all scales, from the household to the community and regional levels. The technologies to improve freshwater availability for communities are of two types. One well with one or two Hand Pumps is installed for a beneficiary population of about 500 persons. For more than 500 persons, a Borehole with a pipe-borne reticulation system is installed. The size of the

borehole and the number of tap heads installed depends on the size of the beneficiary population. Water-efficient technologies can be adopted at the household and community levels. Water-pricing schemes and water-use efficiency policies, on the other hand, are likely to be adopted by communities and municipalities. The technology has the potential of increasing access to water resources for multiple user groups and over longer periods.

There is certainly going to be a rise in water demand for all sectors. Domestic water consumption is the most critical to water conservation (71%) followed by public sector (Central and Local Government, 21%). Bearing in mind the fact that there are the impending climate change impacts of saline intrusion from sea level rise and low aquifer recharge due to low rainfall, water conservation will definitely be challenged.

Table 8: Gambia Volumetric water consumption by sector in 2011 (Source: PURA annual report 2011)

Category	M^3/Year	Percentage
Domestic Water Use	14,666,789	71
Commercial	523,016	03
Tourism and Hotel	1,085,614	05
Agriculture	86,675	00
Local Government/Area Councils	735,553	04
Central Government	3,615,704	17
Total	20,713,351	100

3.1.2.3 Actions and Activities selected for inclusion in the Water Conservation TAP

In the analysis of barriers to adoption of Water Conservation, the following barriers have been identified

- Low income of NAWEC;
- Operating and Maintenance Inefficiency;
- High Rate of Non Revenue Water due to leakage
- Poor and outdated infrastructure;
- Lack of legal and institutional policies;
- Inadequate human capacity; and
- Poor community and consumer attitude;
- Heavy dependence on groundwater source.

In this assessment, actions have been identified to lift specific barriers (see Overview Table below). These actions were chosen based on their feasibility and the benefits they will incur in conserving water for the country. A few already being practiced in some countries have also been considered.

Table 9: Overview Water Conservation TAP

Sector	**Water Resources**									
Sub-sector	**Fresh Water**									
Technology	**Water Conservation Technology**									
Ambition	**Water conservation technology is projected to be implemented across the whole country. Some activities though may be limited to the urban areas where there is mains water supply. These will eventually expand to the rest of the country in the long ter.**									
Benefits	**The technology will reduce water losses, shortages ad unaccounted for water presently affecting the water sector. There will be a well coordinated water management system that will drive the nation toward good and responsible uses of water. This will in turn ensure a safe and secure water balance for future generations.**									
Action	**Activities to be implemented**	**Objectives**	**Source of funding**	**Responsible parties**	**How should it be done**	**Beneficiaries**	**Time frame**	**Monitoring**	**Indicators of success**	**Cost USD**
Appropriate valuation of water	• Introduce effective costing and pricing (per unit used) of water;	. To give value to water . To ensure customers do not abuse water	DONORS and GoTG	PURA, NAWEC and DWR	. Do cost analysis . Introduce water auditing . Do an awareness campaign	. Water managers as well as all stakeholders and customers	Short term	DWR	. Customers appreciate value for water and pay for it	100,000
	• Introduce water user charges at the pump facility using Prepaid cards	. To ensure that water use is paid for . To ensure that water is used optimally	DONORS and GoTG	PURA, NAWEC and DWR	. Install water ATM machines at pump sites . Monitoring by staff . Do awareness campaign	Water managers as well as all stakeholders and customers	Short term	DWR	. More revenue is generated from water use	1,600,000
	• Install Metering and billing of all customers	. Take account of water dispensed . Keeps track of water used and its cost at real time	DONORS and GoTG	NAWEC	. Install meters at source and end points . Install software with billing information in the meters	Water managers as well as all stakeholders and customers	Short term	DWR	. Unaccounted for water is reduced . Water supplied is reflected in revenue	3,035,000
	• Revise the currently low cost of service charges and introduce a new rate structure per user category	. To effect water charges at all categories of use . To effect fairness in charging customers . To ensure every drop of water is paid for	DONORS and GoTG	PURA, NAWEC and DWR	. Assess revenue generated by water users through the use of water against cost paid for water . Conduct water audit of all user sectors	Water managers as well as all stakeholders and customers	Short term	DWR	. Report on audit produced . Inventory of water used against revenue made . Information on benefits of water for sectors in monetary terms made	500,000
Develop a system of accounting and tracking the water throughout the whole system;	• Procure and use a leak detection software and equipment;	. To build an efficient water distribution system	NAWEC, GoTG and Donors	NAWEC and PURA	. Develop a good and consistent internet . Develop a furnished laboratory . Train competent IT experts to monitor the network remotely	. NAWEC and public	Medium term	DWR	. Early detection of bursts . Reduced potential property damage and water system liability . Reduced potential for contamination	400,000
	• Design and	. To track leaks	NAWEC, GoTG	NAWEC and	. Train technicians	NAWEC and public	Medium	NAWEC	. Improved operation	400,000

	implement a leak detection and repair strategy;	and bursting in the water conveyance and delivery system	and Donors	DWR	. Build a unit for operation and maintenance of leakages		term		efficiency . Extended life of facility . Lowered water system repairs costs	
	• Overhaul and upgrade the currently obsolete plumbing system and materials	. To reduce the occurrence of burst pipes and water losses due to old materials	NAWEC, GoTG and Donors	NAWEC and DWR	. Do a proper assessment of the whole network . Procure modern plumbing materials . Do public awareness and put in place source of water during changing exercises	NAWEC and public	Short term	NAWEC	. Lowered water losses . Reduced water outage events . Improved public relations and trust of service providers	600,000
Use of water efficient appliances at homes	• The Public Utility and Regulatory Agency (PURA) in collaboration with NAWEC must promote water conservation measure at all user-category levels;	. To create an easy platform for technology diffusion . To mobilize support for technology diffusion	GoTG	PURA, NAWEC, Local Governments, Area Councils	. Use all media houses . Use local governments and councils . Use experiences countries already using technologies Use demonstration sites for public to see benefits Introduce urine collection strategy for watering gardens .	Public	Medium term	DWR, PURA and NAWEC	. Public willingness to accept water conservation technologies	50,000
	• PURA and NAWEC to conduct nation-wide education and sensitization of communities on the water conservation measures especially at domestic level	. To educate the public on water integrity and the benefits of its optimal use and reservation	GoTG	PURA, NAWEC, Local Governments, Area Councils, Min. of Education	. Design awareness materials showcasing facts about world water shortages . Mainstream water education in school curriculum	Public	Short term	DWR, PURA and NAWEC	. Water education improved in the country . Concept about water on infinity changed	50,000
	• Design a policy to encourage households to have water efficient devices (flush toilets, overhead showers, water beds and car washers)	. To ensure legal backing for use of water efficient appliances and fixtures .To ensure there is legal support for enforcing good practices	GoTG	National Assembly, DWR, GTTI,	. Develop and enforce water efficient appliance use policy . Encourage local industries to produce water efficient appliance and fixtures . Ban importation of high flow water appliances	Public and water managers	Medium term	DWR, PURA and NAWEC	. Use of water efficient appliances at homes . market filled with water efficient appliances . Public begins to use water optimally	75,000
Water Accounting and	• Develop and implement a	. To ensure that water audits are	Donors, GoTG and Water Use	National Assembly, DWR	. Borrow experience of countries already doing water	Water managers and public	Medium term	PURA and DWR	Audit policy developed and	80,000

Water Loss Control Measures;	water audit policy and strategy;	enforced to control and induce efficient use of water by sectors	sectors		audits to convince water use sectors . Train personnel on water auditing . Establish a national water audit commission .Enforce the policy . Monitor the water audit programs .Build a database of all audits and track progress . Water use sectors pay for audit services				enacted by parliament . Policy enforced . National water audt commission regularly does audits and keeps records	
	• Educate and sensitize all water use sectors and communities to understand and perform water use audits regularly:	. To help water use sectors optimize their use of water .To help them adopt water reuse and recycling . To help water use sectors make savings in water bills	GoTG and Water Sectors	DWR and PURA	. Introduce water reuse and recycling . Institute a schedule for water audits . Monitor the water audit program .Establish public relations and communication unit .	Water use sectors and water managers	Short term	DWR	. Water audits regularly done by sectors . Optimal use of water . Water reuse and recycling practised . Sectors spend less on water bills	50,000
	• Develop education and information materials on water conservation programs including videos, radios, and community outreach, workshops and Technical Advisory Committees.	. To promote the easy diffusion of water conservation strategies . To create awareness among all stakeholders of world water crisis and the need to manage it for posterity	GoTG	GRTS, Min. of Education, DWR and NAWEC	. Institute and implement regular programs . Do a nationwide sensitization campaign . Monitor public behavior towards technologies . Establish public relations and communication unit	Water managers and all stakeholders	Short term	DWR	. Report on public attitude towards technologies positive	75,000
	• Develop education and information packages on water conservation including understanding of	. To ensure water management is appreciated and effective across all levels of society . To ensure good	GoTG	GRTS, DWR	. Mainstream water education in curriculum . Educate public on all legal and institutional policies . Regularly update public on policy and its implementation . Monitor policy	Water managers and all stakeholders	Short term	DWR	. Young generation already start practicing good water conservation practices . Water bills are paid . Water user charges	75,,000

