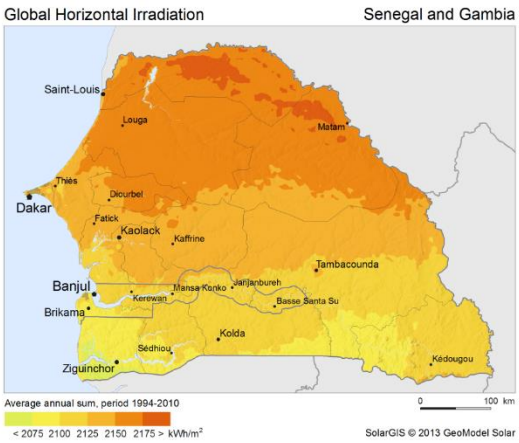


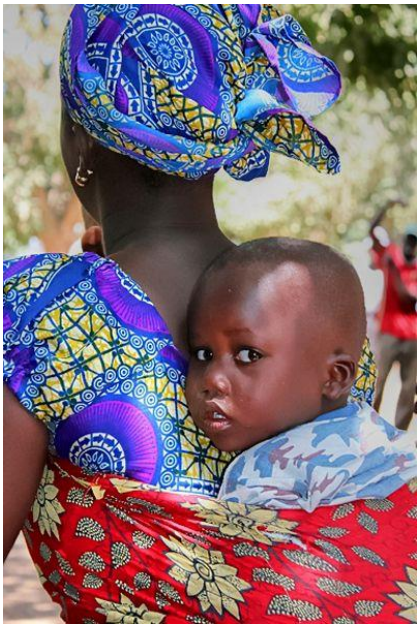
SOLAR POWERED IRRIGATION DEVELOPMENT

IN GAMBIA

A SOLAR ENERGY BASED INTEGRATED PROJECT PROPOSAL

Prepared by

ada Engineering
Consultancy Co.



AN INTEGRATED PROJECT PROPOSAL

Improving Productivity of Gambian farmers project

March-2017

Authour: Dursun Yıldız -Civil Engineer- Water and Energy Expert

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1.EXECUTIVE SUMMARY

1.1.BACKGROUND

Gambia is an agriculture country, 80% of the population live on farming and husbandry . The climate change , poor agricultural infrastructure and the backward means of the production have made the country seriously short of food --the self-sufficient rate only reaches 40 % even in a very good harvest year . It is very urgent for the country to increase its food production to satisfy the food demand. This demand also urgently requires energy to irrigation.

In recognition of the critical need to improve global access to sustainable, affordable and environmentally sound energy services and resources, the United Nations General Assembly has declared 2012 the International Year of Sustainable Energy for All and urged Member States and the UN system to increase the awareness of the importance of addressing energy issues and to promote action at the local, national, regional and international levels. In response, the UN Secretary General has launched a global Initiative to achieve Sustainable Energy for All by the year 2030.

The key objectives under this goal
are: (1) ensuring universal access to modern energy services;
(2) doubling the rate of improvements in energy efficiency; and
(3) doubling the share of renewable energy in the global energy mix.

This document presents the gap analysis of the energy and related sectors of the Gambia, with particular reference to the three objectives of "Sustainable Energy for All."

The Gap Analysis included a situation analysis, with baseline data on sustainable energy production, distribution and utilisation, and covered an assessment of national initiatives on

(1) universal access to electricity; clean fuels and devices for cooking/heating; and mechanical power;

(2) improvements in energy efficiency; and
(3) increasing the share of renewable energy in the national energy mix; and an analysis of sector strengths and weaknesses in specific areas relevant to the sector such as policy, planning, institutions, finance, monitoring (data and accountability), capacity and partnerships.

1.2.GAP ANALYSIS ON UNIVERSAL ACCESS TO ELECTRICITY

The power sector is characterized by a number of strengths which provide opportunities for the realization of the goal of universal access to electricity. The strengths of the power sector include the following:

- The Government's strong commitment to expand the electricity network to many communities in The Gambia;
- Willingness of private sector(investors) to partner with government to provide electricity services;
- Examples of connectivity within the sub-region to learn from;
- Availability of market (domestic and commercial) for the electricity that could be produced in future
- The power sub-sector also faces a number challenges in achieving the stated goal of ensuring wider access to electricity in The Gambia. The sector is challenged by

Inadequacy of the transmission and distribution (T&D) network;

- Lack of fuel diversityas well as high cost and irregular supply of fuel for electricity generation;
- Operational inefficiencies in the key utility company NAWEC resulting in transmission
  and distribution losses;
- NAWEC's poor financial performance;
- Weak regulatory and enforcement capacity;
- Poor reliability of electricity supply from the grid;
- Limited hours of supply of power by stand-alone generators in the rural areas; and
- High electricity tariffs and non-affordability of electricity.

1.3.RECOMMENDED STRATEGIES TO ADDRESS THESE CHALLENGES

Short Term

- Perform detailed transmission and distribution infrastructure analysis to reduce technical transmission and distribution losses, analyze potential interconnections with Senegal, integration into the West Africa Power Pool, and generate a comprehensive T&D master plan;
- Improve financial performance of NAWEC;
- Employ financial advisory services organization to investigate strategies for fuel price volatility reduction;
- Arrange payment of past-due bills by Central and Local Governments;
- Increase use of pre-paid metering. Require that government facilities and electric loads, including street lights, utilize pre-paid meters;
- Amnesty offer to domestic and commercial customers with past-due bills and unbilled use of energy followed by aggressive pursuit of payment with Government

assistance;

- Enhance maintenance plans for generation facilities to improve availability;
- Assess the investment incentive structure to determine if incentives are sufficient to attract private investors;
- Perform detailed renewable energy study for potential domestic sources of power generation;
- Conduct a review of PURA's capabilities and independence including the government, regulators, utility, and IPP to address empowerment of PURA and improvement of the industry;
- Implement demand side management initiatives such as promotion of compact fluorescent lamps (vs. incandescent), energy efficient appliances, energy efficient motors for industrials, and peak shaving tariff structures; and
- Investigate feasibility of upgrading generation facilities to combined cycle operation.

Medium/Long Term

- Solicit financing (using results of incentive review) to implement the actions recommended in the transmission and distribution infrastructure analysis;
- Improve financial performance of NAWEC;
- Adjust tariffs to reflect new, more stable cost structure and incorporate fuel charge adjustment on customer bills;
- Identify the most promising renewable energy projects and provide incentives (based on results of short-term incentive review) to attract private financing; and
- Revisit increased privatization and a less vertically integrated industry structure after the above issues have been addressed.

2. COUNTRY OVERVIEW -The Gambia in Brief

General

The Gambia is the smallest country in Africa. It borders the Atlantic Ocean to the west, and is otherwise entirely surrounded by the country of Senegal. The majority the country comprises the floodplain of the Gambia River, which originates in Guinea before flowing through Senegal and through the Gambia to the sea. The country is therefore generally very flat, ranging from 0 to <100 m above sea level (Bojang at all 2016).

Estimated Population in 2013*	1,849,285
Rural Population (% of total)*	42%
Total Surface Area*	10,120 sq km
Agricultural Land (% of total area)*	60%
Capital City	Banjul
Region	West Africa
Border Countries	Senegal
Annual Freshwater Withdrawal (2013)*	91 Million cubic metres
Annual Freshwater Withdrawal for Agriculture*	43%
Annual Freshwater Withdrawal for Domestic Use*	37%
Annual Freshwater Withdrawal for Industry*	19%
Rural Population with Access to Improved Water Source*	84%
Urban Population with Access to Improved Water Source*	94%

* Source: World Bank

Climate

The climate of the Gambia is largely classified as tropical savannah, apart from the central north region which transitions into hot, arid steppe. There is little spatial variation in average annual precipitation and temperature, other than a slight reduction in rainfall in the central north region.

Gambia has a very distinct wet season between June and October, and is relatively dry from November to April. The wet season is relatively hot compared to the cooler dry season(Bojang at all 2016)..

Surface water

The Gambia is dominated by the perennial Gambia River, which flows along the entire length of the country from the border with Senegal in the east to its discharge point to the Atlantic Ocean to the west.

From the Barraconda rapids to the Atlantic the Gambia has a course of about 350 km. Throughout this distance the waters are tidal, and the river is navigable all the year round by boats drawing 6 ft. of water. At Yarbatenda, a few miles below Barraconda, the river has a breadth, even at the dry season, of over 5oo ft., with a depth of 13 to 20 ft. (Encyclopedia Britanica) .

The Department of Water Resources is responsible for river flow gauging, and currently monitors the Gambia River close to its discharge point to the Atlantic Ocean (Bojang at all 2016).

Outside salinity risk areas , freshwater can be found throughout The Gambia, at depths ranging from 4 to 30 mbgl (metres below ground level). In general, depths increase with proximity to the border with Senegal. Groundwater recharge depends on the quantity and spatial and temporal distribution of rainfall, surface geology, and land use (Accesss Gambia). Good quality surface water within the country is only found in the eastern third of the River Gambia.

From June to December, freshwater availability is boosted by flows from the middle and upper Gambia River Basin areas. Low flows from January to May are mostly sustained by local rainfall (Accesss Gambia).

Soil

Soils across the floodplain of the Gambia River are dominantly Gleysols, which are highly important for agriculture.Lixisols in the north of the country are associated with fine-grained weathered parent material, and natural savannah or open woodland vegetation.

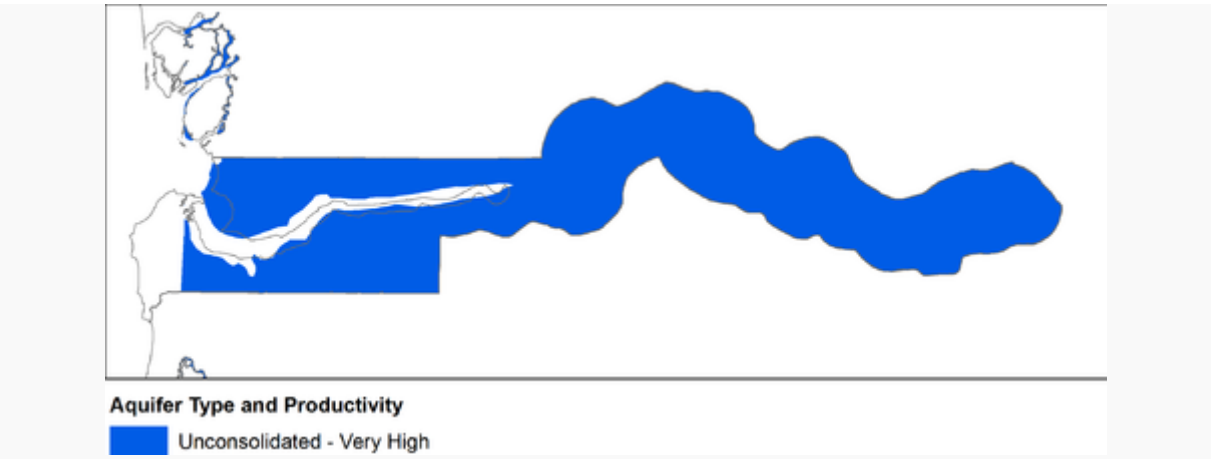
More acidic Acrisols are found in the coastal region. This soil type is common in the wetter parts of Africa, and is generally deficient in nutrients. Regosols, which cover a significant area inland, are reflective of the largely unconsolidatedunderlying geological deposits(Bojang at all 2016)..

Hydrogeology

This section provides a summary of the hydrogeology of the main aquifers in the Gambia. More information is available in the references listed at the bottom of this page. Many of these references can be accessed through the Africa Groundwater Literature Archive.

The hydrogeology map on this page shows a simplified version of the type and productivity of the main aquifers at a national scale (see the hydrogeology Map resource page for more details).

There are two main aquifers in the Gambia: the upper Quaternary unconsolidated sands comprise a shallow sand aquifer (SSA), which is an important aquifer throughout the Gambia. The deeper Cretaceous sediments form a deep sandstone aquifer (DSA). More detail can be seen below(Bojang at all 2016)..



Unconsolidated

Named Aquifers	General Description	Water quantity issues	Water quality issues	Recharge
Shallow Sand Aquifer (SSA)	The shallow sand aquifer (SSA) is composed predominantly of fine to coarse sand, and is found and exploited across the extent of Gambia. It can be subdivided into 2 units: the phreatic aquifer, which comprises the Holocene sediments, and the semi-confined aquifer, which comprises the underlying Pliocene sediments. The two aquifers are separated by a 15-30 m clay-silt layer which allows limited hydraulic connection between them. Yields are generally in the range of 1-30 l/s and can be greater than 30 l/s in the most productive areas. Hydraulic conductivity and transmissivity generally ranges from 5-30 m/d and 100-10000 m²/d, respectively. Storage is generally between 10-4 and 10-2. The SSA typically varies from 5-25 m thick and the water table may sit between 4 and 50 m below ground level. Boreholes are generally drilled to depths of 35-100 m.	Groundwater abstraction is significantly less than recharge and water levels fully recover during the wet season.	There are no major groundwater quality issues. Isolated instances of elevated iron concentrations have been reported.	When mean annual precipitation is above 900 mm, recharge is generally in the range of 250 – 300 mm. This is a result of direct infiltration.
Deep Sandstone Aquifer (DSA)	The deep sandstone aquifer (DSA) comprises mainly unconsolidated sands and loosely consolidated sandstones, typically at depths of 250-450m. Groundwater in the DSA is confined, and is very old water of 'fossil' origin, between 4000 and 40000 years old. Exploitation of the DSA would require deep boreholes (up to 380 m), and potential yields have been estimated at 40 l/s.	Storage in the DSA has been estimated at 650,000 M cubic metres, of which only 80,000 M cubic metres is thought to be potable.	In the east of Gambia, groundwater in the DSA is potable, but in the west the old confined groundwater is typically highly mineralised, with total dissolved solids in the range 1000 to 2000 mg/l, and fluoride concentrations between 2 and 5 mg/l. If required, highly mineralised water in the western parts of the DSA could be abstracted and mixed with groundwater from the SSA at a ratio of 2:1 to expand the exploitable water resources of Gambia.	There is no appreciable modern recharge to the DSA.

Groundwater Status

Groundwater abstraction from the main unconsolidated aquifer (SSA) is less than average annual recharge. Total groundwater availability could be significantly increased by exploiting the DSA(Bojang at all 2016).

Groundwater use and management

Groundwater use

The national water supply in Gambia is derived entirely from groundwater.The following groundwater abstractions are currently known:

207 boreholes with hand pumps, 260 boreholes with solar pumping systems, 84 boreholes with electric pumping systems, and 1634 hand dug wells with hand pumps (Department of Water Resources) (Bojang at all 2016)..

Groundwater management

The Department of Water Resources is responsible for the development, utilisation and protection of groundwater in Gambia. They issue permits, which are required for both borehole drilling and groundwater abstraction.The National Water and Electricity Company (NAWEC) is mandated to provide water supply in the Greater Banjul Area and surrounding provinces(Bojang at all 2016)..

Groundwater monitoring

The Department of Water Resources established a network of 38 groundwater level and quality monitoring boreholes in 2014. These are distributed across Gambia and are equipped with automatic data loggers. The recorded groundwater level observations are collected every 3 months, and the data is stored in the GeOdin database in the Department of Water Resources.The same network is used to monitor groundwater quality (Bojang at all 2016)..

2.1 GEOGRAPHY

The Gambia is located on the west coast of West Africa and extends about 400 km inland. The width of the country varies between 24 to 28 kilometres across the length of the country and thus The Gambia covers a land area of 10,689 square kilometres in total. It is bordered on the North, South and East by the Republic of Senegal and on the West by the Atlantic Ocean. The country has a tropical climate characterised by 2 seasons, rainy season June-October and dry season November-May (Health Policy).

The natural vegetation type of the Gambia is Guinea Savanna Woodland in the coastal area, that gradually changes into Open Sudan Savanna in the east. The climate is Sudanosahelian characterized by a short rainy season from June to October and a long dry spell from November to May with scattered vegetation and forest cover. Mean annual rainfall
varies from 900 mm in the south-west to about 500 mm in the north-east.

Mean temperatures vary from 14oC to 40oC and generally higher in the eastern part of the country. The country has a total arable land area of 558,000 ha and about 320,000 ha or 57 percent is cropped annually. The estuary basin of The Gambia River is a tidal inlet with a saltwater intrusion ranging from 180 km in the rainy season to 250 km in the dry season. Agriculture is mostly rainfed, and only about six percent of the irrigation potential has been used.