	water bills, need to manage water, technologies to conserve water, legal and institutional policies on water related issues;	practices are easy to enforce across all levels . To promote the value of water . To promote the integrity of water			implementation .				are enforced with ease	
	• Build and strengthen the technical and managerial capacities and skills of service providers to execute their duties effectively;	. To build institutional capacity to manage and develop water . To ensure water managers have a clear vision of their roles and responsibilities	GoTG and donors	DWR	. Train personnel . Create a well coordinated institutional framework . Build well equipped offices . Ensure all legal and regulatory tools are known and at their disposal	Water managers and Service providers	Short term	DWR	. Water management is well coordinated . Well defined link between all players in the water sector	50,000
Building legal and Institutional Framework:	• Conduct a complete analysis of the status of the legal and institutional requirements of the water sector with a view to adopting water conservation technology;	. To harmonize all legal and institutional instruments concerned with water resource management . Develop a new Water Bill that incorporates IWRM and Water Conservation Technologies	Donors, GoTG	DWR and Stakeholders	. Make an inventory of all legal and institutional . Consultation workshops instruments concerned with water management and development . Identify any omissions, conflicts and duplications in the legal and institutional frameworks . Based on the outputs and outcomes of the analysis, update the Water Act and Regulations paying particular attention to the requirements and principles of Integrated Water Resources Management (IWRM) . Report on the analysis of the tools and make recommendations	Water managers, Water use sectors	Short term	DWR	. IWRM and water conservation technologies mainstreamed into the new and updated water bill	150,000
	• Implement all the recommendations contained in the update Water Act and Regulations, particularly the institutional	. To restructure and develop a new legal and institutional framework . To develop a water resource knowledge and information	Donors, GoTG	DWR, National Assembly	. Finalize the legal regulative framework and provide modalities for effective coordination . Improve the monitoring network set-up, consolidate and expand water resource management and information system	Water managers, Water use sectors	Short term	DWR	. Regulations finalized and enacted . Reliable data produced . WRMIS used regularly and data transferred to WRMIS . Information	1,833,600

	arrangements such as the incorporation of the vision of the National Water Policy, the enabling environment for relevant ministries and departments and the National Water Management Authority;	system . To do water resource development and monitoring . To mainstream climate change implications on ecosystem . To develop a Transboundary water sharing and collaboration mechanism . Ensure stakeholder awareness and participation . Develop human resources of NWRMA			Develop a web based tool for information sharing . Establish groundwater protection zones . implement water demand management program . Conduct scenario analysis and modeling of groundwater availability . monitor flows and recharge . Carry out research studies on ecosystem . prepare year-to-year budget agreement with OMVG . Prepare state of water reports yearly . carry out training needs assessment . implement training programs				available to managers and other stakeholders . Research studies carried out and findings published . Groundwater boreholes well protected . Outcomes of ecosystem studies published . Transboundary cooperation in effect . NWRMA established with clear mandates . Formal stakeholder structures established with clear roles and responsibilities in water management . Staff capacities enhanced and service delivery improved	

3.1.3 Action Plan for Groundwater Recharge

3.1.3.1 Overview of the Groundwater Recharge Technology

Groundwater (or aquifer) recharge is an activity that aims to increase the natural replenishment or percolation of surface water into the ground aquifer, so that groundwater level stays stable relative to its rate of abstraction by the people for different purposes. The activity is typically confined to the areas with depleting aquifers and the final selection of a recharge technique is therefore site specific and needs extensive hydro-geological studies.

Apart from replenishing groundwater level, the technology offers some other important cross-sector co-benefits, such as conservation or disposal of flood water, control of saltwater intrusion in areas below sea level and with frequent exposure to sea currents, storage of water to reduce pumping and piping cost and water quality improvement (Asano, 1985). The technology has many major applications, such as, in wastewater disposal and treatment, crop development, stream flow augmentation and prevention of land subsidence, among others (Oaksford, 1985).

In the Gambia, agriculture sector is the biggest user of groundwater making up almost 90 percent of the total groundwater use, followed by household and domestic uses. The situation is quite opposite in large urban centers, especially in the province of Foni, where groundwater is vulnerable to iron and the entire population of Foni relies on extracted groundwater for their daily domestic needs. This high level use of groundwater for irrigation comes with a high cost however, which is reported to be typically 30 times higher than the cost of surface irrigation water in the Central River Region at the Jahally Pacharr irrigation system within the region. Nevertheless, it is the most preferred choice by the local farmers due to a very high percentage of crop yields.

The technology is of prime significance and value in areas of the Gambia where groundwater is the only easily accessible and highly reliable source of water for both irrigation and domestic purposes. The province of Nyani and Sami, for example, faces a sharp decline in groundwater table of almost 37 meters below ground level threatening both the survival of human lives in certain hyper dry areas, and the sustainability of irrigated agriculture. To cope with such situation, it's of great importance to introduce a climate change adaptation technique. Artificial groundwater aquifer recharge technique is one among various techniques which can be employed to address the issue.

In the Gambia, it requires financial support from donor communities to excavate or construct recharge structures for the first time. This technique will be an underground water aquifer rejuvenation demonstration pilot project in the Gambia. The technology aimed at increasing recharge of groundwater flow of country wide. Water levels usually drop in open wells at some area within the country. The experience with full-scale artificial recharge operations in the country is almost non-existent, and hence poses a great challenge to fully estimate the cost effectiveness of such operations at a large scale specifically under the looming uncertainty of climate change.

3.1.3.2 Targets for technology transfer and diffusion

The main target group for this technology is those communities in dryland areas of the country with high risk of water shortages and face critical challenges in accessing clean water for domestic purposes, livestock and irrigation use.

- Set-up groundwater monitoring network for those critically vulnerable areas where groundwater is below a certain threshold value;
- Undertake detailed feasibility studies for the selection of suitable sites for various groundwater recharge structures such as excavation of artificial reservoirs.
- Construct demonstration and pilot groundwater recharge projects to improve visibility of declining groundwater issue in the country, and gain support from the concerned communities.

3.1.3.3 Actions, Activities and Project Ideas for the diffusion of technology

To improve the groundwater recharge condition in the Gambia and lift the barriers to diffussion, some key approaches are identified and proposed:

- ✓ Introduce and implement market based water permitting and licensing systems, with suitable subsidies or loans, to bring the high cost of construction and maintenance of water reservoir systems down;
- ✓ Promote and regulate conjunctive use of available surface water (canal or runoff water) with groundwater to manage water quality and cost for the irrigation purposes;
- ✓ Adopt whole-aquifer approach for R&D activities; a good starting point could be developing and maintaining a comprehensive database of information on groundwater users, various types of uses, groundwater abstraction quantity, aquifer conditions, water table depth and groundwater quality;
- ✓ Favor traditional local practices and indigenous knowledge in the participatory decision-making processes at the local level;
- ✓ Integrate strong conflict resolution mechanisms in groundwater governance system in order to resolve regulatory and advisory policy issues at the community level.

Table 10: Overview of Aquifer Recharge TAP

Sector	**Water Resources**									
Sub-sector	**Fresh Water**									
Technology	**Aquifer Recharge Technology**									
Ambition	**Aquifer Recharge technology will be prioritised for areas with extremely high (deep) water tables.**									
Benefits	**The Aquifer recharge technology replenishes groundwater storage and supplements water sources to meet increasing demand and mitigate changing climate impacts. The technology also mitigate or control salt water intrusion into coastal aquifers.**									
Action	**Activities to be implemented**	**Objectives**	**Source of funding**	**Responsible parties**	**How should it be done**	**Beneficiaries**	**Time frame**	**Monitoring**	**Indicators of success**	**Cost USD**
Establishment of Sustainable groundwater management structures	• Introduce an awareness creation campaign on groundwater governance	. To provide an insight on groundwater systems dynamics . To promote sustainable water use	Donors and GoTG	DWR, NEA, MoH, MoLG	. Identify the relevant stakeholders including estate developers . organisation of workshops, seminars and outreach programmes . publication of groundwater articles	. General public and including the stakeholders	Short term	DWR	. the level of awareness improved . increased availability of water .estates are better planned to include road drainage and reservoirs	80,000
	Application of groundwater abstraction regulations	. To register all the existing and new abstraction boreholes . To document all water use by different sectors	Donors and GoTG	PURA, NAWEC, GBoS and DWR	. Update the water abstraction borehole inventory . develop a robust and dynamic geospatial database . issuing of water abstraction permits	General public, water users and the stakeholders	Short term	DWR	. the number of water abstraction points registered and the accounted water use by various sectors	500,000
	• Improvement of groundwater quality through integrated waste management system	. prevent groundwater contamination . enhance groundwater quality for domestic use	Donors and GoTG	DWR, NEA, MoH & MoLG	. raise awareness of stakeholders to properly manage waste . proper location of waste dump sites	General public, water users and the stakeholders	Short term	DWR	. Improved water quality parameters to meet the WHO standards	800, 000
	• Application of groundwater modelling	. To understand the interaction of the groundwater and the environmental . To comprehend, predict and manage groundwater resources	Donors and GoTG	DWR	. Provide training on groundwater modelling .To gather all hydro geological data . utilise a user friendly groundwater modelling software . develop groundwater abstraction scenarios	General public, water users and the stakeholders	Short term	DWR	Improvement in the groundwater resources planning for sustainable water resources availability	300,000
Artificial	Country wide	. To assess the	Donors and	Land Survey	. Do a feasibility study	Project	Short	DWR	. Feasibility study	200,000