2.2 DEMOGRAPHIC CHARACTERISTICS

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 it is estimated to reach 1.79 million.
In 2003, about 50% of the population lives in the rural area; and women constitute 51% of the total population. The total fertility rate was 5.4 births per woman and this perhaps explain the very youthful population structure. Nearly 44% of the population was below 15 years and 19%

between the ages 15 to 24. Average life expectancy at birth is 64 years overall. Since the 1980s the population of The Gambia has undergone major changes and is now characterised by accelerated rate of urbanization. With 50% of the population living in the urban areas which covers relatively less land area, population density was very high in the Banjul and Kanifing, as can be seen in Table 1.

The agricultural sector accounted for about 29% of GDP in 2009. It provides employment to 75% of the country's population and meets about 50% of the national food requirements. Its share of the country's total exports is 70%, thus constituting a substantial part of The Gambia's foreign exchange earnings. Gambia's Gross Domestic Product was about US$ 730 million in 2009 and Gross National Income per capita was US$ 440.

Most recent World Bank Report about Gambia indicates that Gambias (2015) population is 1,99 million and GDP (2015) US $ 938.8 million. Gross National Income per capita increased to US$ 471 in 2015.

Table 1. Population of the Gambia 2003

Region	Land Area, sq. km	Population, persons	Population Density (persons/sq.km)
Banjul Municipality (BCC)	12	35,016	2,867
Kanifing Municipality (KMC)	76	322,735	4,272
West Coast Region (WCR)	1,764	389,594	221
North Bank Region (NBR)	1,618	72,167	77
Lower River Region (LRR)	2,255	172,835	45
Central River Region (CRR)	1,895	180,703	64
Upper River Region (URR)	2,070	182,586	88
The Gambia	10,690	1,360, 681	127

Source: Excerpt from the 2003 Census Report

2.3 ECONOMY

According to the United Nation System Common Country Assessment 2011, The Gambia is one of the poorest countries in the world ranking 151 out of 169 countries in the 2010 United Nations Development Programme (UNDP) Human Development Index (HDI). This is in spite of the fact that The Gambia has implemented programmes to reduce poverty since 1994, when the first Strategy for Poverty Alleviation (SPAI) was launched. From a Gambia Bureau of Statistics (GBOS) poverty assessment, the overall poverty level in 2008 was estimated at 55.5% of the population. This marks a slight decline from the 58% estimated in 2003. Recently however, a multidimensional poverty index (MPI) analysis showed that 34% of the population lives on less than an equivalent of US$1.25 per day, and 57% on less than US$2.00 per day. The poverty level is still worse at the rural areas at 68% compared to 40% in the urban areas.
Economic growth has rebounded from an annual average of 5.9% from 2003-2006 to about 7% in 2007. In 2008 Real GDP grew by 6.3%, led by strong growth in tourism and the construction industry. The contribution of the different economic sectors to overall is shown in the Table 2.2.
These fluctuations are largely attributable to the effect of weather conditions on agricultural

output, but also due to variable growth in key sectors such as tourism, industry, re-exports, trading activities and construction in recent years.

2.4 ENERGY SITUATION

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 is limiting growth in productive sectors such as the agro-processing and manufacturing sectors.

The Gambia has some potential to tap renewable energy sources that are in widespread use in countries around the world such as solar, biomass, and geothermal. While most of these technologies show reasonable potential based on the limited information available, further detailed studies would be required to definitively determine the most economical solutions.

2.4.1. ENERGY CHALLENGE OF THE GAMBIA

The Gambian government recognises 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:

- Heavy reliance on imported petroleum products to meet the country's energy requirements, placing a heavy burden on the foreign exchange reserves;
- Limited investment in new assets and inadequate maintenance of old and ageing electricity power facilities;
- Growing population and rapidly growing demand for all forms of energy; and
- 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. Table 2 presents the evolution of the energy mix in The Gambia

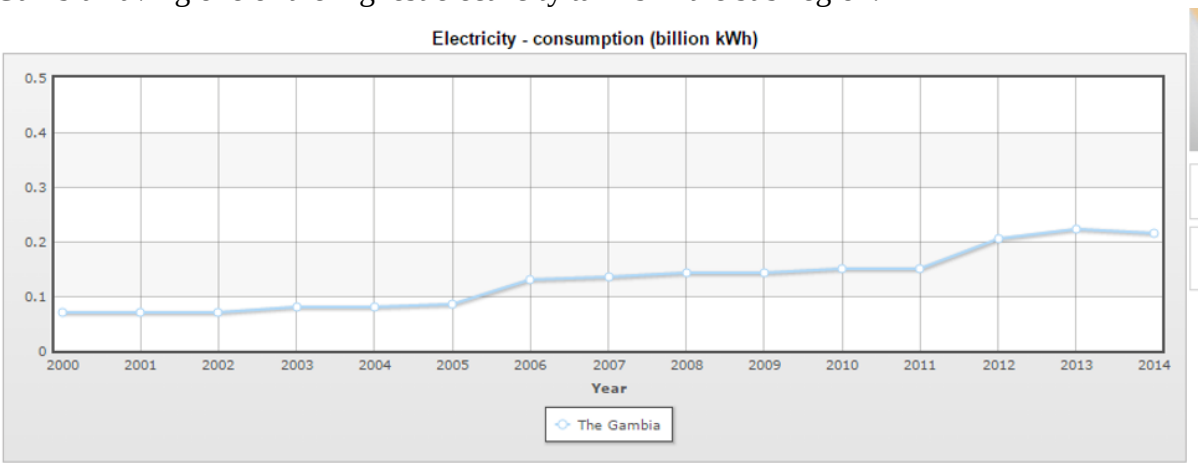
Table 2. : Evolution of the Energy Mix of The Gambia

YEAR	BIOMASS/ FUELWOOD	ELECTRICITY	PETROLEUM	LPG	RE	TOTAL
1996	295.940	4.190	72.160	1.160	0.070	373.530
1997	304.820	5.330	71.720	1.210	0.080	383.170
1998	313.960	6.160	76.980	1.260	0.090	398.460
1999	323.380	7.170	81.880	1.310	0.110	413.850
2000	333.090	6.850	86.890	1.360	0.110	428.300
2001	343.080	8.770	83.770	1.420	0.110	437.150
2002	353.370	9.900	83.100	1.470	0.121	447.960
2003	363.970	8.860	82.460	1.530	0.132	456.950
2004	374.890	7.170	84.730	1.590	0.133	468.510
2005	386.140	9.440	86.040	1.660	0.134	483.410
2006	397.720	10.370	95.880	1.720	0.134	505.830

Source: DoSEMR for Energy, 2008

2.4.1.1. Electricity Generation and Consumption

Electricity is produced using heavy fuel oil in the Greater Banjul Area and diesel oil for the provincial operations. All the fuel used in electricity production is imported at great cost to the economy. Not only is the foreign exchange involved a major issue, but the country is vulnerable to the price volatility of the oil prices. This amongst other factors leads to The Gambia having one of the highest electricity tariffs in the sub-region.



Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
The Gambia	0.07	0.07	0.07	0.08	0.08	0.08	0.13	0.13	0.14	0.14	0.15	0.15	0.2	0.22	0.21

Figure1. Electricity Consumption

Billion kwh

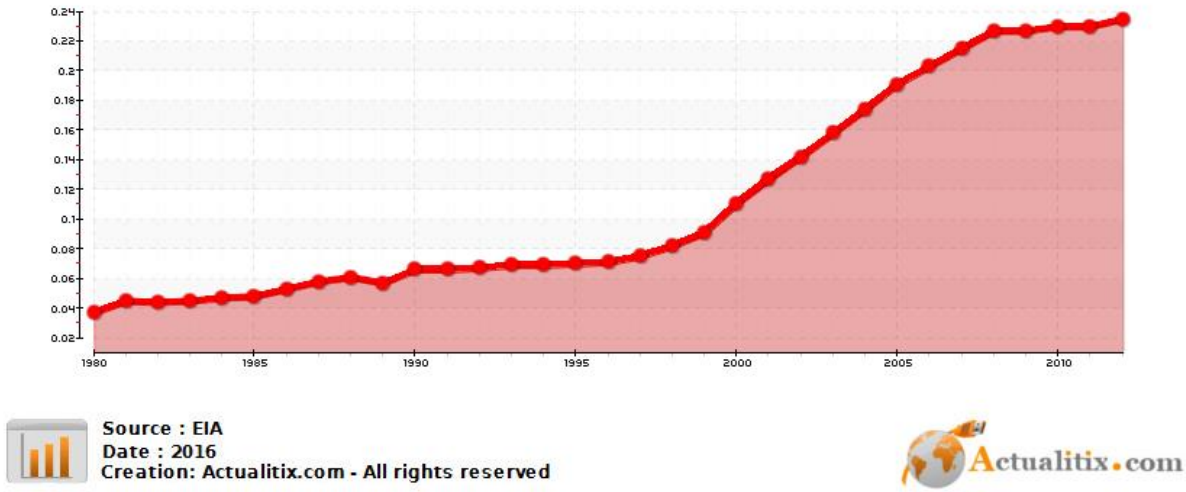


Figure 2. Electricity Consumption

Increse in electricity consumption is given in Fig.2 and Fig.3. Currently there are three major power plants in The Gambia, mostly in the Greater Banjul Area namely Kotu and Brikama (see Tables 3 and 4).
In Brikama, the National Water and Electricity Company (NAWEC) and an Independent Power Producer (Global Electric The overall availability of plants at Kotu in particular remains low due to mechanical breakdowns.

In 2001, only 73GWh of electricity was produced from the station whilst in 2010 the production rose to 104GWh. The only one Independent Power Producer (IPP) in The Gambia started operation in 2006. Its mode of electricity production is similar to the NAWEC Kotu power station that uses heavy fuel oil. Huge investments have also been made in electricity generation in the Provinces (see Table 5).

Table 3.: Installed Electricity Generation at Kotu, 2011

Power Station	Installed Capacity, MW
KPS-G1	3.0
KPS-G2	3.0
KPS-G3	3.4
KPS-G4	6.4
KPS-G6	6.4
KPS-G7	6.4
KPS-G8	6.4
KPS-G9	6.4
KPS-G11	0.0
BPS-Wartsila	9.0
Total	50.4

Source: NAWEC, 2012

Table 4. Installed Electricity Generation at Brikama

Power Station	Installed Capacity, MW
BRK-G1	6.4
BRK-G2	6.4
BRK-G3	6.4
BRK-G4	6.4
G5	0.0
G6	0.0
Total	25.6

Source: NAWEC, 2012

Table 5.: Installed Electricity Generation in the Provinces, 2010

Provincial Stations	Installed Capacity, kW
Barra	368
Kerewan	536
Kaur	145
Farafenni	1,400
Bansang	600
Basse	1,560
Total	4,249

Source: NAWEC, 2012

Figure.3.Gambia River

Unfortunately, the River Gambia (Figure 3,4)offers no potential for hydropower, and within the borders of The Gambia there is no drop in level of more than 10m from one end of the river to other.
However, the OMVG, the organisation for the exploitation of the river Gambia, proposed a regional energy project to construct a dam on the river in southern Senegal. The power would then be shared by all the member countries through high voltage transmission. Due to escalating costs and fragile political environments in many of the countries involved, the implementation of the project has been delayed for more than 30 years.

Figure 4. The Gambia River

The Gambia is entirely dependent on fossil fuel for electricity generation. The power network is principally owned and operated by the National Water and Electricity Company (NAWEC). The main power station at Kotu runs on heavy fuel oil (HFO) and in rural areas, NAWEC operates six small scale power systems served by stand-alone electricity subsystems in provincial centres. Given the volatility in petroleum prices, the government has recognized that developing new local and renewable resources is critical to meeting its economic objectives; and has therefore indicated its desire to promote renewable energy development by creating the necessary policy environment and legal framework.

Based on 2013 data, Gambia's national electrification rate reached 36%, (2% in rural areas, 60% in urban areas). Gambia has been working towards establishing solar energy, and they have high potential in the development of solar power and solar thermal technologies. The Gambia Renewable Energy Centre has been established, and their goals include promoting the use of renewable energy, advising the government on renewable energy techniques and carrying out adaptive research.
However, Gambia is facing quite a few financial constraints. Their constraints include high capital cost, high transaction cost, and lack of dedicated financing for renewable energy in the banking institutions. The financial resources necessary for Gambia to have electricity for the next three years is $112.5 million.

2.4.2. SOLAR ENERGY IN GAMBIA

The Gambia currently has small solar photovoltaic (PV) and solar thermal systems installed, most commonly at rural hospitals, schools and private residences. The average annual solar insolation for The Gambia is 4.5-5.3 kWh/m2-day, which represents a high generating potential for the country The cost of solar energy systems continues to be high; however, the recent adoption of solar energy systems in various countries globally has had a positive effect on driving down installed costs of new solar PV systems.

Figure 5.Solar Radiation in the Gambia (Source Flores 2010)

In the future, it is anticipated that such a system could offer a cost effective solution for the sustainable development of The Gambia. However, at this time, this technology should continue to be considered for smaller scale distributed applications as there appear to be other, more economical options available to The Gambia for large scale generation.