recharge of aquifers	geographic survey	geographical suitability of the recharge schemes . To verify the infiltration capacities of the soils . To assess the suitability of various recharge systems	GoTG	Unit, Geology Unit	. Produce report and share with area councils and implementers of the project in each area	implementers	term		report produced . Rainfall variability known . Soil properties known . Best structure for recharge implanted and functional	
	Construction of artificial recharge systems	. To prepare the ground for storing water and eventual infiltration	Donors and GoTG	DWR, NEA, Area Councils	. Improve road drainage system . Construct water traps by excavation of soil to reasonable depth . Construct recharge basins and canals . Build a drainage system and reservoirs in the urban and estates	Water managers and users	Short term	DWR	. Improved aquifer yields . Reduced flood and disaster risks	500,000
	Forestation	. To improve surface runoff retention . To replenish land cover . To maximise aquifer recharge	Donors and GoTG	Department of Forestry	. Create buffer zones . Select trees that increase aquifer recharge . Plant trees . Manage and keep trees	Aquifer recharge managers and water use sectors	Short term	Department of Forestry	Blossoming buffer zones available in the country	50,000
	Operation and maintenance	. To prevent erosion of basin and canal banks . To maintain the effectiveness of the systems . To reduce siltation in the systems	Donors and GoTG	DWR	. Develop an operation and maintenance program . Yearly cleaning of recharge systems	Aquifer recharge unit, stakeholders	Short term	DWR	. Effectiveness of structures ensured	200.000
TOTAL COSTS										**2,630,000**

CHAPTER 4 TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR THE ENERGY SECTOR

4.1 TAP for the Renewable Energy sub-Sector

4.1.1 Overview Of Energy – Electricity Sector

The Gambia has overall low electrification rates. The national electrification rate is 34.5 per cent (World Bank, 2016), in rural areas 25.7 per cent of the population has access to electricity and in urban areas the proportion is 41 per cent (Table 4.1). In 2012, only 2 per cent of rural areas had access to modern fuels and 5.02 per cent has such access in urban areas. Banjul, the capital, has the highest electrification rate while the least electrified are the North Bank and Central River Administrative Regions (REEEP, 2012). There have been initiatives to improve the extent of electrification, but progress is slow. A 6.2 MW capacity project started in 2000 had only achieved 2.2 MW of capacity by 2009 (REEEP, 2012). The energy intensity (the ratio of the quantity of energy consumption per unit of economic output) was 5.5 per US dollar (2005 dollars at PPP) in 2012. The compound annual growth rate (CAGR) between 2010 and 2012 was -1.27 (World Bank, 2015).

The share of renewable energy in the total final energy consumption (TFEC) was 49.7 per cent in 2012. Traditional solid biofuels form the biggest share of renewable sources at 49.7 per cent of TFEC in 2012 (World Bank, 2015).

Table 11: Gambia's progress towards achieving SDG7 – Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicators	Year					
		1990	2000	2010	2012	2000-2010	2011-2015
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Per cent of population with access to electricity	18	34	31	34.5		
	7.1.2 Per cent of population with primary reliance on non-solid fuels	2	4	5	5.02		
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	58.9	50.3	41.0	49.7		
7.3 By 2030, Double the rate of improvement of energy efficiency	7.3.1 GDP per unit of energy use (constant 2011 PPP $ per kg of oil equivalent)	22.5		17.57 (2007)			
	Level of primary energy intensity(MJ/$2005 PPP)	5.8		5.7	5.5	5.7	5.53

Sources (World Bank, 2015), (World Bank, 2016)

In The Gambia, a complete reliance on imported petroleum fuels has resulted in a balance of payments deficit. The impact has been an acute shortage of electricity supply, with low investments and productivity impacting on the overall economy. The electricity generation capacity increased tremendously after the commissioning of the power plant in Brikama (4 x 6.5 MW generators running on HFO), in August 2006. The first truly independent power producer (IPP) power plant of 25 MW has an output capacity of 22 MW. This new installation adds to the existing installed capacity at the main power station at Kotu by about 28 MW, to provide an available capacity of 50 MW in the Greater Banjul Area.

To complement to the country's development priority e.g. attaining sustainable development through green growth and attaining energy security, the power generation and use from renewable energy will be requiring technological support that will contribute to the reduction of GHG emission and poverty.

4.1.2 Action Plan for the Wind Turbine Technology

4.1.2.1 Introduction to Wind Turbine Technology

The supply of modern energy services plays a significant role in the development of economies. The availability of energy provides for greater opportunities in the productive sectors, in value addition, in services and also for the domestic sector, all contributing to economic growth. Conversely, the absence or limitation in modern energy supply restricts economic growth. The lack of reliable power and the high cost of energy are seriously limiting investment in The Gambia and are limiting growth in productive sectors such as the agro-processing and manufacturing sectors.

Wind power is a more preferable energy source than solar, hydro, geothermal and biomass due to its cost effectiveness, environmental soundness and unlimited availability. In 2004, the Government conducted feasibility study on Renewable Energy shows that some of the regions in Gambia have great potential for application of wind power facilities. Therefore, certain measures need to be undertaken by respective organizations in order to accelerate the wide application of wind power technology.

The Gambian government recognizes the problem and has, as one of its key objectives, to ensure a reliable and adequate supply of energy, both conventional and renewable energy, at affordable prices. Some of the major challenges are seen as: (a) heavy reliance on imported petroleum products to meet the country's energy requirements, placing a heavy burden on the foreign exchange reserves; (b) limited investment in new assets and inadequate maintenance of old and ageing electricity power facilities; (c) growing population and rapidly growing demand for all forms of energy; and (d) limited capacity to develop renewable energy projects in the country. The major sources of energy in The Gambia are biomass, electricity, petroleum fuels and renewable energy (i.e. Solar systems).

With the above background, together with extensive stakeholder discussions, in the Part I of the TNA report, three technologies for climate change mitigation in Gambia were shortlisted for the energy sector. Out of these three technologies, an extensive multi-criteria decision analysis (MCDA), which was used to prioritize technologies was done and wind turbine technology top the list for the energy sector.

A wind turbine installation consists of the necessary systems needed to capture the wind's energy, point the turbine into the wind, convert mechanical rotation into electrical power, and other systems to start, stop, and control the turbine. In addition to aerodynamic design of the blades, design of a complete wind power system must also address design of the hub, controls, generator, supporting structure and foundation. In addition, wind turbines need regular maintenance to stay reliable and available; in the best case turbines are available to generate energy 98% of the time. And as technology needed for wind turbines continues to improve, the prices will decrease as well.

According to the National Energy Policy document, the aim of the Renewable Energy (RE) sub-sector is to support sustainable development. The specific objectives are to (a) promote renewable energy such as solar, wind and biomass; (b) develop a domestic production capacity from RE fuels and technologies; and (c) ensure the sustainable supply of RE fuels and technologies at competitive prices through private sector participation.

An example of a pilot project on harnessing electricity from a 150 kVA generator Wind Turbines is being implemented in Batakunku Village.The Batakunku windmill is a philanthropic project which provides electricity for the villagers when there is wind, with any excess being pumped into the transmission network, and power obtained from NAWEC when there is no wind. The project also marked the first implemented IPP involvement in the generation and distribution sectors. In addition, wind pumps are not very prevalent in The Gambia. The Ministry of Water Resources indicated that the European Union funded some wind pumps along the coastal villages in the early 1990s. The pilot systems were installed in Brufut, Tanji and Batakunku by the Atlantic Coast. However, none of these systems are currently working, with most of the systems abandoned and rusting. Many more wind pumps are currently in use in the country but they have been private projects mostly on private farms.

4.1.2.2 Ambition for the Wind Turbine TAP

The Government of The Gambia has identified initial targets for application of alternative energy sources in the National Energy Policy (2005) and National Development Plan (2018 – 2021). Application of grid-connected wind power technology is in line with the country's social, economic and environmental development priorities. The overall target to develop this technology has been based on the national and sectoral strategies, plans and programs such as the National Development Plan of The Gambia, National Energy Policy and other plans of the country. The National Energy Policy was launched in June 2005 and it defines broad policy objectives and strategies, including those for rural electrification and renewable energy. It contains objectives for electricity which encompass improving and expanding the generation,

transmission and distribution of electricity, reducing the cost of electricity, encouraging investment in the supply of rural electricity, and encouraging the use of alternative technologies (Ministry of Energy, 2005). In the renewable energy sub-sector, the policy promotes the use of renewable sources of energy and encourages the use of renewable energy technologies and the development of a domestic production capacity. The policy also seeks to ensure a sustainable supply of technologies at competitive prices in the private sector.