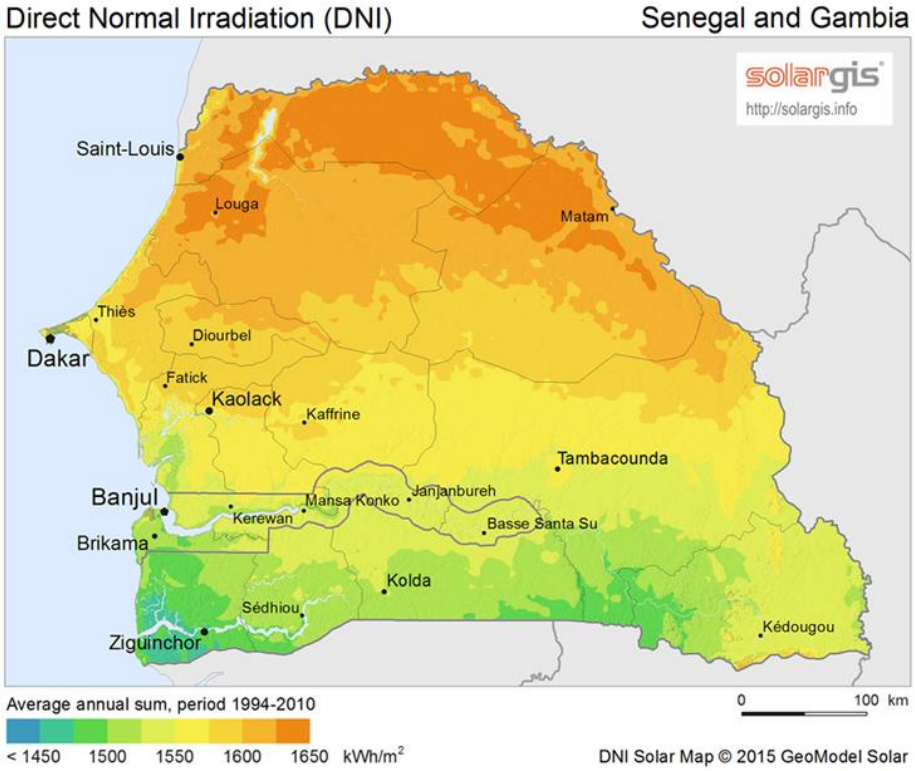


Figure 6.Direct Normai Irradiation in Senegal and Gambia

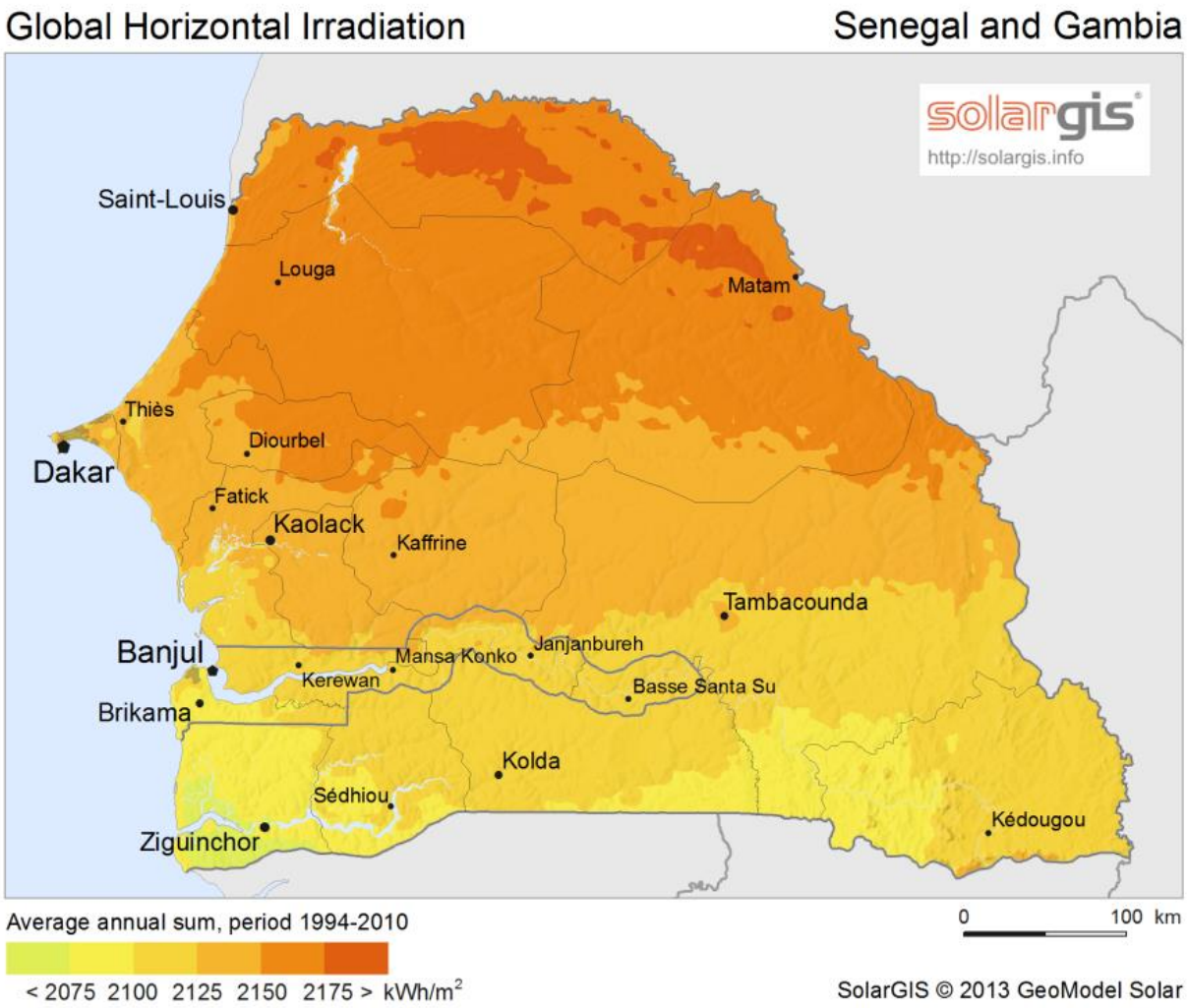


Figure 7 Global Horizontal Irradiation in Senegal and Gambia

As solar radiation reaches good values all over the country(Figure 6,7), several energy (electricity) supply possibilities can be explored. Preliminarily, PV Power Plants, Solar Home Systems (SHS) and Hybrid Diesel-PV Systems could be considered. The existing PV based energy generation projects (i.e. the European Union-sponsored solar PV pumping, SHS projects and PV-Diesel hybrid system in Darsilami) supports this consideration.
Although normal irradiance figures in The Gambia strongly support the present Solar Water Heating applications in the tourism industry, it is very difficult to envisage any solar thermal power generation plant, as an electricity supply option in the Renewable Energy Master Plan (REMP) forThe Gambia, due to the relatively small power capacity requirements in the country. At the present technology state of the art, the technical and economic viability of such Concentrated Solar Power (CSP) power plants are in the same or over range of installed capacity in the whole country (Flores, 2010).

Solar energy has had the most successful application of renewable energy in The Gambia and it has been used extensively since the early 1980s. Early uses included rural water supply and remote power for telecommunication facilities. Recently solar thermal is being used for water heating even at the industrial level. These solar thermal units range from tank and collector

systems for standards households to networks types with vast arrays of collectors connected to single tanks with mechanical pumping systems.

2.4.3. SOLAR POTENTIAL AND USE

The Gambia's geographical location gives it plenty of sunlight hours. The country receives 2,500 hours of sunshine yearly and the daily solar energy potential is an average 2.5 kJ per square centimetre area (2.5KJ/cm2). The government is encouraging use of alternative energy and the use of solar PV cells and associated equipment is on the rise be it for domestic, commercial or industrial use.

The use of alternative and renewable energy in the country is gaining recognition, especially the use of solar PV. This interest comprises both individuals and groups. However, the deterring factor in the widespread utilization of renewables is the initial cost of investment, which is beyond the reach of many Gambians.
Most solar PV and wind installations are donor funded. The cost of the systems is tied to foreign exchange fluctuation. A 55 Wp solar PV costs about D11,000 while a 75 Wp costs about D16,000. Whenever the Gambian Dalasi depreciates, the cost of systems will increase correspondingly.

The following companies are operating in solar energy sub-sector include Gam Solar, VM The Gambia Limited, SWEGAM, Dabakh Malick Energy Centre DMEC, Gambia Electrical Company, CHYBON Solar Systems, and SANFOSI Solar, Consultancy and Engineering Services.

Over the years, a lot of systems have been installed for applications such as water pumping, telecommunications, refrigeration, and community lighting under various projects including the CILSS Regional Solar Programme (RSP) funded by the European Development Fund (EDF). The companies also provide PV systems, imported from abroad, for domestic lighting.

2.4.3.1. Modern Energy for Productive Uses

Productive uses of energy involve the utilization of energy – both electric and non-electric energy in the form of heat or mechanical energy - for activities that enhance income and welfare. These activities are typically in the sectors of agriculture, rural enterprise, health and education. Examples of such activities include pumping water for agriculture, agro-processing, lighting, information and communications, and vaccine refrigeration. The promotion of the productive uses of energy is an important aspect in the design and implementation of rural energy projects. Initiatives on productive uses of energy in The Gambia include the installation of solar pumps.

2.4.3.2.Solar Powered Water Pumps

The promotion of solar-powered water pumps was initiated in the Gambia in the early 1980s at a bore hole in Jambanjaleh with funding from Saudi Arabia and German Technical Assistance. A second pilot plant was later installed in Mandinaba as part of a UNDP-funded project (World Bank Report, 1983). These pilot projects proved economically viable and

sustainable leading to their rollout throughout the country. Currently, there are over 200 solar powered water pump systems in the country (See Figure 8).

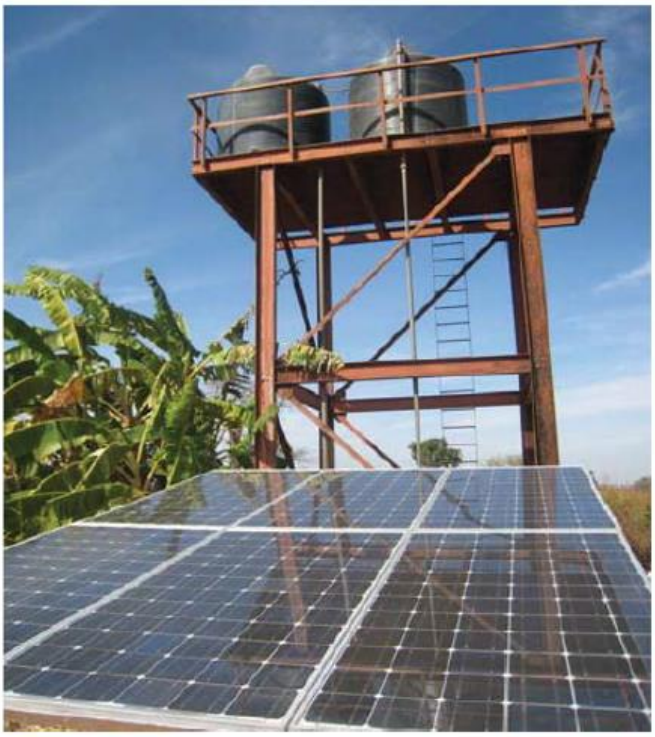


Figure 8. Solar Water Pumping Systemat Hospital at Bwiam,Foni Kansala District

3. INSTITUTIONAL AND POLICY FRAMEWORK IN ENERGY SECTOR

3.1. Key Institutions related to Energy

Until 2007, the power sector was controlled by NAWEC, a vertically-integrated monopoly that handled generation, transmission, and distribution of electricity in the country. In 2007, the Global Electric Group (GEG) was contracted by NAWEC to build, own, operate, and maintain one of the two power generation facilities in the greater Banjul area. This nearly doubled the available capacity in the country from approximately 31MW to 55MW. Discussions were held with several potential IPPs but GEG was the only one that didn't require sovereign or external guarantees, and therefore it was selected for the contract. Although this agreement set the precedent for the use of the independent Power producer (IPP) structure in The Gambia, no new power generation capacity has been added since, despite interest from other potential IPPs. As covered in detail later in the report, reasons for this include inadequate transmission and distribution (T&D) infrastructure, a financially unstable off-taker, and an ineffective regulator. Figure 9 outlines the organizational structure within the energy sector.

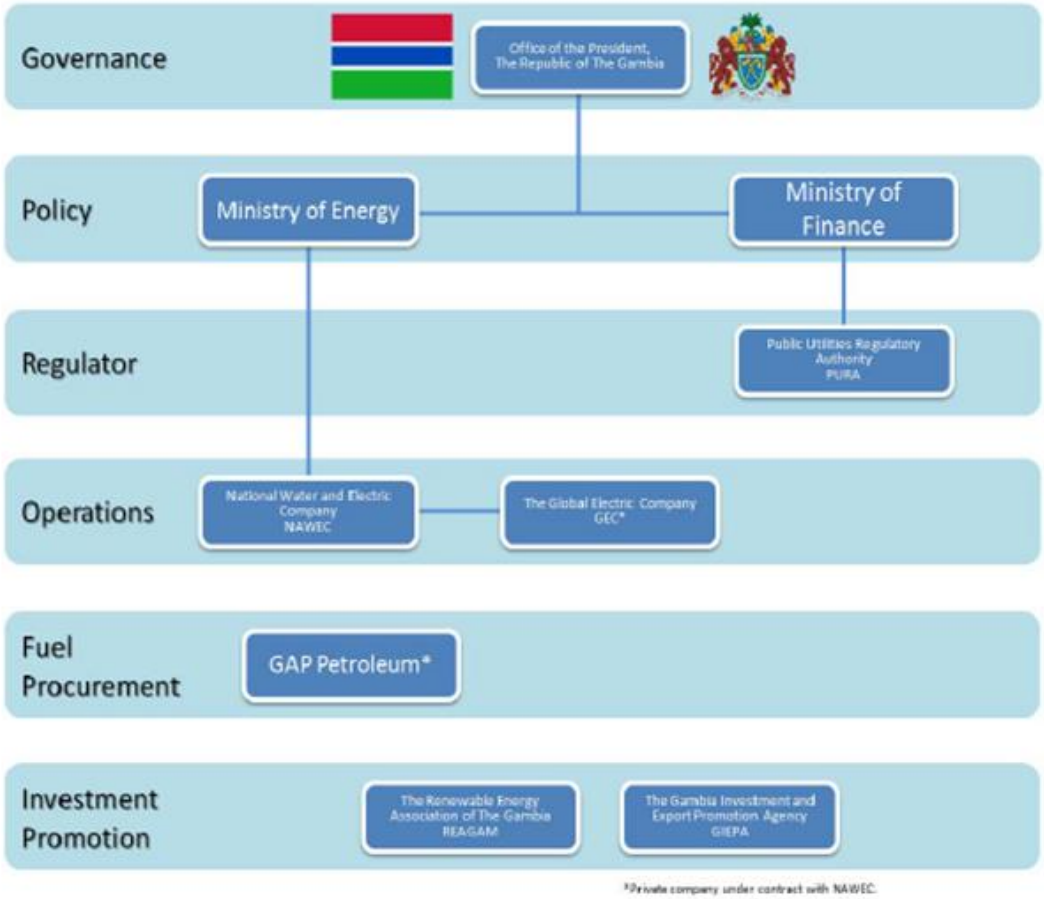


Figure.9. Gambia Energy Sector Organizational Structure

Descriptions of each institution relevant to the energy sector and their individual responsibilities along with relevant legislation are summarized in the sections below.

3.1.1. Office of the President, The Republic of The Gambia

The Office of the President receives the information from all of the ministries as they relate to each specific energy objective and ultimately has the final authority on the regulations, tariffs, and on contracting of any IPPs for the well being of the country.

3.1.2.Ministry of Energy

The Ministry of Energy oversees the entire operation of the energy sector for the country and provides support and assistance to National Water and Electric Company (NAWEC) and the Global Electrical Group Ltd (GEG) to provide recommendations on the institution of energy related tariffs to the President.

3.1.3. Ministry of Finance

The Ministry of Finance plays an important role in the energy sector, by which they receive the recommendations of PURA, evaluate the financial implications, and provide recommendations to the President.

3.1.4.National Water and Electric Company (NAWEC)

NAWEC is responsible for the operation and maintenance of one of the two power generation facilities in the greater Banjul area, the transmission and distribution of power within the country, and establishing and collecting the electric tariffs for all customer classes. NAWEC also establishes and administers Power Purchase Agreements (PPA) with the private power producers in the country.

NAWEC Gambia Ltd. (III)

NAWEC Gambia Ltd. is the country's main utilities supplier. It was incorporated in June, 1996 as a company limited by shares under the Companies Act of 1955. Its main Kotu Power Station is the principal generator serving the Greater Banjul Area in the Kanifing Municipality. Nawec is involved in the generation and provision of electricity, drinking water & sewerage services for domestic, industrial & commercial uses. The regulatory authority, PURA, has the mandate to regulate the electricity and water markets in the Gambia.

History:
The creation of Nawec can be followed back to the year 1972, when the Gambia Utilities Corporation Act created the GUC to supply and conserve electricity and water for the general public, industry and domestic households. GUC was formally dissolved in 1993 following a Presidential Executive Order.
The Management Services Gambia Ltd. (MSG) and the Utilities Holding Corporation (UHC) were asked to take over the functions of GUC. Under the new agreement the responsibility of managing the asset's profitability was given UHC while MSG (owned by a French company, SOGEA) was awarded the operating lease. MSG's lease was ended by the Government on the 23 February, 1995 thereby leaving the management of assets and operations to UHC. In June 1996 MSG and UHC had amalgamated to form the NAWEC we know today.

Ownership:
It has an authorized share capital of D500 million (50 million shares valued at D10 per share). The government currently owns 92.7% of the fully paid shares, SSHFC 5.8% and GPA 1.5%. The intention was for NAWEC to be owned 97% by government. Once the shareholders pay the original designated amounts the percentage shareholding will be as originally contemplated.

Private Involvement:

Potential Divestiture Strategies:-
Public / Private Partnerships (PPPs)
Independent Power Producers (IPPs)
Privatize billing & other support services

In 2006 the Electricity Law was passed that has opened up the generation component of the electricity sector to private investors and an Independent Power Project (IPP) of 23MW capacity was expected to begin power generation in July / August 2006. The law also allows for private sector participation in the distribution of electricity. In October, 2006 the Gambia Government announced that it had signed a 5-year contract, its first Power Purchase Agreement (PPA), on on Friday 28th September, 2006, with Global Management System,

and Independent Power Provider, to take over electricity generation only from Nawec. The director of GMS is Muhammad Bazzi.

Operational Problems:

As a public enterprise, it was not operating on a commercial basis and couldn't generate sufficient financial revenues to maintain and upgrade the systems & infrastructure.

Supplying electricity on a commercial basis is marked by a number of problems. These include under-investment, an inflexible tariff system, rising fuel prices, distribution and transmission losses and non-payment of large bill arrears particularly by large commercial & industrial consumers. As a result, the company has huge difficulties in meeting its operating costs, investing in generation capacity expansion and replacing obsolete equipment. Despite the fact that NAWEC has managed to achieve financial sustainability for its normal operations, it has limited resources to properly expand the electricity system. As a result the system is not robust enough to meet the growing demand and requires significant investment to operate efficiently.

Local Generating Capacity:

In the rural areas, NAWEC is operating 6 small scale power systems served by stand-alone electricity subsystems in the provincial centres of Bansang (420KW), Janjanbureh (270KW), Kerewan (142KW), Basse (640KW), Farafenni (400KW), Mansakonko (400KW). Juffureh and Kamuna are smaller stations that serve NAWEC's water reticulation systems in their respective areas.

The total installed capacity is 2.272 MW at these power stations and is often less than the total instantaneous demand, whose peak is estimated to be about 2.8 MW in 1999. These power stations operate on diesel generator sets that feed into isolated medium and low voltage networks which when available, supply electricity for 12 - 15 hours a day. These systems lack sufficient installed capacity. These centres are also not self-sustaining in terms of revenue and depend on subsidy revenues generated in the Greater Banjul Area (GBA).

Besides only serving a small customer base of 2,640 customers, the provincial power stations provide the essential electricity supply for the water reticulation systems in Farafenni, Basse, Bansang, Mansakonko, Jangjanbureh, and Kerewan. At present, a Rural Electrification Project is underway and has entered its final phase.

Legal Framework & Sector Policy:

- Draft Energy Policy
- Electricity Law Enacted

Electrical Distribution Structure:

In Gambia electrical power is by thermal transmission and is transmitted for distribution via 5 radial 11-kilo volt (kv) feeders and three 33 kv feeders that form a ring in the GBA. The 33 kv feeders feed medium voltage substations where the voltages are transformed to 11 kv for distribution.

NAWEC'S generating capacity is located in one major power station on land in Kotu in the Greater Banjul and stand alone stations in the provincial towns.

The current maximum available capacity at Kotu Power Station is 25.3 MW at peak load times. Most of the generators at Kotu use Heavy Fuel Oil (HFO), which is contributing to foreign exchange difficulties in meeting the country's import needs and the negative environment impacts from the emission of greenhouse gases.

The provincial generators are run on diesel fuel. The provincial inland energy networks are not connected to the Kotu transmission system. By end of 2005, NAWEC had a total customer base of 54,976 in 990 zones grouped into 6 categories.

Water Provision:

NAWEC is also responsible for the supply and conservation of potable water. Its activities are largely confined in the GBA and the ten Provincial Growth Centres. Water in the GBA is obtained from the underground water table. In the 5 administrative regions, potable water service delivery is as the need arises, and is provided by numerous bodies using various techniques. The Area Councils have legal responsibility for water supply but resource limitations and technical capacity means that services are primarily delivered through specific donor funded projects and UN funded projects.

In 2005 12,689 cubic metres of water was sold representing a negative growth rate of - 6.26. The drop in sales could either be attributed to losses in the reticulation system or illegal connections. In the same year D89,378,992.78 was collected in revenues. The following table shows the various well fields and the number of boreholes in each well field.

Sewage:

The only sewerage systems in The Gambia can be found in the capital at Banjul, and few hotels in the Kanifing Municipality (KMC). Banjul has about 3,000 customers and total turnover in 2005 was D4 million. The sewage service delivery system is heavily subsidised by the other divisions of NAWEC, such as electricity, since its revenues cannot cover its operational running costs.

3.1.5 Global Electrical Group Ltd (GEG)

GEG, an independent power producer and subsidiary of Global Trading Group N.V. (GTG), is contracted by NAWEC to build, own, operate and maintain one of the two power generation facilities in the greater Banjul area. GEG does not provide any transmission or distribution infrastructure or services for the power that they generate, nor do they establish or collect any electrical tariffs from any customers. GEG's PPA is a must-run, take-or-pay contract with fuel price adjustments. More details on the PPA are provided under the Cost of Power subheading in section below.

3.1..6 GAMPetroleum (GAP)

GAP Petroleum, an affiliate of GEG, is responsible for the contracting, storage and delivery of the majority of the country's fuel supply. Conversations held during the mission indicated that GAP is in some way affiliated with GEG and GTG, however the exact relationship was not

clear. No evidence was observed that indicated that the fuel sale transactions between GAP and GEG were anything other than arms-length transactions, although the fuel sale agreement was not made available to the team. In May 2008, GAP completed construction of a new fuel storage facility.
This facility, capable of storing 51,000 metric tonnes of HFO, LFO, and LPG, provides approximately 6 months worth of storage for the three fuel types. Indications from the mission are that the investment made by GAP to establish the fuel storage facility has effectively made them a monopoly supplier of HFO and LFO in the country (including to NAWEC).

3.1.7 Public Utilities Regulatory Authority (PURA)

The Public Utilities Regulatory Authority was created by The Gambia Public Utilities Regulatory Authority Act of 2001 and is the authority which regulates the activities of the country's public utility sectors (electricity, water and telecommunications). The functions of PURA as called out in the Act include:

- Provide guidelines on rates and fees for the provision of regulated public services;
- Examine rates and fees chargeable for the provision of regulated public services;
- Protect the interest of consumers and of public utilities;
- Monitor and enforce standards of performance by public utilities;
- Initiate and conduct investigations into standards of services by public utilities;
- Promote fair competition among public utilities;
- Conduct studies relating to economies and efficiency in the provision of regulated public services to consumers;
- Collect and compile data on regulated public services and their provision necessary for the performance of the Authority's functions;
- Provide advice in respect of regulated public services and their provision;
- Maintain a register of public utilities and the services they provide;

Publish, in such manner as it considers appropriate, information relating to the Authority's functions and activities;

- Recommend and administer, in accordance with the Act, a licensing system in respect of public utilities;
- Provide advice or assistance to a public utility to assist or enable the utility to comply with a requirement of the Act or of any license;
- Prepare any relevant documentation necessary to give the Authority the power to regulate public utilities in accordance with the Act; and
- Perform such other functions as may be imposed on it by any other legislation.

With respect to the independence of PURA the Act states that "The Authority shall not be subject to the direction or control of any person or authority in the performance of its functions or exercise of its powers under this Act and shall act in all matters and at all times impartially". The Act also states that "The Authority may, with approval of the appropriate person [Secretary of State], suspend or cancel a license if it is satisfied that the public utility is not complying with or has not complied with any provision, term or condition of the license". Therefore, PURA has the authority to suspend licenses, but only with the approval of the Secretary of State responsible for the energy sector. While the Act also discusses fines to be levied on non-compliant utilities, the language used is somewhat ambiguous. The Act states that if a public utility fails to provide information to PURA or provides false information, it "commits an

offence and is liable on conviction to a fine". This implies that the court system would have to convict the utility in order for fines to be levied.
PURA's important role in setting electricity tariffs was further refined by the Electricity Bill of 2005. as detailed below.

3.1.8 Renewable Energy Association of The Gambia (REAGAM)

REAGAM is a non-profit cooperation of approximately 17 to 19 private and public companies and individuals active in the promotion of renewable energy projects such as small solar PV installations, solar thermal, micro hydro, cooking stove improvements, and the expansion of jathropa growth for oil production in The Gambia.

3.1.9 The Gambia Investment and Export Promotion Agency (GIEPA)

GIEPA, created by The Gambia Investment and Export Promotion Agency Act of 2010[1], serves the primary functions detailed below:

- Promote investment in The Gambia by projecting its image as an investor friendly country;
- Conduct investment missions to attract investors to The Gambia;
- Facilitate the securing of investment incentives by investors;
- Provide investors with the necessary information to apply for incentives;
- Undertake the analysis of applications for incentives, for location in an export processing zone or to become an export processing zone operator;
- Collect data on investment, particularly investments that have received incentives;
- Monitor the performance of investors in respect of their obligations as set out in their investment proposals, or special investment certificate and take appropriate action in the event of a violation;

Formulate and implement investment export and enterprise development guidelines and investment promotion strategies;

- Promote and facilitate the development of micro, small and medium enterprises;
- Register and keep a record of all investment enterprises;
- Undertake trade and sector studies. Including market surveys, with a view to identifying investment opportunities;
- Advise Government on investment, export and industrial policy and related matters; and
- Do any other act which may be incidental or conducive to the attainment of the objectives of the Agency or the exercise of its powers under this Act.

3.1.10 Other Institutions

The **Department of Forestry** plays a leading role in the fuelwood sector both in terms of policy formulation and regulation. For example, vehicles importing charcoal pay a levy per bag of charcoal once they enter The Gambia and are subject to inspection by the Forestry Department staff. The Department is also very active in promoting community forestry as a sustainable way to exploit forest resources not only for fuelwood but also for other products such as honey.

[1] Replacing *The Gambia Investment Promotion and Free Zones Agency* (GIPFZA) created by the Gambia Investment Promotion Act of 2001

The **Department of Community Development**is under the Ministry of Local Government and Lands,. The department promotes the efficient management of fuel wood resources through the promotion of substitutes, and improved end-use appliances, such as improved cooking stoves and biogas research.The Department has two regional facilities in Mansakonko and Brikama.

The **National Environment Agency (NEA)** is tasked with the formation, implementation, monitoring of compliance with environment standards.

3.2 ENERGY POLICY AND OTHER RELATED POLICIES AND LAWS

3.2.1 The Energy Policy

The Gambia's Energy Policy, 2005 was approved by the Secretary of State in June 2005. The policy sets out the objectives for the Government for the energy sector and also the aims for the renewable energy sub-sector. The main aims of the electricity sub-sector are to:

- Ensure that there is an adequate, efficient and affordable electricity supply to support socio-economic development in an environmentally-sustainable way;
- Improve the reliability and security of power supply as well as enhance power sector efficiency;
- Promote the long-term sustainability of power sector operations by encouraging more private sector participation in power supply.

The specific development objectives with respect to electricity are to:

- Improve and expand generating, transmission and distribution capacity to improve the reliability and quality of electricity services and cater for load growth;
- Reduce the cost of electricity;
- Encourage investment in rural power supply;
- Encourage the use of alternative and efficient technologies and fuels for electricity.

The aim for the Renewable Energy sub-sector is to ensure the promotion and utilisation of renewable energy in support of sustainable development in the country. The specific objectives are:

- Promote the utilisation of renewable forms of energy such as solar, wind and bio-mass;
- Promote the use and develop, to the extent possible, a domestic production capacity fo renewable energy fuels and technologies;
- Ensure the sustainable supply of renewable energy fuels/device/technologies at competitive prices through private sector participation.

3.2.2.Electricity Act, 2005

The Electricity Act was enacted in 2005 to promote the development of the electricity sub-sector in The Gambia, to encourage private investment in the sector, promote competition, set out the responsibilities for policy and regulation and to regulate electricity service providers. The Act sets out, inter alia, the objectives, licences and licensing procedures, tariff principles and accounting standards for the electricity sub-sector. The objectives of this Act are to -

- promote the generation, transmission, supply, dispatch and distribution of electricity inThe Gambia;
- set standards relative to electricity services;
- promote electricity efficiency and supplies;
- ensure sufficient and reliable electricity supplies for the population and the economy of The Gambia at just and reasonable rates;
- establish cost-effective and reliable electricity supplies for all classes of consumers;
- effect a transition to a private investor controlled and operated electricity sector in which, through competition, where feasible, and regulation in non-competitive markets, prices accurately reflect the costs of efficient production, transmission, dispatch, and distribution of electricity;
- establish a framework for the regulation of the electric sector;
- assign responsibility for overall policy development in the electric sector to the Department of State and relieve the Department of State from regulatory Responsibilities in the electricity sub-sector;
- encourage private sector investments in electric sector activities;
- encourage domestic and foreign private capital participation in the electric sector;
- promote competition in the electricity market; and
- encourage the production of electricity through the use of renewable energy.

3.2.3. Public Regulatory Authority Act, 2001

This Act established the Gambia Public Utilities Regulatory Authority (PURA) as the body responsible for the regulation of public utilities including energy services (electricity, petroleum and gas). The Act provides for the licensing arrangements to be administered by PURA. However the power to issue licences (for generation, distribution and transmission of electricity) is vested with the Minister for Energy. The licensing arrangement allows PURA the power to protect the interests of the public utility and of the consumer. The intention is that PURA will become self-funding and be seen as completely independent.

3.2.4. Draft Energy Strategy and Energy Action Plan, 2010

The Ministry of Energy is publishing an Energy Action Plan for the period 2010-2014. The Energy Action Plan has nine key objectives for the next four years, in line with the objectives of the Energy

Policy. These are set out below; for each objective there are clear strategies and a number of related activities set against targets and budgets:

- Increase electricity generation, transmission and distribution capacities;
- Improve access to electricity and safe drinking water;
- Provide affordable electricity and water;
- Improve national security through street lighting projects;
- Promote the use of renewable energy and energy efficiency;
- To regulate the downstream petroleum sub sector;
- To encourage the re-exportation of petroleum products to neighbouring countries;
- Strengthen the institutional framework; and
- To popularize the use of LPG by making the price affordable.

3.2.4.1.Gambia Investment and Export Promotion Agency (GIEPA) Act 2010

The Act establishes the Gambia Investment and Export Promotion Agency (GIEPA) to among others:

- Promote investments in The Gambia by promoting its image as an investor friendly country;
- Facilitate the securing of investment incentives by investors;
- Undertake analysis of applications for incentives, location of export processing zones or export processing zones operators;
- Monitor the performance of investors in respect of their obligations as set out in their investment proposal, special investment certificate and take appropriate action in the event of violation;
- Formulate and implement investment, export and enterprise development guidelines and investment promotion strategies;
- Promote and facilitate the development of micro, small and medium scale enterprises;
- Undertake trade and sector studies including market surveys, with a view to identifying investment opportunities; and
- Advise government on investment, export and industrial policy and related matters.

The Act in addition to guaranteeing the rights and obligations of investors also provides for incentives for various categories of investment and priority investment defined either by sector or geographic location. Also specified in the Act are incentives for export promotion including the establishment of export processing zones, and support to micro, small and medium scale enterprises

3.3. STRATEGIES AND PLANS

3.3.1. Universal Access to Electricity

Over the last ten years access to electricity by the general population has increased significantly especially for the urban population. In 2000, the number of residential customers connected to the public utility company's networks was about 36,000 customers, but this has increased to just under 100,000 in 2011. Figure 10 shows the long term electricity generation in The Gambia. It is very clear that over the last five years electricity generation has risen sharply due to rapid urban development. However, this figure represents only the supply side as full demand is still unmet.

In 2000, only 111 GWh of electricity was generated, but in 2010 this figure more than doubled to 234 GWh. The Government has made a strong commitment to expand both rural (provincial) and urban electrification. Since 1994, more than 50MW of new generation capacity has been added, which has improved the power supply significantly. However, this must be reviewed within the context of increasing demand. NAWEC estimates that the annual growth of electricity demand in The Gambia is 6 MW.

In 2001, the electrification rate of the City of Banjul was estimated to be about 70% and 20% for the entire country (National Energy Policy, 2005). The national electrification rate in 2010 was estimated be 40%. The residential sector has seen the highest growth in terms of electricity consumption (see Figure 11). The overwhelming acceptance of prepayment meters has contributed to the strong demand for the electricity sector. Another factor for the increased

demand is the government policy to reduce the cost of electricity meters by 50% for provincial consumers in 2009 from D6000 (US$200) to D3000 (US$100). Furthermore, low income households were granted a relief with the introduction of a lifeline tariff where the first 40kWh consumed was charged at a subsidized rate of D2.02 (US$0.07/kWh).

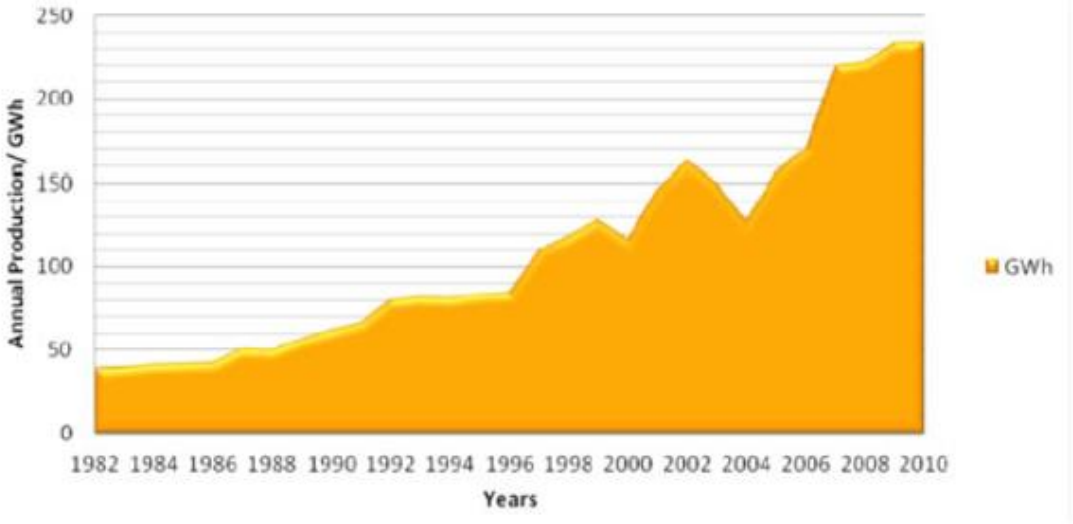


Figure 10: Historic Generation of Electricity in The Gambia (MOE/PURA)

Recently NAWEC has embarked on the expansion of the grid infrastructure and a medium voltage transmission line (33kV) has been extended 120 km to the end of the western region. This will inevitably increase access to the majority of the population in the GBA (see Table 6). Figure 12 shows the Electricity Grid Infrastructure in The Gambia.