Furthermore, the new energy policy highlights the importance of energy in meeting sustainable development goals. The Policy prioritizes rural electrification and promotes the use of renewable energy resources such as wind and solar for electricity generation, particularly in the rural areas. The Policy includes a target of achieving at least 30 per cent renewable energy generation capacity by 2018. From information from the population census of 2003, the population is estimated at 1.36 million and was growing at the rate of 2.74% per annum. With this growth rate, the population by the year 2011 is estimated to reach 1.79 million. The TAP describes the ambitions of the prioritized in terms of coverage and number of beneficiaries to be reached in the future. This technology is intended to benefit about 100 communities (of about 500 households per community).

With regard to the country's social development priorities, application of the above-mentioned technology will create new employment opportunities. Typically a capacity of 1 kW of wind energy creates work for 15-19 persons. The growth of wind energy will contribute to state energy security consolidation and will also have a positive influence on public opinion, which would realize the necessity to protect the environment and reduce consumption of energy resources. Regarding the country's economic development priorities, the technology will reduce energy production costs. Moreover, development of the national wind energy industry will decrease the initial capital investment as locally produced products will be relatively cheaper than imported ones.

With regard to the country's environmental development priorities, the application of wind energy has zero emission of CO2 and will lead to decrease of SO2 and NOx emissions, which have a negative impact on woods, crops, generally on vegetation and particularly on the endangered species.

4.1.2.3 Actions, Activities and Project Ideas selected for diffusion of Wind Turbine and TAP

Given the current situation in Gambia with regard to development and diffusion of wind turbine as a technology for energy sources, in the course of TNA process several barriers have been identified. These barriers have been categorized as economic and financial barriers and non-financial barriers. While economic barriers primarily include high cost and inexistent of local manufacturers, the non-financial barriers are mostly those associated with the limitations of the current institutional structure, the current policy and regulatory framework and those associated with information and awareness with regard to wind turbine. Based on these identified barriers, suitable enabling measures which will assist the country in overcoming these barriers have also

been identified. These enabling measures have further been defined and elaborated on with concrete action for each in the next section of this report.

To improve the penetration of Wind Turbine Technology actions have to be taken to remove the economic, financial and non-financial barriers discussed in the preceding paragraphs. The economic and financial measures needed to overcome high financial costs associated with setting up wind technology, must include the establishment of clear procedures for providing incentives or subsidies for encouraging private participation in the technology to facilitate the availability of necessary finance. This could potentially be done by using domestic and international funding sources to provide incentives for promoting public private partnerships in setting up wind turbine technology. These funding sources could be used to provide incentives such as tax rebates, and custom duty exemptions on import of related equipment. Also, it has been identified that significant access to loans and acceptable interest rate could be alternative option to a large scale commercialization of wind energy technology.

The action plan goes further and sets the timeline and tentative budget and identifies key stakeholders to be involved in the planning and implementation process. Most of the activities will be implemented for the duration of 5 years and stakeholders with major responsibilities include President's Office – Division of Environment and Energy, Ministry of Energy, NAWEC, Gambia National Petroleum Company, NGOs and the private sector. Potential sources of funds have been identified to include the Government of The Gambia, Development Partners (e.g. UNDP) and MFIs (e.g. African Development Bank, The World Bank).

During the preparation of TAP for grid-connected wind power technology, measures have been assessed taking into account their priorities, time scale, related stakeholders, key indicators for measuring implementation and funding resources.

Table 12: Overview of the Wind Turbine TAP				
Sector	**Energy**			
Sub-sector	**Electricity**			
Electricity	**Wind Turbine plant**			
Ambition	**communities (of about 500 households per community)**			
Benefits	**igate GHG emission (0.04 megaton per year)**			
Action	**Activities to be implemented**	**Sources of funding**	**Time frame**	**Budget as per Activity (USD)**
Establish a unit to oversee the implementation of the TAP	Recruit staff Establish and equip the office	Government Development Partners	1 - 3.5 year	300,000
Action 1: Establish economic feasibility of wind power energy	Activity 1.1: Conduct economic (including market survey) feasibility of the wind power energy	Government Development Partners	1 – 2 years	200,000
Action 2: Create awareness of both developer, and users of the technology	Activity 2.1: Develop awareness material targeting different stakeholders (i.e. Private Sector, Decision Makers, Users of the wind energy technology, financial institutions)	Government Development Partners	1 – 2 years	20,000
	Activity 2.2: Develop a communication strategy Profile the target stakeholders particularly the adopters of the technology	Government Development Partners	1 – 2 years	15,000
	Activity 2.3: Implement awareness campaign on wind energy technology	Government Development Partners	1 – 3.5 years	115,000
Action 3: Build / strengthen capacity of key stakeholders	Activity 3.1: Develop specialized training aimed at building the capacities in relevant institutions – in areas of fabrication, installation, operation and maintenance of wind power systems	Government Development Partners	1 – 3.5 years	600,000
	Activity 3.2: Strengthen NAWEC to absorb more electricity generated from renewable energy sources	Government Development Partners	1 – 3.5 years	500,000
	Activity 3.3: Strengthen inter-ministerial coordination	Government	1 – 2 years	10,000
	Activity 3.4: Strengthen capacity of Gambia Meteorological Service – to generate reliable data for energy mix forecast and planning	Government Development Partners	1 – 3.5 years	500,000
Action 4: Enhance access to financing	Activity 1.1 Develop financial incentives to assist lowering the cost of wind power project (e.g. introduce subsidies, tax exemptions)	Government Private sector	1 - 2 years	20,000
	Activity 3.2: Engage in dialogue with development partners to provide subsidies for the technology as it contributes to global benefit	Development Partners	2 - 3.5 years	20,000
	Activity 1.4: Establish a Renewable Energy Development Fund to enhance investment and deployment in RE technology (i.e. wind energy)		1 – 3.5 years	950,000

Sample Project Idea

Project Title: Project to pilot the promotion of the use of wind energy

Project Background

The country's coastal areas offer the most realistic options for wind energy; one analysis indicates wind speeds of 5.5 m/s at a height of 50 m on the coast and 3m/s inland (Ceesay, 2012). Wind energy is currently used for water pumping. In 2009, a 150 kVA wind project was being implemented by an Independent Power Producer (IPP) in Batakunku Village, in Kombo South district. It provides electricity for the community and the excess is channeled to the transmission network. GAMWIND another IPP, is operating a 900 kW wind park that is also tied to the grid (REEEP, 2012). However due to lack of knowledge and capacity, local authorities, private sector, NGOs and local communities do not appropriate funds or resources for this renewable energy. Wind turbine energy source has been identified as one of the priority mitigation technologies by the TNA/TAP process, as it is in line with development priorities and technological advancement needs of the country. The main barriers to deployment and dissemination of the technology are lack of awareness and adequate skills/capacity of local authorities, private sector and communities on advantages and use of the technology. Another barrier is weak access to acceptable financial means to purchase the technology. The proposed pilot project envisages the measures to effectively address the information, technical knowledge and capacity building barriers, and create linkages with financial institutions providing funding and loans at suitable terms acceptable for local users. The project has great value as it addresses capacity/building, technical and financial barriers of technology deployment. Implementation of project activities will result in increase of awareness of local communities on economic and environmental advantages of technology deployment. The project has a great potential for being replicated in other regions of the country, as its effective practice will be demonstrated by organizing study tours to the project area.

Project goal: The main project goal is to promote deployment of wind energy in local communities by increasing level of awareness, improving knowledge and skills of community residents, local authorities, private sectors, NGOs and other relevant stakeholders, in order to overcome capacity building/information barriers. Another goal is to create access to information on financial opportunities at current market and improve linkages of local communities with financial institutions, such as credit unions, banks, other relevant state and international funds.

Project objectives: Increase awareness level of local communities, local authorities, private sector and other relevant stakeholders on advantages of wind energy; Increase technical capacity of relevant stakeholders involved in technology application; Promote application of wind energy at community level through practical demonstration of its advantages; and Increase access to financing (credits, loans, grants) at acceptable terms for technology deployment.

Project activities:

- Recruitment and/or training of local consultants to undertake selection of sites carry out feasibility studies and produce the necessary facility designs;
- Conduct an Environmental Impact Assessment of the project and obtain certification from the National Environmental, NEA.
- Launch workshops for presentation of project goals and objectives;
- Organize round-table discussions with relevant stakeholders;
- Information campaigns and outreach activities (including websites and other internet sources) to increase awareness level;
- Capacity building trainings for representatives of local authorities, private sector, NGOs, other relevant stakeholders and community residents to undertake various aspects of the construction, operation and maintenance of the technology;
- Specific trainings to increase technical capacity of relevant stakeholders (technical service providers) to improve quality of provided services;
- Implement pilot projects at community level, including installation of wind energy equipment at community level for the benefit of individual households, local authority buildings, private business buildings and so on;
- Organize study tours with participation of representatives of surrounding communities in order to demonstrate effective project results and enable replication of project activities;
- Improve market linkages of target communities with relevant market players, including financial institutions, in order to create enabling framework for further application of wind energy by local communities;
- Organize national conference in order to present project achievements to wider group of stakeholders.