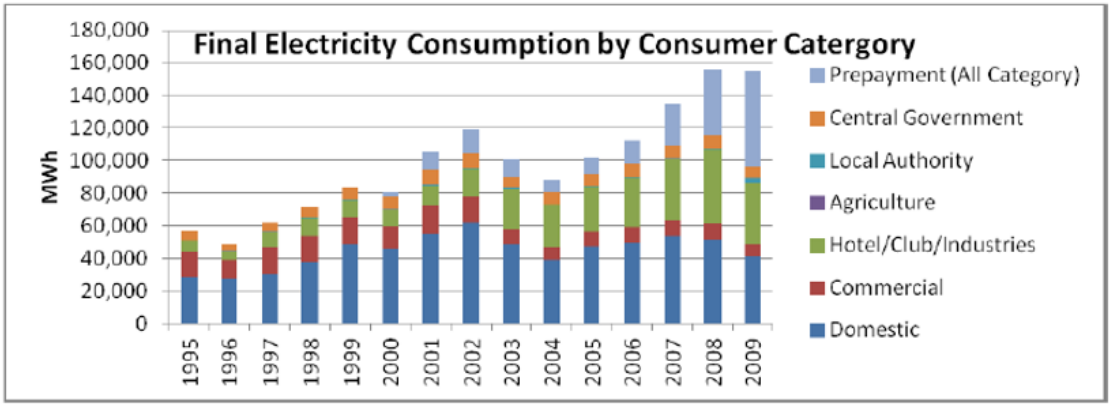


Figure 11. Final Electricity Consumption in the Gambia by Consumer Category

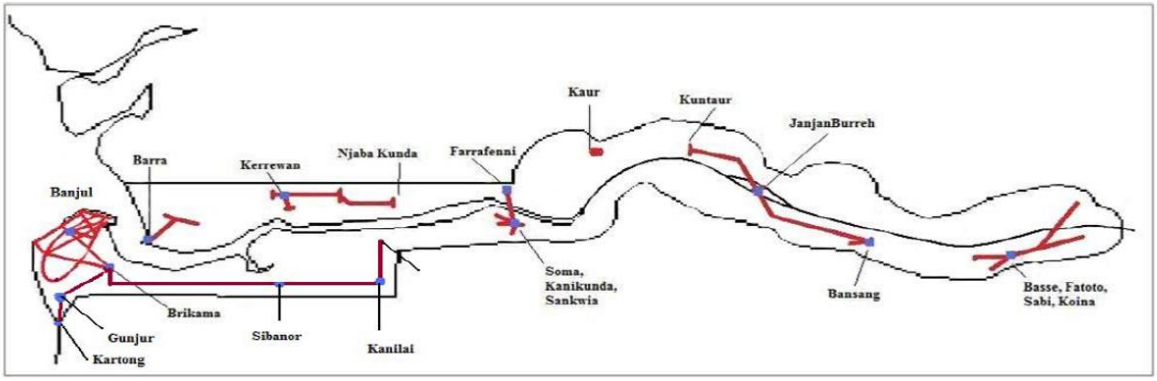


Figure 12. Electricity Grid Infrastructure in The Gambia

Table 6. Rate of Access to Electricity by Local Government Area

Region	Electrification Rate
Banjul	93%
Western	22%
UpperRiver	14%
LowerRiver	12%
CentralRiver	7%
North Bank Region	6%

Source: Ministry of Energy, 2011

Table 7.Electricity Tariff in the Gambia, 2011

Customer Category	Consumption Band	Current Tariff / D/kWh	Current Tariff / US $/kWh
Domestic	0 - 40 kWh	2.24	0.07
	41 - 600 kWh	7.20	0.24
	601 -1000 kWh	7.75	0.26
	balance	8.40	0.28
Commercial	Flat Rate	8.60	0.29
Hotel / Club / Industries	Flat Rate	8.95	0.30
Agriculture	Flat Rate	8.00	0.27
Area Councils	Flat Rate	8.70	0.29
Central Government	Flat Rate	8.70	0.29
Prepayment Domestic	Flat Rate	7.20	0.24

Source: NAWEC, 2011

In spite of the lifeline tariff for low income households, affordability of electricity remains a highly sensitive issue. Regional benchmarking shows that electricity in The Gambia is very expensive for both residential and commercial consumers. Table 7 shows the tariffs for the various categories of consumers. Table 8 below compares the tariffs in The Gambia with some of its West African neighbours. As shown in the table, The Gambia has the highest tariff as a percentage of per capita GDP even after the two recent reductions.

Table 8.Comparision of Tarrif Affordability in Select West African Countries

	Effective Residential Tariff (US cents) @ 100 kWh/month Usage[2]	2009 Monthly Per Capita GDP ($US)[3]	% of Monthly Per Capita GDP Spent on 100 kWh of Electricity
The Gambia[1]	21.2	98	21.7%
Senegal	23.8	139	17.2%
Burkina Faso	20.0	103	19.5%
Cote d' Ivoire	11.9	134	8.9%
Ghana	8.2	128	6.4%

1: Information provided during the mission to The Gambia (no two-part tariff fixed charge was included as information provided did not suggest the presence of one)

2: Source: Power Tariffs: Caught between cost recovery and affordability - World Bank

3: Source: OECD database - http://stats.oecd.org/

Affordability and reliability of electricity also remains the biggest challenge for industry consumers. Consultation with the Manufacturers' Association as well as the Hotels' Association highlighted the fact that the cost of energy severely limits their business growth and competitiveness. In both the manufacturing and tourism sectors, the cost of electricity was reported as high as 30% and 35% of total operating cost, respectively. Figure 13 gives a graphical presentation of the Power Sector Planning and Expansion Strategy of The Gambia, with the aim of addressing some of the challenges of the sector.

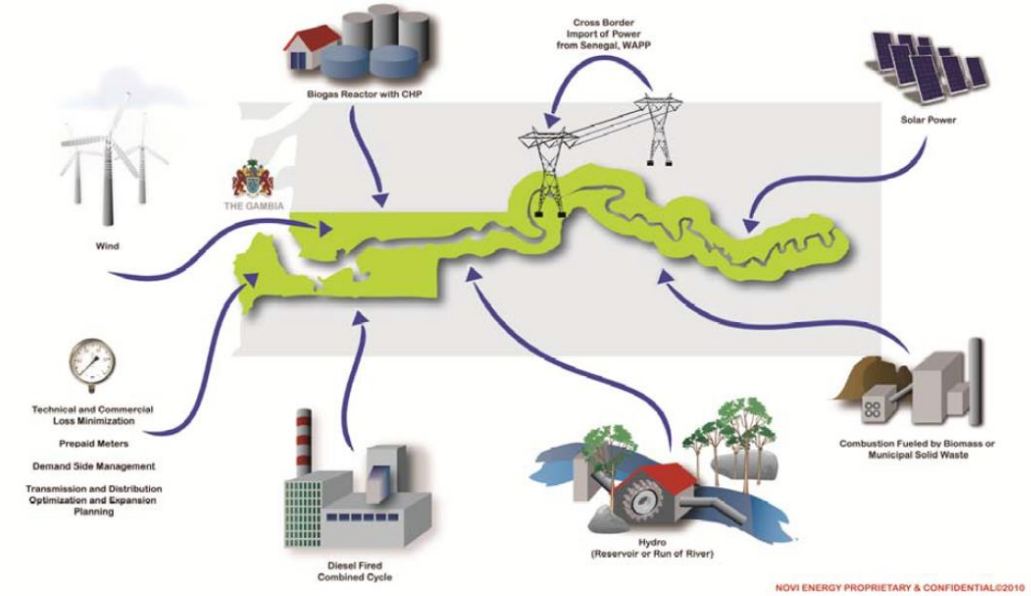


Figure 13. Power Sector Planning and Expansion Strategy of The Gambia
Source: World Bank, 2010

Over the longer term, The Gambia has an opportunity to enhance and diversify power supplies by tapping into the West Africa Power Pool (WAPP). Ongoing planning by the WAPP includes hydro power projects expected to be developed in member countries of the Gambia River Basin Development Organization (OMVG) that include Guinea, Guinea Bissau, Mali and Senegal, in addition to the Gambia. Under the WAPP, preparations are currently underway for the development of a power systems development subprogram that would link the networks of The Gambia, Guinea, Guinea Bissau, Mali and Senegal with a 225 kV transmission line of 1674 km length interconnecting the five countries (Gambia portion would be 183km). Two hydropower generation projects are integrated with the transmission line project under consideration:
128 MW hydropower project at Sambangalou; and 240 MW hydropower project at Kaleta. Given the large size of the overall projects, and considering the need to mobilize resources and build capacity over time, OMVG is considering a phased implementation of the project, starting with the Kaleta hydropower plant (240 MW) and 1151 km transmission lines connecting the five OMVG members.
The Gambia should begin planning for this first phase while preparatory and fund-raising activities continue to implement the second phase which includes the Sambangalou power plant and closing of the transmission loop. The first phase is expected to be completed by 2016.
The main objective of the OMVG subprogram is the regional management of water resources in order to develop power generation, irrigation and navigation; and cooperation amongst the counties in sectors including transport, agriculture, environment and energy. The five OMVG member states belong to the isolated Zone B countries. Of these five OMVG member states only Senegal is currently connected to the WAPP grid through the OMVS network, and has a sizeable power sector, with a total installed generation capacity of 514 MW. The installed generation capacity in the four remaining countries combined is about 300 MW. The OMVG sub-region (particularly Guinea) has abundant hydro resources that are considered suitable for power generation, but have not been exploited yet. Studies estimate that Guinea's hydro-generation potential (technically and economically feasible) could reach 6,000MW.
Regional cooperation under the OMVG/WAPP can help Guinea to unlock this potential, with benefits for the whole subregion, including The Gambia which currently relies heavily on imported oil for power generation, and is looking for opportunities to diversify electricity supply mix towards cleaner energy sources.
There are several steps The Gambia can undertake to prepare for the interconnection including: initiating the planning of the distribution network needed to absorb their share of energy; a technical grid synchronization and integration study; and capacity building measures to understand the operations of a high voltage transmission system.

3.3.2. Gap Analysis

The power sector is characterized by a number of strengths which provide opportunities for the realization of the goal of universal access to electricity. The strengths of the power sector include the following:

- The Government's strong commitment to expand the electricity network to many communities in The Gambia;
- Willingness of private sector(investors) to partner with government to provide electricity services;
- Examples of connectivity within the sub-region to learn from;
- Availability of market (domestic and commercial) for the electricity that could be produced in future

- The power sub-sector also faces a number challenges in achieving the stated goal of ensuring wider access to electricity in The Gambia.

The sector is challenged by:

- Inadequacy of the transmission and distribution (T&D) network;
- Lack of fuel diversityas well as high cost and irregular supply of fuel for electricity generation;

Operational inefficiencies in the key utility companyNAWEC resulting in transmission and distribution losses;

- NAWEC's poor financial performance;
- Weak regulatory and enforcement capacity;
- Poor reliability of electricity supply from the grid;
- Limited hours of supply of power by stand-alone generators in the rural areas; and
- High electricity tariffs and non-affordability of electricity.

Recommended strategies to address these challenges include:

Short Term

- Perform detailed transmission and distribution infrastructure analysis to reduce technical transmission and distribution losses, analyze potential interconnections with Senegal, integration into the West Africa Power Pool, and generate a comprehensive T&D master plan;
- Improve financial performance of NAWEC;
- Employ financial advisory services organization to investigate strategies for fuel price volatility reduction;
- Arrange payment of past-due bills by Central and Local Governments;
- Increase use of pre-paid metering. Require that government facilities and electric loads, including street lights, utilize pre-paid meters;
- Amnesty offer to domestic and commercial customers with past-due bills and unbilled use of energy followed by aggressive pursuit of payment with Government assistance;
- Enhance maintenance plans for generation facilities to improve availability;
- Assess the investment incentive structure to determine if incentives are sufficient to attract private investors;
- Perform detailed renewable energy study for potential domestic sources of power generation;
- Conduct a review of PURA's capabilities and independence including the government,regulators, utility, and IPP to address empowerment of PURA and improvement of the industry;
- Implement demand side management initiatives such as promotion of compact fluorescent lamps (vs. incandescent), energy efficient appliances, energy efficient motors for industrials, and peak shaving tariff structures; and
- Investigate feasibility of upgrading generation facilities to combined cycle operation.

Medium/Long Term

- Solicit financing (using results of incentive review) to implement the actions recommended in the transmission and distribution infrastructure analysis;

- Improve financial performance of NAWEC;
- Adjust tariffs to reflect new, more stable cost structure and incorporate fuel charge adjustment on customer bills;
- Identify the most promising renewable energy projects and provide incentives (based on results of short-term incentive review) to attract private financing; and
- Revisit increased privatization and a less vertically integrated industry structure after the above issues have been addressed

3.3.3. Planned Programmes on Renewable Energy

To support the government on energy source diversity, institutions such as the Gambia Renewable Energy Center (GREC) and REAGAM have been established to research, develop, and promote the various renewable energy technologies in an effort to harness the full potential of renewable energy in The Gambia.
The Ministry of Energy as part of their Strategy Plan has identified the promotion of the use of renewable energy and energy efficiency as two of their objectives. The Ministry has indicated that there are three strategies that need to be targeted in order to improve the implementation of renewable energy generation: 1) The development of legal and regulatory framework as it relates to renewable energy and energy efficiency; 2) increasing the usage of Solar PV and Wind turbines for electrical generation; and 3) the inception of incentives for independent investors in renewable energy.

The Ministry has provided a plan that identifies the usage of Solar PV and Wind turbines as priorities, and they have allocated the largest amount of investment to address this program. Although, the Ministry's Action Plan did not provide information to support the basis for these allocations, the Ministry did receive a two-phased study from the African Development Bank that may have guided their decision. The first phase of the study was to screen the renewable sources of energy and evaluate the potential, technical feasibility, and environmental benefits for The Gambia (28). The Government of The Gambia then decided that further feasibility studies be conducted to focus on two projects:

- Small Scale Wind Park – A small wind farm (4MW) near the city of Brufut; and
- Solar Home System Program – Development of Solar Home Systems (SHS) for rural households and other PV systems for schools, medical clinics and telecommunication centres.

The Small Scale Wind Park is a proposal that would be the first wind park project in the country. The project included the installation of medium sized (600kW) proven wind turbine types in the town of Tujereng. The wind park was proposed as a two phase project with the installation of three turbine units during each phase. The feasibility study included the use of new and re-powered wind turbines to demonstrate the influence on project economics.

The Solar Home System Program was recommended to the Government as an energy supply option for remote communities or small villages where connection to the transmission and distribution network are not feasible. The SHS Program included the installation of approximately 10,200 SHS and PV systems for rural clinics (30 systems), schools (54 systems), and in community centers for telecommunications (18 systems). The proposal on the program

noted that the SHS program is very expensive in terms of generation costs over the project's lifetime but it was more economical than conventional power generation solutions that would require transmission and distribution network extension.Both studies have provided the appropriate amount of information for the Government to make a determination on whether to proceed with projects. However, neither of the projects hasbeen pursued yet by the Government.
Targeting The Gambia's potential for renewable generation and evaluating the economic viability of the various technologies should help improve the country's self-sufficiency and ability to meet the increasing power demand.

4.CHINA & GAMBIA PRE AGREEMENT ON ENERGY PRODUCTION

Gambia's Ministry of Petroleum and Energy and Sinohydro, a state-owned Chinese company, have agreed on energy production that will enhance better and affordable electricity supply across Gambia in 23 March 2016.

Officials from both sides were on negotiations on how to increase energy production in the West African nation which continues to suffer from energy supply shortages.

After the meeting lasted three days , Sinohydro's Africa vice president Liu Xiaomin statetd that

"The discussion was fruitful and it will help Gambia a lot to improve on our energy sector, to boost power production in Gambia by consummating a 50 megawatt generation plant to replace the country's aging power generation capacity; install a 132KV (kilovolt) power transmission backbone line; and reinforcement of 33 KV transmission systems in the Greater Banjul Area of The Gambia", according to the officials at the meeting.

"When we fully finalised the deal, the project will greatly enhance the country's ability to produce electricity for Gambians," said Momodou Njie, permanent secretary at the ministry said."Our objective is squarely to meet the short and medium term power needs of Gambians,"

5. .A MULTI PURPOSE PILOT PROJECT PROPOSAL POWERED BY SOLAR ENERGY IN RURAL AREA

SOLAR POWERED PUMPED ,SOLAR POWERED OVENS FOR BREAD PRODUCTION AND SOLAR POWERED CHICKEN PRODUCTION PROJECT.

Solar powered village ovens offer a highly efficient source of heat in rural area . These ovens are ideal for people living off of the power grid, rural area or for those who would benefit from a dependable source of back up heat.

Solar power system is the most cost effective energy system for this integrated project

The proposed integrated multi purpose, integrated solar based project (Figure 14)consists of three main parts as follows;

1. Solar powered irrigation for 20 ha agricultural land and water supply for daily use
2. Solar powered village oven for 500 bread /day
3. Solar powered chicken production system with capacity of 2000 eggs.

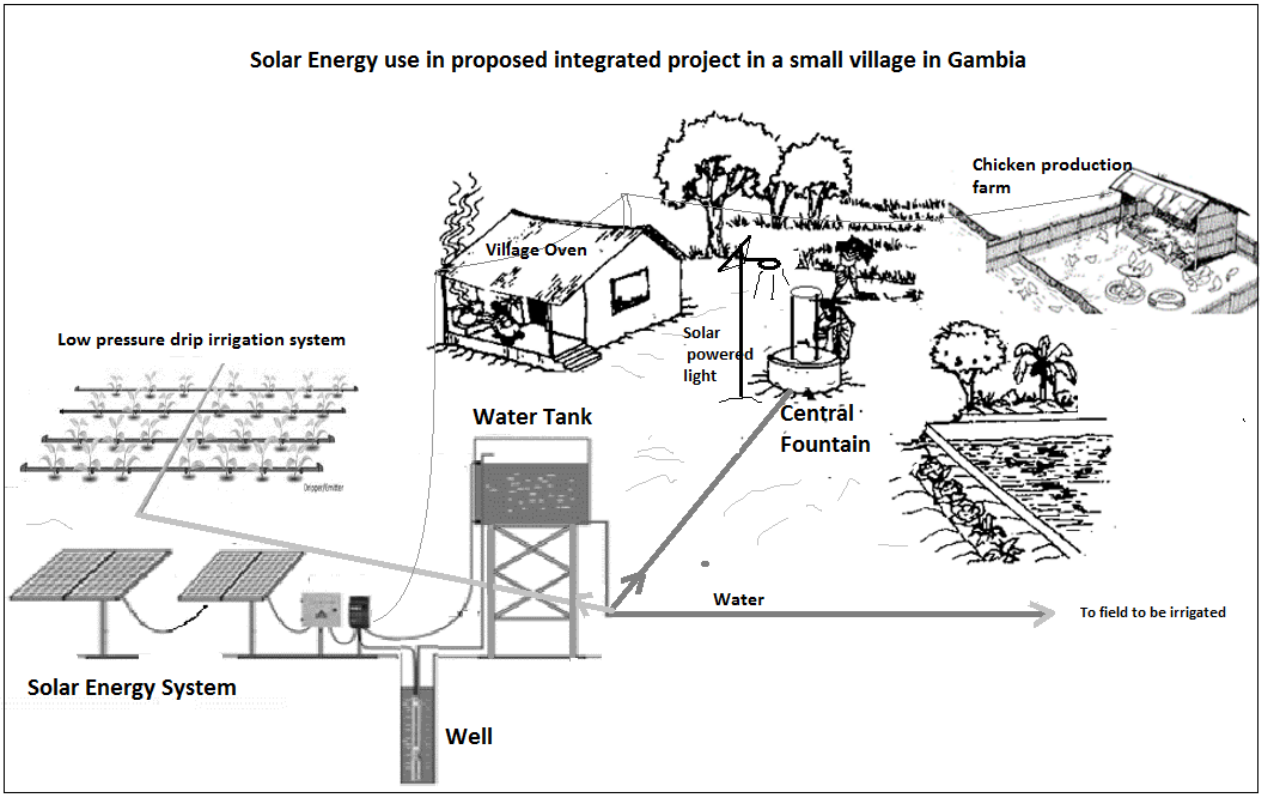


Figure 14. Solar based Multi Purpose Project Scheme

PART 1

5.1. Solar Powered irrigation water supply and daily water supply

Use of solar power in farming is an ideal solution to irrigation in developing countries.Solar energy might be one of the easiest ways for farmers to produce energy. The use of solar energy in agriculture is becoming increasingly popular and the energy produced from this renewable source can be used either on the farm or in the local power grid, providing the farmer with an additional income.

One of the areas in agriculture that benefits the most from solar energy is irrigation, especially in arid regions. The main reason is that using the sun for irrigation represents a virtuous circle: when the sun shines, it feeds the irrigation system and crops needs more water when the sun shines a lot. Therefore, a large quantity of energy is available when it is actually needed.

According to literatüre (18) first Solar Powered Water Pump pilot unit has been installed at a borehole near Jambanjole. The system was donated by the Government of Saudi Arabia and installed by German technicians.

A second pilot unit has been installed at Mandina Baas part of a UNDP-financed project. 2/ The implementing agencies for this project, the Water Resources Department and the UN Department for Technical Cooperation for Development, plan to evaluate the performance of the unit at a later date.

5.1.Proposed Solar Powered Pumped Irrigation System

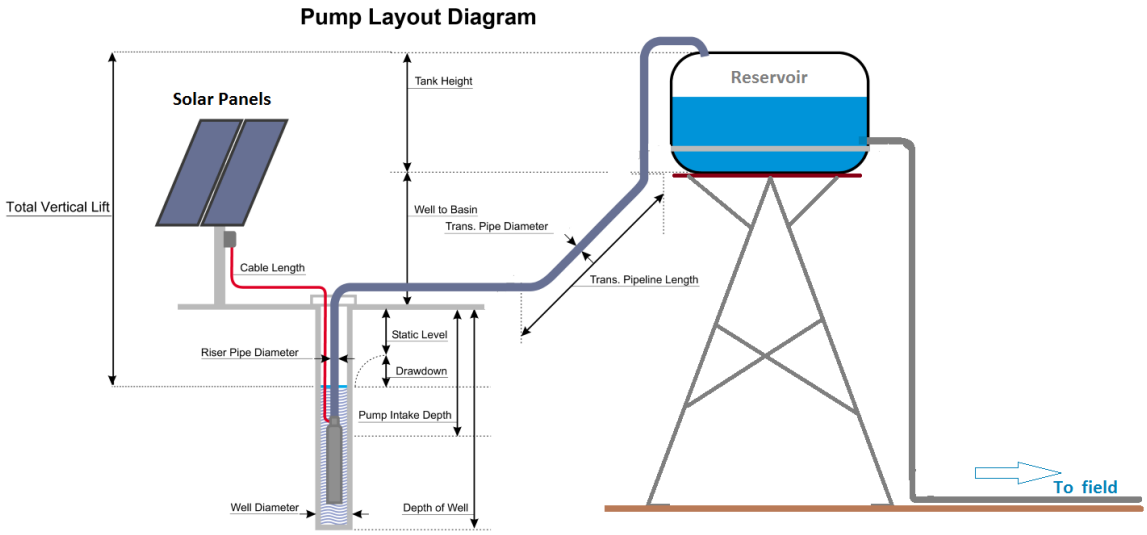


Figure 15. Solar Powered irrigation system

In the proposed system ,the pumps used for the transport of the water are equipped with solar cells. The solar energy absorbed by the cells is then converted into electrical energy via a invertor (Figure 15) which then feeds an electric motor driving the pump. Most of the traditional pump systems mainly work with a diesel engine or with the local power grid. However, these two modes of operations present disadvantages compared to solar pumps.

Figure 16. Solar powered irrigation

Figure 17. .Solar Powered sprinkler irrigation in Turkey.

In many rural areas in Gambia, lack of electricity grid forced us using an independent and alternative energy system such as solar energy. It can be a solution for the farmer to secure a safe power source and for the public grid to avoid saturation. (Figure 16,17)

Figure 18.Mobile Solar Powered irrigation system

Diesel pumps are slightly more efficient than AC powered pumps as they allow greater flexibility. However, one of the main constraints is that this system relies on the fuel availability, added to a greater impact on the environment. Diesel-driven pumps are cheaper than solar-powered pumps but the operating costs are quite high and depend heavily on the diesel price. In solar-powered systems, it works the other way round, that is, although this system is relatively expensive, the source of energy is free, therefore, after the amortization period, there are no longer operating costs (only the maintenance costs must be considered). Therefore, solar pumps turn out to be a viable long term investment (Figure 18).

Many Gambian farmers fetch the water directly from the well or the rivers and irrigate their fields using buckets. If farmers of those regions could have access to a motorized pump, they would increase their yield by 300%.

Solar powered pumps should be choosen as a very low energy consuming pumps . Therefore old pums in the fields should be replaced with new high-tech and low energy consuming pumps

. Replacing exisisting old pumps can bring an additional cost but allow low energy consuming and higher efficiency .

The solar energy generation sytem after irrigation period may be used to produce all year round, even in dry season and thus to increase their income and living standarts as it is proposed this multi purpose project.

The principle of the drip irrigation method is quite simple. With the use of various valves, hoses and pipes, water drips slowly and at regular intervals to the roots of the plants. Therefore, there is no water waste as water goes directly where it should go, contrary to a sprinkler system in which water evaporates into the air or seeps into soils where no plants grow. Therefore, drip irrigation method enables to grow more crops with less water, turning it into a highly efficient irrigation method (Figure 19).

Figure 19. Solar powered agriculture

Part 1 Project Description

The fully automatic irrigation system which takes water directly from the groundwater with 20 m of water head and 90m3 daily water output.
This project consists of solar powered pumps by photovoltaic solar panels, an holding tanks, and piping connecting the components.

The tanks and solar panels are mounted on an elevated platform. The panels provide electricity to the pump, which is submerged in the well. The tank (Figure..) supplies the water to agricultural land in the area.

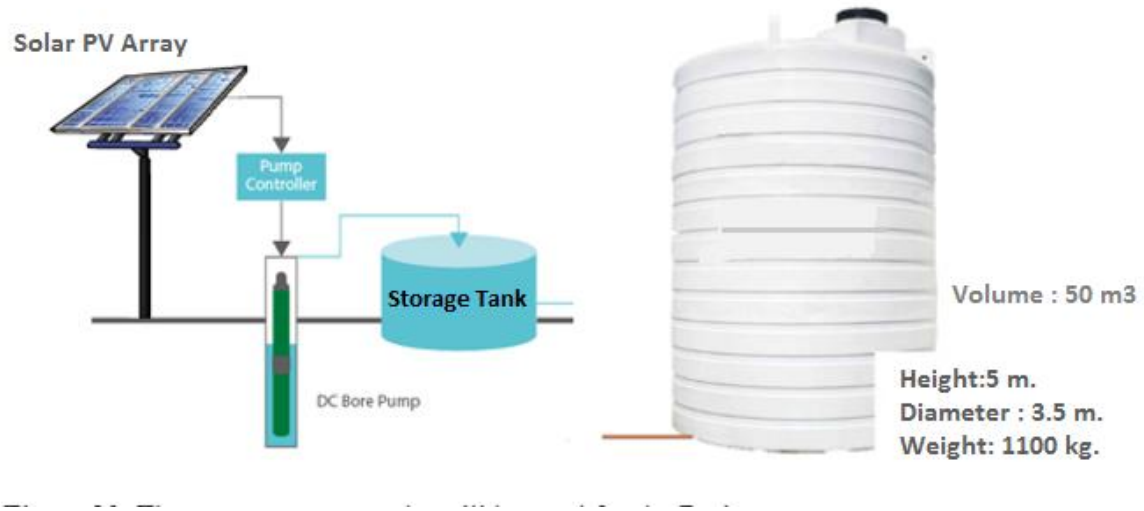


Figure 20. The modüler water storage tanks that will be used for the Project

The pump raises the water to the level of the platform, and running water is available for the agricultural land powered by gravity.

Economic Benefit:

The solar pumping system has an average annual power generation of 116, 800 KWh, which thus can save 985 tons of standard coal, reduce 439 tons of carbon dioxide emission and 21.5 tons of sulfur dioxide, and lessen smoke and dust emission of 15.7 tons and industrial ash 283.1 tons within its life span of 25 years.

Using solar energy as its power enables the solar pumping drip irrigation system to save 70% water, improving agriculture water usage efficiency, and in the meantime, saving the use of fertilizer and pesticide, thus reducing environment pollution.

Social Benefit:

This Project includes the installation and testing of the system, farmland water diversion, farming of the test field and training of local technical staff . The completion of this solar water conservancy agriculture irrigation pilot demonstration project will satisfy the water demand of the 20 ha irrigable land.

Now the planting seeds grow quite well in the 20 hectares of testing field. Upon solving the water difficulty, the solar irrigation system will enable three times farming in a year compared with the previous yearly one time farming, consequently raising the yield output.

Solar pumping technology can be a speedy remedy to solve local agricultural water problem, the assistance of modern agriculture development of Gambia and the raising grain yield as well as its self-sufficient rate.

Solar Powered Sprinkler and Drip Irrigation Systems

Solar sprinkler or drip irrigations (Figure 21,Figure 22 ,23) are combination of solar energy and sprinkler and drip irrigation facilities . Sprinkler irrigation is a method of applying irrigation water similar as rainfall. Pressed water is distributed through a pipe system, then gets sprayed into the air and irrigates entire soil surface through spray heads so that it breaks up into small water drops which fall on the ground. It is suitable for almost all field crops like food, vegetables, forestry and garden plants, etc. It is also suitable for plains and hills in warm area, as well as for spraying pesticide and fertilizing with liquids.
Drip irrigation is a form of irrigation that saves water and fertilizer by allowing water to drip slowly to the roots of many different plants.,(Figure 21).

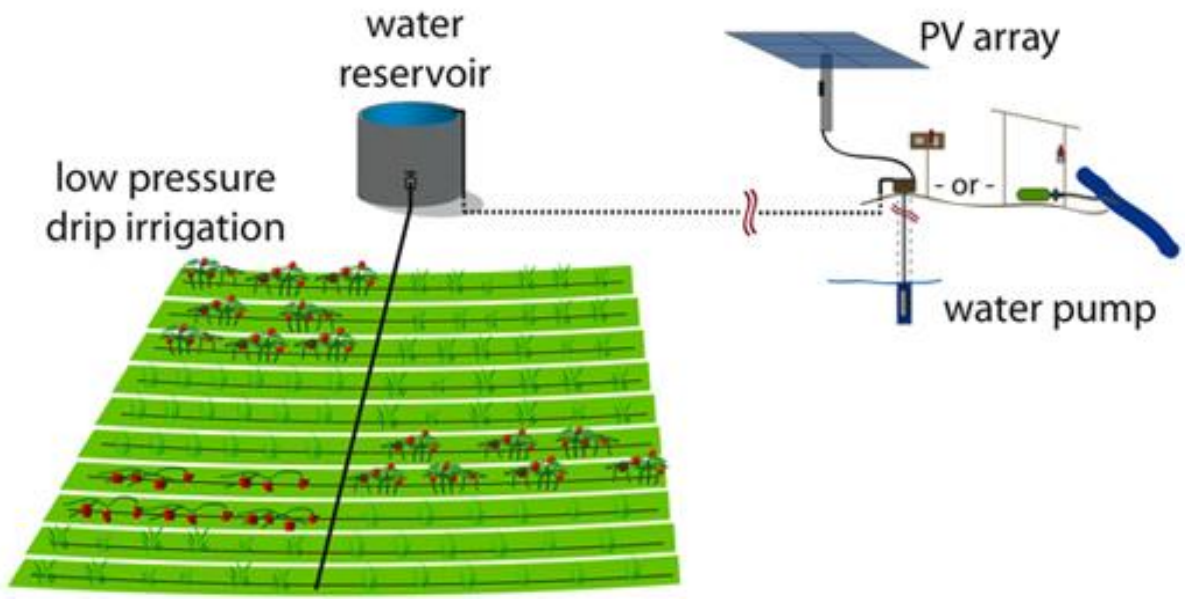


Figure 21. Solar Powered Low pressure drip irrigation system

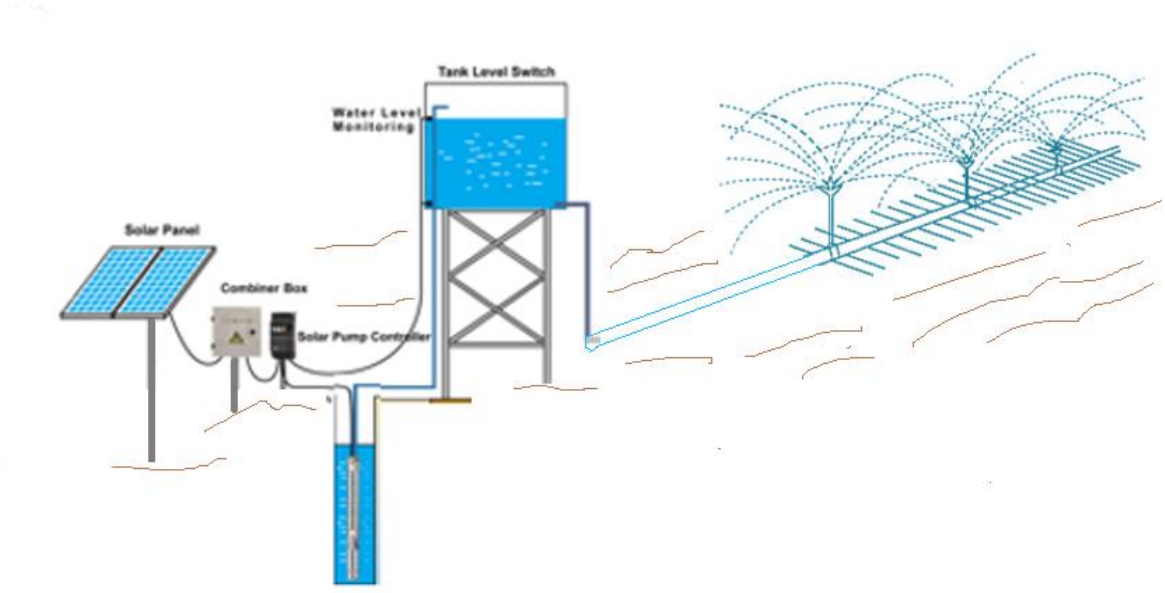


Figure 22. Solar Powered Sprinkler irrigation system

Figure 23. Sprinkler irrigation system

TREADLE PUMP as a additional power for the Project

In the Proposed Project in the end of the irrigation network, the water head may not be enough. In this case it is needed an additional water-lifting device.