Project outputs:

- A detailed feasibility report on wind energy generation in The Gambia providing necessary information related to its potential, suitability, cost, etc.
- Installation of wind energy equipment at 100 communities (of about 500 households per community);
- Reduction of approximately 189 thousand or more tons of GHG emission;
- Six round-table discussions with participation of representatives of relevant ministries, agencies, institutions;
- At least 1000 participants, including representatives of local authorities, private sector, local community residents, NGOs, with improved knowledge and capacity of economic and environmental advantages of technology deployment;
- Four study tours with at least 100 participants in order to share effective practices;
- At least 20 local residents to receive affordable loans from financial institutions to deploy technology;
- At least three financial institutions and four wind energy equipment producers/importers involved in project;
- Two national conferences organized to disseminate project achievements at national level.

Project beneficiaries: Project beneficiaries are local communities situated in urban and rural areas of The Gambia, as well as local authorities, private sector, NGOs and other relevant stakeholders. The current project will cover four pilot communities (totaling 500 households) and will have 500 direct project beneficiaries. It is intended to enhance replication of applied best practices in territories of the country with wind energy potential. As a result of the project, total reduction in GHG emission will be 189 thousand tons per year, taking into account that each household will use 2 kW/hour less energy from general electric power per day -- on average 300 days per year.

Relevant stakeholders: State Company on Alternative and Renewable Energy Sources, Ministry of Finance and Economic Affairs, Local Government Authorities; Private sector (financial institutions, producers/importers of wind energy equipment); and Civil Society Organizations;.

Project duration: 3.5 years

Project budget: 3,250,000 USD

Project sustainability: Information campaigns, capacity building activities and study tours for demonstration of effective practices are designed to achieve project sustainability. Practical demonstration of advantages of applied technology will lead to replication of technology use by other communities. The project will contribute to the country's sustainable development priorities (economic, environmental and social), as it will result in sustainable energy supply to local communities, improved living conditions, creation of new jobs and improved ecological conditions (reduction in GHG emissions).

Project deliverables: At the community level, the pilot project will lead to significant results and will enable the demonstration of best practices to other local communities.

Project scope and possible implementation: The project will cover four local communities (totaling 500 households) situated in rural and urban areas with high wind energy potential. All relevant stakeholders (state institutions, agencies, private sector, local authorities, NGOs, local communities) are interested in project implementation. In the past there were similar project initiatives, however they were at the individual level and lacked capacity building or financial components.

Risks: The main risk of project implementation is low interest of local communities in technology deployment. This risk will be mitigated through effective awareness-raising activities to be organized during the project implementation period.

Project monitoring and evaluation: The project will be monitored by a Project Steering Committee. Representatives of different state institutions, agencies, NGOs, private sector and local authorities will be included in the Project Steering Committee. Project results will be assessed by external evaluators, as well as by relevant state institutions (Ministry of Finance and Economic Affairs, State Company on Alternative and Renewable Energy Sources) responsible for project coordination.

CHAPTER 5 TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR THE TRANSPORT SECTOR

5.1 TAP for the Transport Sector

5.1.1 Overview of the Transport Sector

The role of Gambia transport sector in its development is critical; this important role has been identified in the framework of successive National Development Plans (NDP), including the 1998-2006 National Transport Policy (NTP), and now of the NDP 2018-2021 (Improving and Modernizing Infrastructure). This can be illustrated more clearly by the fact that certain sectors (the agricultural, industrial, and tourism sectors) demand the transport system to enhance their productive capacity and competitiveness, e.g. transport provides connectivity and access in the urban and rural areas to transport freight, passengers, agricultural produce to markets, etc. Hence an efficient transport system facilitates economic development and reduces poverty.

There are however critical challenges (identified in the 1998-2006 NTP) that the transport sector must respond to. These have been re-echoed in the NTP 2018-2027, and they relate to the isolated Regions within the country, significant mobility needs of the population estimated at 1.7 million with increased rate of urbanization, lack of integration of various transport modes, inadequate transport policies and regulations to achieve operational efficiency, huge gaps in transport infrastructure financing, inefficient road traffic safety system and non-compliance with axle-load regulations and provisions, weak institutions and capacity and insufficient private sector involvement/Local Construction Industry.

As the population and economy have grown, the total number of vehicles in the Gambia from 2005 to 2016 is estimated at 84,056, (GBOS, 2016). This figure, compared to 11,000 estimated in 1997 (the National Transport Policy (1998)) indicates a significant increase in the rate of motorization in the country over the past 11 years. From the diagnostic study conducted in 2013, the road vehicle (excluding motor cycles*)* fleet has been growing at an average annual growth rate of 2.23 per cent. In terms of population, with the rapid rate of urbanization due mainly to the continuous rural-urban migration, the Greater Banjul Area (GBA) presently hosts more than 50 per cent of the national population, putting more strain on the transport system and ultimately affects the productivity of the economy of the area. There is currently growing traffic congestion road trauma and air pollution, and Government therefore needs to improve urban transport and land use planning.

To reduce GHG emissions from transport, there are three main strategic responses: avoid or reduce travel, shift to more environmentally clean modes of travel, and improve energy efficiency and transport technology (GTZ 2007). Instruments to promote sustainable transport may be broadly divided into five categories: planning, regulatory, economic and finance, information, and technological instruments. Under the TNA project, technology is not limited to

hard instruments or equipment, but also includes practices and policy tools, and therefore covers the whole range of instruments required for sustainable transport.

In The Gambia, all urban transport is road-based which has led to widespread traffic congestion in the larger settlements, especially in the capital city of Banjul and on the Mamadi Maniyang Highway from West Field to Tabokoto, during peak hours. There is no urban mass transport at this stage in The Gambia. The rapid growth of second hand vehicle ownership is mainly associated with the absence of mass transport. Thus, an energy efficient urban transport system would not only reduce GHG emissions, but also alleviate traffic congestion and improve local environment quality. Gambia does not currently have vehicle emission standards, which results in highly polluting vehicles being operated on the roads. This has negative impacts not only on GHG emissions, but also on air quality standards in the major settlement.

In addition to the above mentioned issues, it is found that lack of an urban transport master plan is another major challenge. It is common practice that urban transport master plan is an integral part of urban planning. This issue may be closely associated with inadequate coordination of key players involved in urban land use planning. Therefore, integration of all transportation modes and measures into urban planning shall be promoted in order to improve the transportation sector. Furthermore, it is important to have a well elaborated urban management master plan that shall not consider just on road and road network improvement, but also focuses on diversification of urban transportation modes, basic traffic law, policy and regulation improvement, and engagement of private investment and public involvement. Thus, energy efficient mass transport and vehicle (i.e. direct fuel injection technology) is selected for the purpose of developing this TAP.

5.1.2 Action Plan for the direct fuel injection Technology

5.1.2.1 Introduction to direct fuel injection Technology

The demand of modern transportation services plays a crucial role in the socio-economic development of any nation. The availability of efficient and fast transport mode provides for greater opportunities in the productive sectors, in value addition, in services and also for the domestic sector, all contributing to economic growth. Conversely, the absence or limitation in modern transportation modes restricts economic growth. The lack of awareness in modern vehicle use and the high cost are seriously limiting investment in The Gambia and also limiting growth in productive sectors such as the mass transportation and manufacturing sectors.

Under the transport sector, the Technology Needs Assessment report identified three technologies, namely direct fuel injection system, Fuel cell electric car and turbocharger. Out of these three technologies, direct fuel injection topped the ranking using an extensive multi-criteria decision analysis (MCDA) undertaken in Part I, which was used to prioritize technologies for barrier analysis and possible enabling measures for technology.

Direct fuel injection is a fuel-delivery technology that allows gasoline engines to burn fuel more efficiently, resulting in more power, cleaner emissions and increased fuel economy. The two most critical differences between a direct injection engine and a standard gasoline engine are how they deliver fuel and how the fuel mixes with incoming air. These basic premises make a tremendous difference in an engine's overall efficiency. Direct fuel injection systems can optimize fuel delivery by injecting fuel directly into the cylinder at a high pressure, in contrast to conventional systems that inject fuel into the intake air stream at a lower pressure. Direct injection systems allow better control of the fuel-air mixture and can reduce fuel consumption by 1 to 3%, saving money and reducing impact on the environment and greenhouse gas (GHG) emission. Over 10 years, this reduction corresponds to fuel cost savings of $134 to $914 and carbon dioxide (CO2) reductions of 280 to 1,930 kg.

With regard to the country's social development priorities, application of the Direst Fuel Injection technology will create new employment opportunities. Regarding the country's environmental development priorities, the application of direct fuel injection has zero emission of CO2 and will lead to decrease of SO2 and NOx emissions, which have negative impacts on woods, crops, egetation and particularly on the endangered species.

5.1.2.2 Ambition for advancing the Direct Fuel Injection TAP.

In view of the country's strive to undertake climate proofing activities, and to realize the targets set for vision 2021 and The Gambia National Transport Policy (NTP) 2018- 2027, sets the target to provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons. A number of initiatives are being taken in the transport sector, which include streamlining passenger transportation through improvement in public transport system and pollution prevention in vehicles.