The treadle pump (commonly known as pedal pump) is a water-lifting device similar in principle to the hand pump (20). It is so simple to use that even a child, a woman or even an old person can operate the pump by manipulating his/her body weight on two foot pedals or

treadles and by holding a bamboo or wooden frame for support. One can even make a comfortable sitting arrangement and pedal while being seated (20).

Table 9. *Treadle pump discharge and head assuming a useful power output of 35 Watts.* **(20)**

Head (m)	1.0	2.0	3.0	4.0
Discharge (litres/sec)	3.6	1.8	1.2	0.9

Most treadle pumps release water into furrows, as they have no delivery pressure. The 'Super Money Maker' treadle pump manufactured by ApproTEC in Kenya has a delivery pressure of about 10 metres, and thus can release water through a flexible pipe on top of the crops. A reasonably fit man between 20 and 40 years old can produce a steady power output of 70 Watts (= 0.1 hp) .But a useful water lifting power of 35 Watts is a reasonable estimation for a man operating a treadle pump. The discharge and head for a useful power of 35 Watts are given in Table 9.

In practice, treadle pumps can be used when the required suction head does not exceed 4 to 6 metres.

Irrigation capacity of treadle pumps

In Gambia it is estimated that peak crop water requirements are about 8mm/day and irrigation efficiency is about 75%. Peak irrigation water requirements are then 8 mm/ day (= 80 m^3/ha per day). Considering the human effort demanded to operate a treadle pump, 8 hours per day is a reasonable estimation of maximum daily pumping time.

Table 10 *Irrigation capacity of treadle pumps assuming a steady useful power of 35 watt 8 hours per day* **(20)**

Head (m)	1	2	3	4
Discharge (litres/sec)	3.6	1.8	1.2	0.9
Volume pumped in 8 hours (m^3)	102.75	51.38	34.25	25.69
Irrigation capacity (ha) in highland	1.28	0.64	0.43	0.32
Irrigation capacity (ha) in lowland	0.93	0.47	0.31	0.23

Treadle pumps irrigation capacity (or irrigable area) is given in Table 10. Under most common conditions (head between 2 and 4 m), irrigation capacity of a treadle pump is between 0.2 and 0.6 ha in Ethiopia. However, considering human effort to operate a treadle pump, we recommend to limit irrigated area to 0.5 ha (21).

For a farmer wanting to irrigate a small area from a shallow water source (less than 4 metres below the surface) a treadle pump may be a good choice. A very large amount of time and human effort is needed to provide the same power as a small engine. When using a treadle pump, it takes approximately 30 minutes of continuous human effort to pump what a small motorized pump (2.3 kW = 3 hp) can pump in one minute!(20).

The Pilot Demonstration Project Area

The Gambian solar energy based agriculture irrigation demonstration project is located in the city of Karantaba , Lower Gambia River area in the Western Province of Gambia.(Figure 24,25).

Figure 24. Layout of the proposed solar powered irrigation and multipurpose project area

Figure 25 .The Project Area

As a first step, a 20 ha agricultural land are choosen to be irrigated by solar powered pumps (Fig.25). In the very preliminary planing stage, it is decieded to install one modüle of solar powered pumped system has a 1800 W_p installed capacity to irrigate one hectar agricultural land .
The Project will totally has 20 modules solar powered pump system that each one has 1800 W_p installed capacity . But among them, only one modül that will be installed in nearest place of the willage will have 20 000 W_p installed capacity to produce enogh energy to supply daily water use demanad to central fountain ,agricultural water demand as well as produce electricty to village oven and chicken production farm.
The system is suitable to draw groundwater from 3-15 m depth to pump it 5 m high water tank .The sytem will generate electricty from photovoltaic solar panels and capable to draw 100 m^3 groundwater daily.
This project is also includes to dig 20 wells in the prescribed agricultural land .These 20 wells will be dug and lined with cement, with the shaft about 1.5 meters in diameter.

In this proposed project, it is aimed to irrigate 20 ha agricultural land with solar powered systems to lead using solar power in agricultural sector in Gambia.

Lightining Village Square

In the proposed project a six meter high solar powered lightining pole is designed to light village square and central fountain area.(Figure 26)

Solar powered light system will charge itself in only three hours under the sun light to light during 12 hours continously. During the cloudy weather conditions it can be operable in economic mode during one week.

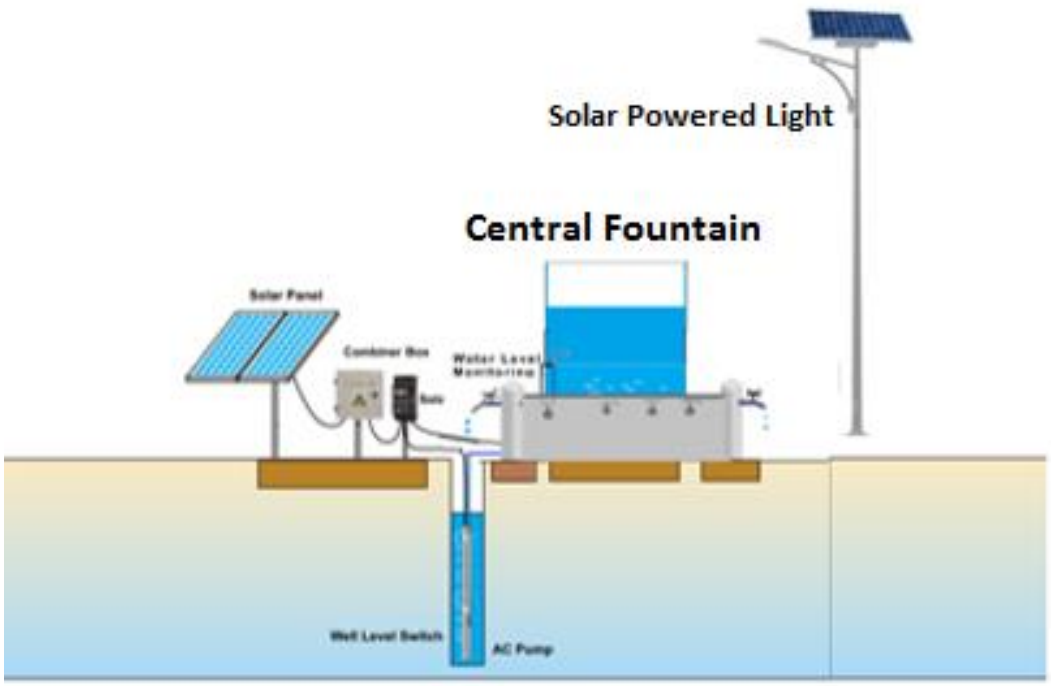


Figure 26. Solar powered lighting pole in central fountain area

PART II

5.2. Solar Energy for Cooking

The goal of promoting solar cookers and other sun-based technologies in Gambia, a sun-rich but economically challenged country ,is to improve the living conditions of the poorer segments of the population and reduce the deforestation pressure on the locally endangered forests. In addition, by using the energy of the Sun we can reduce local CO2 emissions which partly contribute to man-made climate change.

The Government is having serious difficulties servicing the country's growing oil import bill because of declining groundnut production and export prices which have reduced foreign exchange earnings to critically low levels.

Urban households in the Gambia have access to three sources of energy for cooking: fuelwood, kerosene, and LPG. Charcoal was the main fuel before 1980, when GOTG banned its production and use throughout the country. The extent of electric cooking irn these households is not likely to be very significant. An analysis of the relative prices of these
sources per unit of useful heating energy (Table 11) indicates that fuelwood is much cheaper than electricity, LPG, or kerosene. There is therefore no clear price incentive for consumers to switch from fuelwood(18).

Table.. 11. Energy Equvalent Costs of Cooking Fuel in the Urban Household. Source : (18)

Fuel Type	Energy Content (Units/GJ)	Fuel Unit	Retail Price (bututs/Unit)	Cooking Efficiency (%)	Energy Cost (bututs/Useful GJ)
Fuelwood	19.3	kg	37 b/	0.1	7,150
Kerosene	28.7	liters	147	0.3	14,063
LPG	21.6	kg	283	0.6	10,188
Electricity a/	280.0	kWh	52	0.7	20,800

a/ Represents current domestic tariff for consumption above 1100 kWh per month.

b/ Based on Banjul retail price of D 1.00 per bundle of 7 small sticks, each weighing approximately 0.5 kg.

As it was recommended in the Solar Home System (SHS) Program, off grid renevable energy systems could be an energy supply option for remote communities or small villages where connection to the transmission and distribution network are not feasible.
The proposal on the program noted that the SHS program is very expensive in terms of generation costs over the project’s lifetime but it was more economical than conventional power generation solutions that would require transmission and distribution network extension.

Storey Stone-Based Electric Oven

Solar electricity energy powered oven proposed in the Project has a capacity of 300 bread/day .The effective area size of the oven is 140cm x 140cm . This oven may be used for cooking the meal as well. After bread production the oven has kept constant temperature 150-200 ^{0}C during eight hours (Figure 27)

During the day ,electricity of the oven will be supplied by solar energy generation system installed nearby the village (Figure 28) .

Figure 27. Solar powered oven for bread production and cooking meal

Figure 28. Solar powered oven for bread production.

PART III

5.3. 2000 Chicken eggs capacity incubators and chicken production farm

Electricity of the proposed chicken eggs incubator will be supplied by batery supported solar system located in the nearby village (Figure 29). Incubating eggs is a challenging, process. it is completely worth the time and effort to gain experience and small scale food security in a village in Gambia .

Figure 29. Fully otomated chicken eggs incubator system

Incubation

It takes 21 days on average for an egg to hatch once incubation begins. Before placing the eggs inside, turn on the heat source and measure the temperature and humidity over a 24-hour period, making adjustments as necessary to create the optimal environment. Once the incubator is functioning properly, it's just a matter of maintaining the environment until the chicks hatch. Place the eggs on their side in the incubator, close the door and check the levels religiously to make sure nothing goes askew. Water may have to be added to the pan occasionally to keep the humidity up. At day 18, add more water to boost the humidity level.

Continue turning until day 18, but then leave the eggs alone for the last few days.
Once the chick is free from the egg, let it dry off in the warmth of the incubator before moving it a brooder, where it will spend the first weeks of its life.

Chicken Farm

Raising chickens on a small scale farm is proposed as 3 th stage of the proposed Project.
In the proposed farm, the outdoors ranging area is free for chickens . Free-range concept has continuous access to an outdoor range during the daytime. The range should be largely covered in vegetation and allow more space. Access to fresh air and daylight means better eye and respiratory health.

The proposed chicken farm will have covered area with easy constructed tent as shown in Figure 30. Ventilation of the chicken poultry tent will be powered by batery supported solar energy system.

Figure 30. Chicken Poultry Tent

Figure 31. Chick production system and the outdoors ranging area

5.4. Project Impact in General

The multi purpose solar based powered pilot demonstration project's impacts can be clasified as follows;

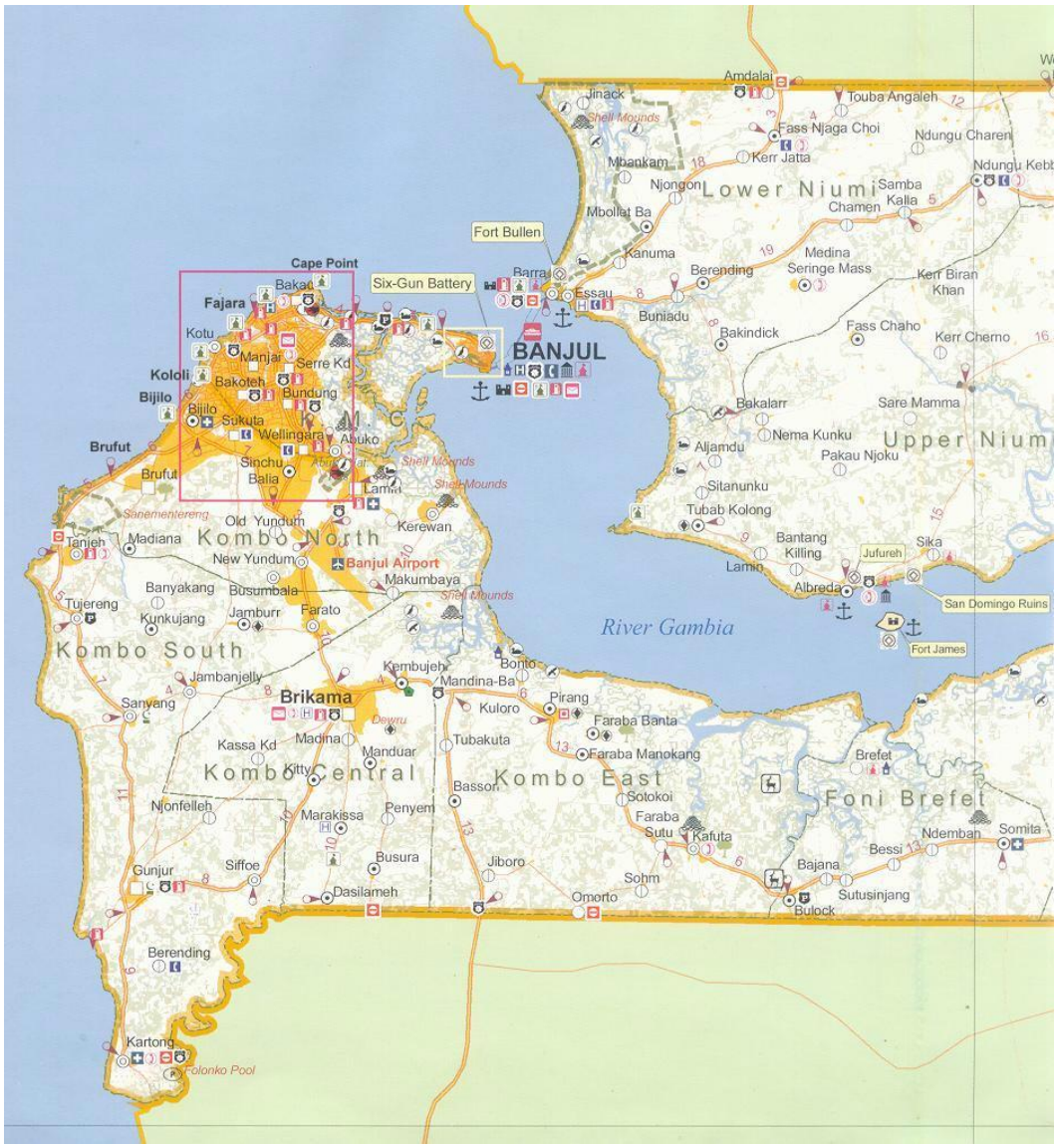
- This Project will benefit to use solar energy in agricultural production ,
- This project will benefit to gain knowledge and experince to increase the yield,grow self sufficient food in Gambia.
- A fountain built in the middle of the village gives residents easy access to clean water.
- A solar energy based village oven gives residents easy access to bread and easy cooking meal facilities.
- Gathering the water needed for daily life will be easy, especially mothers and girls
- Use of solar power in chicken farm gives village residents an opportunity to be producer
- This Project as a pilot demonstartion projects will be an importan step further and an essential driving force to development of the Gambia

5.5 Estimated Cost of the Proposed Project

The 60 KW installed capacity solar powered irrigation system has a total cost of approximately US$ 350 000.
The Total Project cost including all three parts can therefore be estimated as US$ 850 000 .