Most of the vehicles registered annually in The Gambia are imported second hand, with the average age of vehicles over ten years. Vehicle licensing is under the purview of the Police, and practically all vehicles are licensed irrespective of age of vehicle. The preponderance of over-aged vehicles in the fleet has resulted in low availability and high spare parts requirements as well as environmental pollution. This, compounded by the poor road conditions, would result in high vehicle operating costs. It also raises safety concerns due to poor mechanical inspections facilities for establishing vehicle road worthiness, and environmental issues of pollution.

Clearly, this requires appropriate response from Government in terms of policy support. In this situation where transport operators do not invest enough for fleet renewal, Government can consider incentives (such as tax relief on vehicles, spare parts, technology etc.) to encourage fleet renewal and improved vehicle standard for public service vehicles operators.

Application of direct fuel injection technology lines with the country's social, economic and environmental development priorities. With regard to the country's social development priorities,

application of the above-mentioned technology will create new employment opportunities, less green house emission and pollution.

5.1.2.3 Actions and Activities selected for inclusion in the Direct Fuel Injection TAP

In spite of the fact that the country's economy is in the early development stage, the government has established strategy and programmes for the development of the transport sector taking into account its environmental, economic and social advantages. However, at the present time the market for direct fuel injection technology is not economically viable for technology producers/importers, as transportation means whether formal or informal users are accustomed to the use of cheaper and affordable means of transport. The current tariff policy and market condition of The Gambia does not create a favorable economic environment, which leads to a decrease in the interest level of private sectors investing in the technology and considers it risky.

High cost of investment and infrastructure is another barrier to the development of the sector. This leads to low interest and lack of initiatives from the private sector. Not having access to low-interest and long-term financial means (loans, credits), the private sector is unable to provide sufficient investment for the development of the technology. Current interest rates in the financial market are high and the private sector does not have access to suitable financial means at local and international market.

Presently, all technology related to direct fuel injection is imported into the country, as there is no local production of the technology. This leads to high prices and high investment costs, which impede large private sector investments in the sector. Capacity of local institutions dealing with tertiary education as well as research and development activities is low and does not meet up-to-date requirements. This is mainly due to the lack of public financing and insufficient fiscal support to institutions. As a result, technical capacities of institutions are under developed. Consequently, private sectors are obliged to apply to international institutions providing relevant services, which are relatively expensive.

To lift the preceding barriers, relevant actions and activities have been identified. Economic and financial measures include:

- Support and promote the production and/or import and the current marketing of direct fuel injection systems and other necessary equipment by the government through different subsidy mechanisms (such as tax discounts/exemptions). Promoting local production of technology will lead to decrease in technology prices and investment costs;
- Technology is not cost-effective at current tariff rates. Relevant economic regulations, such as regulations of tariff system, should be provided in order to promote investments in the sector. Market oriented tariff systems will make the sector attractive for private sector investors;
- Government should support the investors in this field by providing long-term and low-interest loans through different state funds, private sources (different Banks) and international funds (GEF, UNEP, UNFCCC and among others). Having access to

affordable financial means, the private sector will be able to provide large and long-term investments to the sector.

Activities to lift non-financial barriers include:

- Provision of necessary regulatory actions by the government in order to create a mechanism for consumer use of direct fuel injection, including tariff regulations;
- Capacity building for research institutions by involvement in different trainings or study tours with the support of government and other international funds in order to improve their skills and capacities;
- Strengthening international research network programmes in order to learn from best international practices;
- Conduct information campaigns on the advantages of applying the technology in order to increase capacity of consumers (local residents, local authorities and private sector) and NGOs in the process; and
- Organizing specific capacity building activities for private sector representatives and local communities in order to increase capacities and awareness level on advantages of transport system technologies.

These measures will result in increase of private sector initiatives in the direct fuel injection system. Moreover, consumers, local communities, municipalities, and private sector will start to widely apply the technology.

Table 13: Overview of Direct Fuel Injection Technology Action Plan				
Sector	**Transport**			
Sub-sector	**Road Transport**			
Road Transport	**Direct Fuel Injection Technology**			
Ambition	10 communities (of about 50 Vehicles and 5 station)			
Benefits	Mitigate GHG emission (0.234 megaton per year)			
Action	Activities to be implemented	Sources of funding	Time frame	Budget per Activity (USD)
Establish a unit to oversee the implementation of the TAP	Recruit staff Establish and equip the office and station	Government Development Partners	1 – 4 year	700,000
Action 1: Establish feasibility study of urban transport master plan	Activity 1.1: Conduct technical feasibility studies (including public transport planning and travel demand management)	Government Development Partners	1 – 2.5 years	550,000
Action 2: Create awareness of both developer, and users of the technology	Activity 2.1: Develop awareness material targeting different stakeholders (i.e. Private Sector, Decision Makers, Users of the technology, financial institutions)	Government Development Partners	1 – 2 years	80,000
	Activity 2.2: Implement awareness campaign on direct fuel injection technology	Government Development Partners	1 – 4 years	250,000
Action 3: Build / strengthen capacity of key stakeholders	Activity 3.1: Develop specialized training aimed at building the capacities in relevant institutions – in areas of operation and maintenance of direct fuel injection systems	Government Development Partners	1 – 4 years	800,000
	Activity 3.2: Strengthen inter-ministerial coordination	Government	1 – 2 years	10,000
	Activity 3.4: Strengthen capacity of public institutions, NGOs and Private sector	Government Development Partners	1 – 3 years	500,000
Action 4: Enhance access to financing	Activity 1.1 Purchase of 50 vehicles and installation at least 5 demonstrative stations	Government Private sector	2 – 4 years	1,500,000
	Activity 3.2: Engage in dialogue with development partners to provide subsidies for the technology as it contributes to global benefit	Development Partners	2 - 4 years	120,000
	Activity 1.4: Establish a road transport development fund to enhance vehicle emission control, inspection and maintenance		3 – 4 years	800,000

SAMPLE PROJECT IDEA - TRANSPORT SECTOR

The proposed project idea is a set of activities focusing on technical aspects associated with evaluating transport modes, undertaking pilots and designing support infrastructure. The project includes an assessment of different transportation techniques and financing models for implementing these techniques. In order to have a better understanding of the kind of support infrastructure needed for setting up and managing transport projects, the project also recommends studying some models on support infrastructure (in terms of direct fuel injection system) of other countries keeping in mind few major settlements of the Greater Banjul area. To support the government policies and plans for the transport sector, the proposed project idea includes (a) Promoting urban public transport using modern technology; (b) Public transport planning and travel demand management and (c) Enhancing vehicle emission control, inspection and maintenance in large settlements. The diffusion and development of such a new technology in Gambia are achievable especially due to the expected decrease in consumption of gasoline fuel: 4 times less.

Project objectives:

- Introduction of at least 50 direct fuel injection vehicles for the purpose of demonstration and promotion of such a mitigation technology in the road transport sub-sector;
- Installation of at least five demonstrative stations;
- Initiatives for a progressive replacement of conventional pollutant vehicles by the direct fuel injection ones;
- Contribution to the GHG mitigation by the importation of new vehicles meeting the direct fuel injection standards;
- Decreasing the importation of fossil fuels through the use of direct fuel injection vehicles

Project Outputs

- Five installed stations for direct fuel injection system;
- Clean vehicles are introduced on the local market.
- Decrease in the use of petroleum fuels by the vehicles and reduction of the GHG emissions;
- Raised awareness and proven advantages of direct fuel injection ownership in Gambia

Relationship to development

- In the short term, preliminary studies aiming at identifying opportunities for establishing a multi-model system of transport based on efficient technologies are initiated ;
- In the medium term, set up the transport services relying more on efficient transportation means and responding to the climate change mitigation obligations;
- In the long term, introduction of more affordable vehicles also accessible to the rural population should be undertaken in consideration of potential future low cost vehicles.

Project Deliverables: At the end of the project, 50 vehicles using both an efficient gasoline internal combustion engine and an efficient motor are operational in Gambia as a pilot project;

Scope and implementation

- This project is limited to the provision of 50 Direct Fuel Injection system fully operational
- A preliminary campaign of sensitization will be organized
- The project at this stage is of a demonstrative nature with a small number of vehicles: just 50 expected to be served by five pilot stations;
- The implementation of this project is possible as far as the budget required is affordable;

Project Activities: The application and implementation of the specific measures for the transfer of Direct Fuel Injection option are as follow:

- Setting up five stations;
- Organize and conduct awareness campaigns for vehicle consumers and suppliers;
- Training of technicians on direct fuel injection vehicles maintenance;
- Purchase and supply 50 direct fuel injection vehicles;
- Monitoring of reduced GHG emissions

Timeline: Duration of project: 4 years

Project budget: 5,310,000 USD

Monitoring and Evaluation:

- Monthly evaluation of performance and consumption of all 50 vehicles;
- The amount of GHG emissions avoided using direct fuel injection vehicles;
- Record of efficient gasoline fuels consumed and electricity delivered by the pilot station;

Responsibilities

- State Company and public institutions on transport will coordinate project activities as the main institution in the field of road transport in the country;
- Ministry of Finance and Economic Affairs will support implementation of the financial component;
- Local authorities will play the role of facilitators in target local communities;
- Private sector partners will be involved as market players actively participating in project implementation;
- NGOs will be responsible for capacity building/awareness-raising activities and dissemination of best practices to other surrounding communities.

CHAPTER 6 TECHNOLOGY ACTION PLAN AND PROJECT IDEAS FOR THE WASTE MANAGEMENT SECTOR

6.1 TAP for the Waste Management Sector

6.1.1 Overview of the Waste Management Sector

Almost all human activities generate wastes of different types and quantities. Wastes can be categorized as solid, liquid or gaseous. The categories can also be based on their sources of generation. Some types of wastes are bio-degradable under natural condition while others are not and can last over a long period of time if not taken care of. Currently, there is no landfill in The Gambia. There exist only two dump sites at Mile 2 and Bakoteh.

Apart from these two formal sites, a number of illegal dumpsites exist, some of which are located on waterways. The GBA and Brikama areas face serious challenges with respect to solid waste management. Insufficient collection is occurring due to lack of municipal resources and extensive equipment downtime as a result of unavailable spare parts. Collected waste is being disposed of improperly at authorized substandard dumpsites, while waste not collected by the municipalities is dumped indiscriminately throughout the community, and particularly in riverine areas. These dumpsites have not been properly sited or managed, and the many temporary dumpsites are degrading the urban environment. These practices are resulting in a littered landscape, surface water and groundwater pollution, air quality degradation, risks of explosion from methane gas for adjacent structures, blocked drains and public health and safety impacts.

The composition of wastes generated by Gambian households typically includes organic waste, garden waste, animal waste, night soil, paper, cardboard, textiles, glass plastic containers and bags, polyethylene, ceramic and stone, metals, leather, rubber and wood wastes. In addition to these components a large amount of sand also finds its way into the waste set out for collection through existing practices of sweeping wastes from the ground of compounds.

The Waste Surveys Report (Louis Berger/GAP Consultants, 2002) carried out a substantive effort to develop household waste compositions for Banjul, Kanifing and Brikama and to look at variations associated with income levels. A combined average of the household waste composition for all three of these municipalities by weight is: sand (46.7%), organic (35%), paper/carton (9.7%), glass (1.2%), wood (2.6%), metals (2.1%), textiles (1.6%), rubber (0.5%), and other (0.7%). It should be noted that more than 80% of the waste stream is organics and sand. This data was used to project a landfill volume after 15 year at 2,000,000 Mg/d, assuming that (a) the average waste rate of 350Mg/d (b) 1 Mg is equal to 1 M3 (waste is not compacted).

In 2015, Waste Aid UK conducted a waste composition study in Brikama, during which 2.497 tonnes of waste were segregated into 45 separate categories, using 25 separate samples (28th April to 2nd May) at Jamisa dump site following UNEP IETC waste characterization protocols. This produced results with an 80% confidence level with the following composition: “Organics”:

36.45%, “Other”: 19.28%, “Plastics”: 15.22%, “Textiles”: 7.80%, “Paper and Paperboard”: 5.81%, “Construction and Demolition”: 5.54%, “Hazardous Waste”: 5.22%, “Glass”: 1.35%, “Metals: 3.32%.

Population increases have resulted in solid waste problems in communities where previously no service was provided and where there has been little or no recognition of municipal responsibility. Municipalities with established solid waste collection and disposal services have found that community development means new problems. As growth presses to a municipality’s borders and vacant land is developed, adequate solid waste disposal sites become less readily available. Frequently, existing methods must be improved or an entirely new system adopted. In addition, poor management of the sector is due to a large extent to inadequate capacity of municipalities to address the problem. Urgent financial and human resources development, together with a substantial financial investment, is required to improve the sector.

There are a number of policies and measures that have been formulated to regulate and give guidance on waste management of various types in the country the main ones being the following:

i Public Health Act (1990): The Act empowers the Secretary of State to formulate regulations regarding the collection, removal and disposal of sanitary waste and other noxious waste. The Act also mandates the Director of Health Services who also heads the Department of Public Health Services to abate nuisances and to remove or correct any condition that may be injurious to public health. It empowers public health officers to monitor environmental and public health regulations. In this regard they have to provide suitable waste disposal sites.

ii The National Water Management Bill (2001): The Act provides for the management and rational utilization of water in The Gambia. Other provisions of the Bill include the creation of a National Water Resources Council that will prohibit the discharge of any effluent from a sewage treatment works or any trade effluent into controlled waters and have power to make drought orders, prohibit the disturbance of groundwater.

iii Local Government Act (2002) makes provisions for the functions, powers and duties of local authorities; development in the decentralized government structures; and local government civil service, traditional authorities and the co-ordination of local government authorities. The Act gives local authorities powers to establish and maintain sanitary services for the removal and destruction of or otherwise dealing with all kinds of refuse and effluent and if any such service is established to compel the use of such service by persons to whom such service is available. The Act provides mechanisms and procedures for disposal of municipal wastes including their enforcement. This is a crucial act because human activities in urban areas generate large amounts of wastes and urban areas in the Gambia are growing rapidly on account of rural to urban migration.

iv National Environment Management Act (1994) provides a legal framework for activities in the environmental sector. It defines some legal basis for a correct use and a viable management of the environment and its components, in order to establish a system of sustainable development in the Gambia. It gives legal guidelines for waste management

including setting of standards, waste disposal sites licenses and control of various types of wastes.

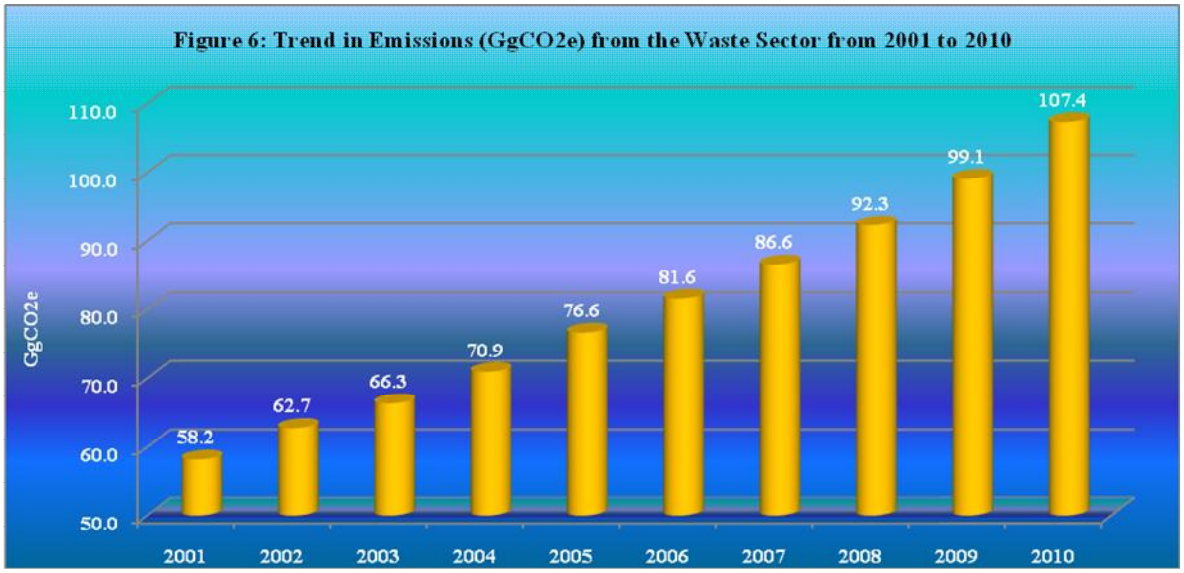
v Environmental Impact Assessment Regulations (2014) require that any major project in the country must undergo Environmental Impact Assessment (EIA). Wastes generation and management is a key component of EIA.

vi Waste Management Bill (2003) is the only specific legislation on waste. It has provision for the development of regulations on all solid and liquid wastes.

vii The National Climate Change Policy (2017) provides "the framework for managing climate risks, building institutions and capacities, and identifying new opportunities for climate-resilient sustainable development in The Gambia".

viii Gambia's Environmental Action Plan (GEAP) seeks to promote and implement sound environmental policy. The GEAP represents the culmination of a series of initiatives and activities coordinated by the NEA. It is the master plan for the environment in the Gambia and contains a National Environment Policy, Framework Environmental Legislation and Environmental Strategy. The GEAP consists of Sectoral Plans for the medium and long term intended to lead to sustainable development in Gambia. The Plan puts special emphasis on environmental management, pollutions and nuisances, and the necessity to safeguard the well-being of the populations.

For the Inventory Year of 2010, total emissions of 107.4GgCO2e were recorded from the Waste Sector. This figure is the average of 115.6GgCO2e following the GDP approach and 99.1GgCO2e following the population approach. Figure 6 shows the trend in emission from the Waste Sector. The GDP and Population approaches and their average show increasing trends in emission from Solid Waste Disposal Sites (SWDS) in The Gambia.



Regarding mitigation of greenhouse gases, inadequate waste data is a major issue regarding both GHG emissions and waste production, for both solid waste and wastewater. Nevertheless, the GoTG included in its NAMA the implementation of an Integrated Waste Management initiative

for solid and liquid waste in the GBA. This is expected to reduce emissions significantly but is also associated with an estimated implementation cost of USD 68 million. The GoTG's 2015 INDC states, under waste management, that combined greenhouse gas emission reductions of 141 GgCO2e in 2020, 239.7 GgCO2e in 2025, and 413.7 GgCO2e in 2030 will be achieved through conditional methane capture, and waste recycling and composting.

6.1.2 Action Plan for the Landfill Design and Management Technology

6.1.2.1 Introduction to Landfill Design and Management Technology

While the National Climate Change Policy (NCCP) of The Gambia concerns all sectors of development and society, the Special Programme for Climate Resilience (SPCR) focuses on defining priority investments within the key climate resilience priorities that include climate proof urban planning and waste management and the development of climate proof infrastructure, sanitation and solid waste management. Waste management poses a major challenge in The Gambia, particularly in the Greater Banjul Area (GBA) and the growth centres. The three urban municipalities that make up the GBA, namely Banjul City Council (BCC), Brikama Area Council (BAC), and Kanifing Municipal Council (KMC), with a total population of more than 500,000 inhabitants, produce in excess of 150,000 tons of waste annually.

The increasing rate of production of waste in the GBA is linked to population growth, business development and household consumption. According to the five-year development plan for the KMC, waste is categorized as municipal or residential waste, commercial waste, industrial waste, clinical waste, construction/demolition waste, electronic waste and liquid waste.

The vulnerability of waste infrastructure to climate change depends on the geographical position and state of the disposal site, as well as its organization in terms of disposals methods and enforcement of relevant regulations. Waste is collected and temporarily stored at community dumpsites, from where it is eventually transferred to permanent dumpsites. The process is largely *ad hoc*, reactive, and unsystematic, and is not guided or monitored by any clearly defined Waste Management Plan. Both Bakoteh and Mile 2 are poorly managed, resulting in their vulnerability to climate-related impacts from flooding of low-lying areas, including spread of water-borne diseases and contamination of the underground water system; and including unknown health impacts of air pollution resulting from continuous burning of the waste.

In addition to the formal dumpsites, a number of illegal dumpsites exist in different locations throughout the GBA, with consequences similar to those posed by the formal sites. Riverine areas in Tallinding, Ebo Town, Faji Kunda and Abuko are particularly affected by pollution due to indiscriminate and clandestine dumping of waste. Consequently, these could contribute to serious ground and surface water pollution through leachates and contaminants when they end up in the riverine areas, potentially affecting aquatic life and the livelihood of populations dependent on the wetlands. The significant negative impacts (current and future) close to a disposal site may gradually spread to become a national problem as wider areas become affected.

The waste problem, which constitutes a real public health problem, requires local solutions involving the range of actors.

6.1.2.2 Ambition for advancing Landfill Design and Management TAP.

While a number of studies carried out over the years have made numerous recommendations, waste management continues to be a major challenge. Problems are particularly severe in the Greater Banjul Area (GBA). From collection, storage and disposal, all aspects of waste management are poorly managed, whilst existing dumpsites including the Bakoteh disposal site are public health hazards as well as being eyesores. Both Bakoteh and Mile 2 Dump sites are no longer capable of handling the volume of waste they were intended to handle, whilst Bakoteh has been rendered unhealthy and ineffective by the uncontrolled urban development and encroachment around it. It is therefore necessary to identify a new site that can replace both Bakoteh and Mile 2. Blockage of drainage channels through indiscriminate dumping of waste reduces the ability to cope with flooding, which is expected to increase under climate change. It is necessary to put in place a series of steps and develop systems to promote climate resilience in the urban areas and growth centres of The Gambia, through actions to make systems and infrastructure for waste management systems resilient to current and future projected climatic changes.

It is proposed to establish dumpsites that will be managed and turned into 25 landfills covering the whole country with higher density in the Greater Banjul Area and the West Coast Region. The problem of designing the most economical solid waste collection and disposal program for a rural or urban area has become increasingly complex in recent years. The problem mounts each year because of several trends: population growth, new home construction, increased industrial activity, shortage of disposal sites, and a significant increase in the production of solid waste resulting from modern packaging and consumer consumption.

6.1.2.3 Actions and Activities selected for inclusion in the Landfill Design and Management TAP

Based on the Barrier Analysis Report (2018), financial and non-financial barriers for the establishment and management of dumpsites and landfills have been identified. Availability of financial resources is a prerequisite for the introduction of Environmentally Sound Technology (EST), due to the fact that the provision of design conditions and achievement of the parameters and quantities of waste management demand will require a strong capital investment and time. Consequently, the high rate of interest (business loans offered by the local banks are within high scope) severely complicate the implementation of projects with technology involved. High transaction cost and transportation also complicate the issue as well as define duties and taxes that lead to the rise of additional costs.

A serious obstacle for the introduction of sanitary landfills is based on lack of skilled technical personnel for construction and maintenance as well as low awareness of the benefits of sanitary landfill as sources of reliable and clean energy. In addition, lack of proper policies and

regulations to guide the process and absence of a strong legal framework to support development and management of landfills are serious barriers.

Identifying relevant measures to lift these barriers is the process of analyzing necessary actions to be taken in order to overcome current barriers to the implementation of prioritized technologies. Some of the actions identified in this study are shown in the following overview table of the Landfill Technology Action Plan.

These should be completely eradicated, based upon improved waste collection strategies that maximize entrepreneurial opportunities. Improved integrated waste management is inextricably linked to updating and enforcing land use planning in the GBA, and indeed throughout the country. For an enhanced urban environment, existing environmental and physical planning laws and regulations should be enforced, to eradicate inappropriate developments on waterways, amongst other issues. The Kanifing Municipal Council (KMC) has recently prepared a 5-year Waste Management Strategy, for which resources are lacking. There is the opportunity to contribute to the implementation of this strategy, for example by funding the critical awareness raising priority component.

Table 14: Overview of Landfill Waste Management TAP

Sector	**Waste**
Sub-sector	**Waste Management**
Technology	**Landfill Waste Management Technology**
Ambition	
Benefits	

Measure	Why the measure is Needed	Responsible Institutions	Time Frame	Cost of the measure and source of funds in US Dollars	Indicators of success	Risks
Provision of financial grants	The small area councils will need to be assisted financially so that they can afford initial construction costs	The Ministry ofFinance and international funding institutions and donor countries	1-10years	12.000,000 USD government allocates 5.000,000 USD international institutions provide 8.000,000 USD	Government allocates at least 5.000,000 US dollars for the project, International institutions and other donors provide at least 8.000,000 USD. At least 4,000 bio-digesters are constructed per year	Lower prioritisation of Rural waste management Weak justification and rationalization of financial assistance.
Low interest loans to small firms	Even with financial grants small companies may need additional financial resources to meet the rest of the costs	Local financial Institutions	1-10 years	5.000,000 USD from financial institutions	Even low income Firms have access to financial resources, landfills for commercial purposes are constructed	Interest rates remain High
Maintain duty and VAT exemption for the equipment	This action will help to keep landfills affordable to the small councils	Ministry of Finance	1-18 years	About 500,000 USD loss of revenue by the Government per year	The Government maintains the policy of duty and VAT exception for renewable energy equipment	
Setting of quality standards for construction and equipment for landfills management	Low quality construction and equipment lead to frequent break down of the system which becomes a barrier to diffusion of the technology	The Gambia Standards Bureau (T G S B)	1-5years	500,000 USD from Government, international institutions and technology suppliers	Landfill management equipment that take atleast1 year without requiring repairs or replacement	The number of skilled technical personnel remain low
Training of technicians for construction and maintenance	If the technicians are welltrained there will be less technical problems and the technology will be more attractive to users	Ministries of Environment,NEA, Regional councils, and technology suppliers and local research and development institutions	1-8years	1.800,000 USD from Government, international institutions and technology suppliers	Progressive availability of well trained personnel in different parts of the country	Institutions put low priority on training programmer for landfills management
Training of technology users	The users of the technology need to be trained in order to enhance efficiency and reduce frequency of system break downs	Ministries of Environment, NEA, Regional councils, and technology suppliers and local research and development	1-8years	800,000 U S D from Government, international institutions and technology suppliers.	Enhanced efficiency of Landfill use.	Institutions put low priority on training programmer for landfills management to protect our environment
Conducting public awareness creation campaigns	Lack of awareness of the benefits of landfill use is a major barrier to its wide diffusion within communities across the country and therefore the need to conduct awareness campaigns	Ministries of Environment,NEA, Regional councils, and technology suppliers and local research and development institutionsand NGOs	1-12years	1.000,000 USD fromGovernment, international Institutions and technology suppliers.	Increasing construction and use of landfills across the country.	Government places low priority on public awareness creation campaigns
Research and Development (R&D)	To modify or improve the technology to respond to the emerging demands from the users	Ministries of Environment,NEA, Regional councils, and technology suppliers and local research and development institutions	1-2years	2.200,000 USD	Users expressing theirneeds for technology modification and getting satisfaction with the modified or new products.	Table 2.2 below shows Technology action plan for Landfills technology.

7. REFERENCES

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