Detailed calculation and information about the systems will be given in the Feasibility Report

5.6. DETAILED GAMBIA MAP

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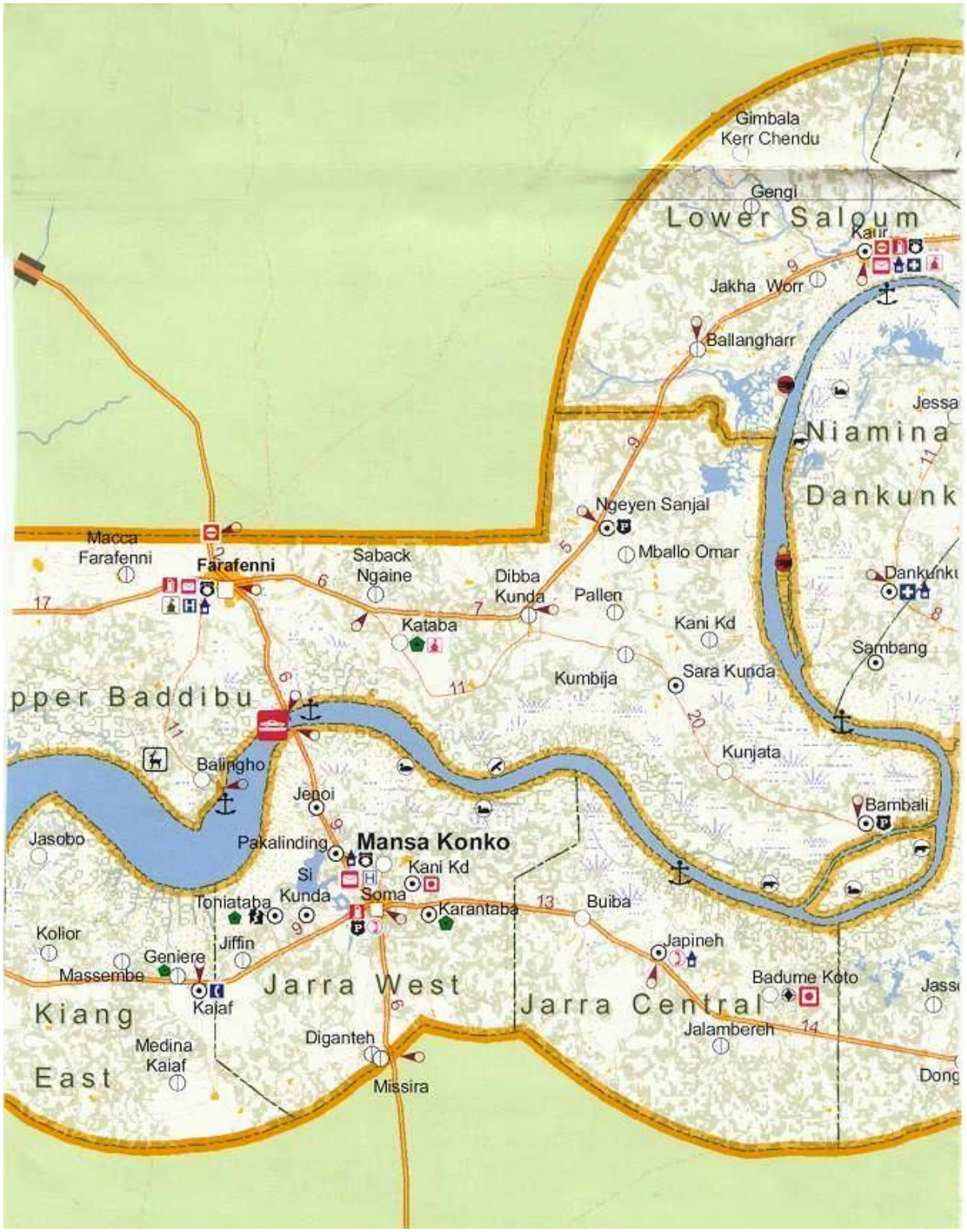
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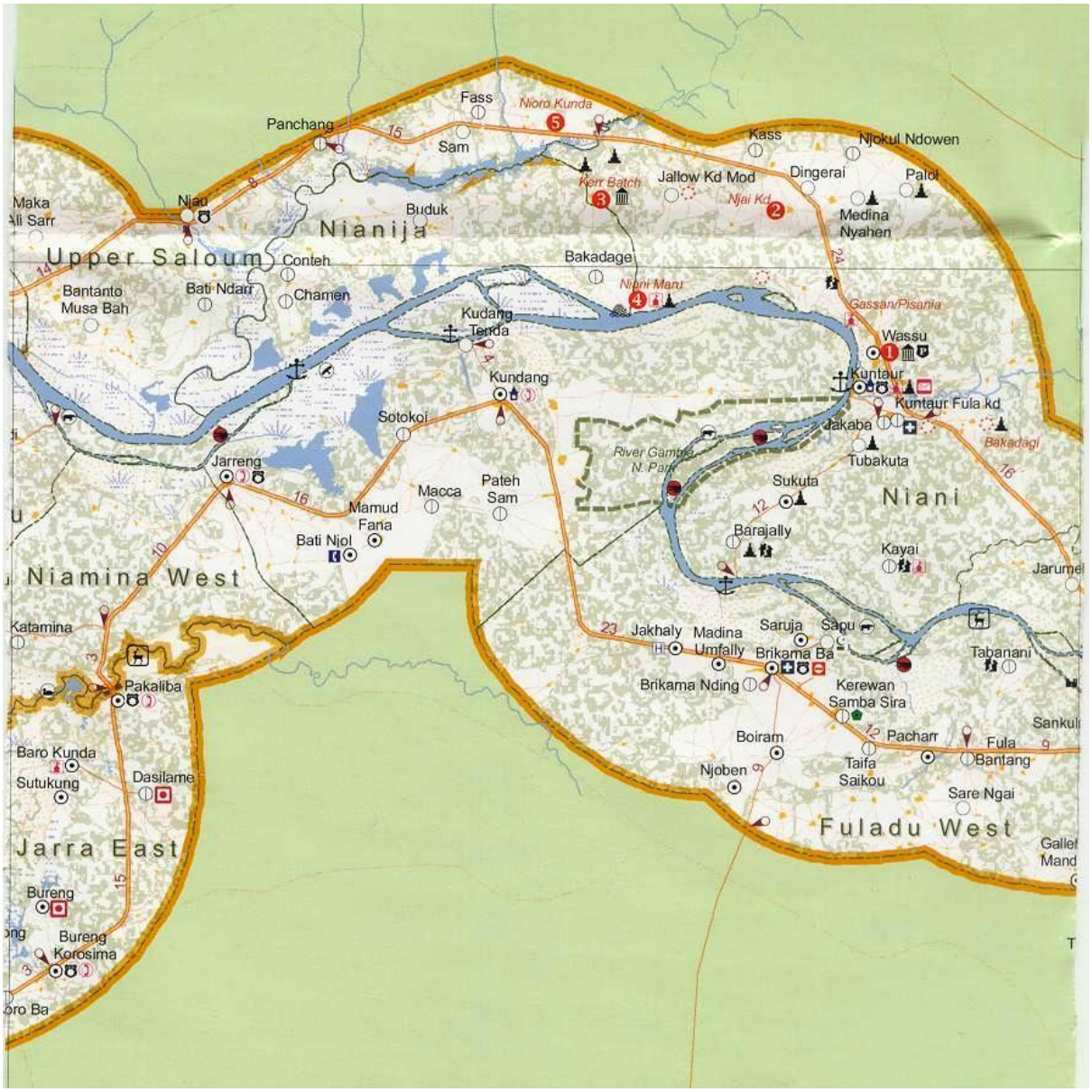
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Wassu
Kuntaur
Kundang
Kuntaur Fula kd
Sotokoi
Jakaba
River Gambia
N. Park
Bakadagi
Tubakuta
Jarreng
Sukuta
Niani
Macca
Pateh
Sam
Mamud
Fana
Barajally
Bati Njol
Kayai
Jarumel
Niamina West
Katamina
Jakhaly
Madina
Umfally
Saruja
Sapu
Brikama Ba
Tabanani
Brikama Nding
Kerewan
Samba Sira
Pakaliba
Sankul
Boiram
Pacharr
Fula
Bantang
Baro Kunda
Sutukung
Dasilame
Njoben
Taifa
Saikou
Sare Ngai
Fuladu West
Jarra East
Galle
Mand
Bureng
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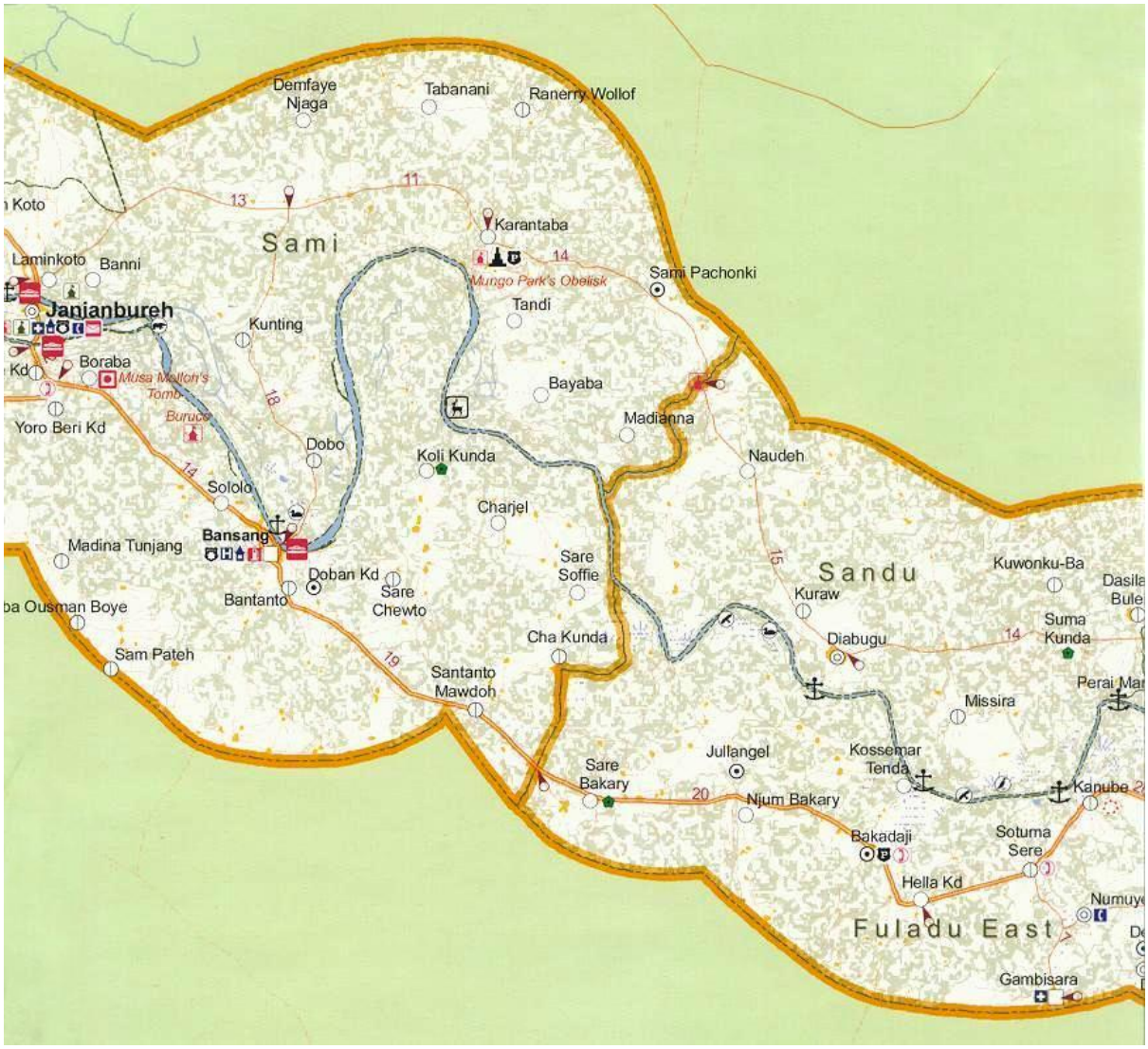
Korosima
oro Ba


Demfaye
Njaga
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Ranerry Wollof
Koto
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11
Sami
Karantaba
Laminkoto
Banni
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Mungo Park's Obelisk
Sami Pachonki
Janjanbureh
Tandi
Kunting
Boraba
Kd
Musa Molloh's
Tomb
Bayaba
18
Buruco
Madianna
Yoro Beri Kd
Dobo
Koli Kunda
Naudeh
14
Sololo
Charjel
Bansang
Madina Tunjang
Sare
Soffie
15
Sandu
Kuwonku-Ba
Doban Kd
Sare
Chewto
Kuraw
Bantanto
ba Ousman Boye
Suma
Kunda
Cha Kunda
Diabugu
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Sam Pateh
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Santanto
Mawdoh
Missira
Julangel
Kossemar
Tenda
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Sere
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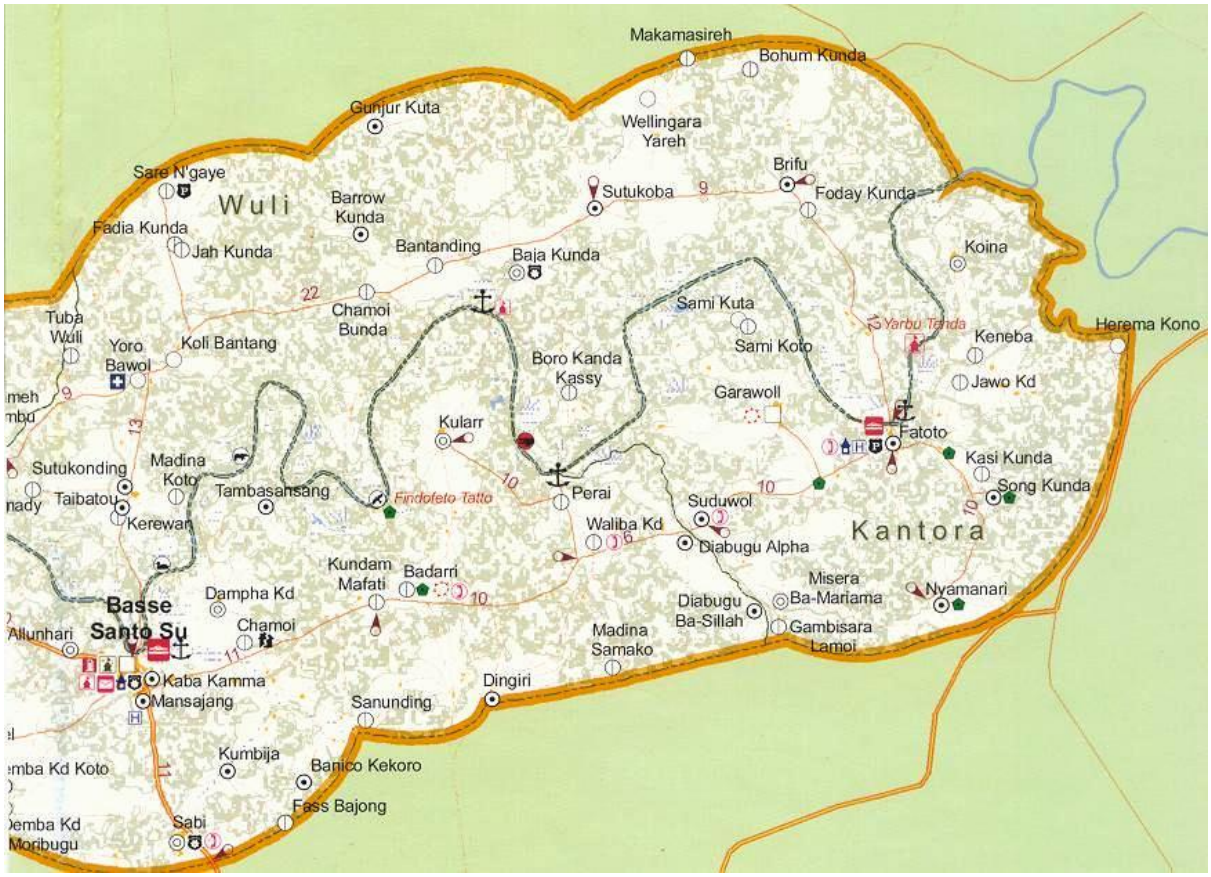
Fuladu East
Gambisara



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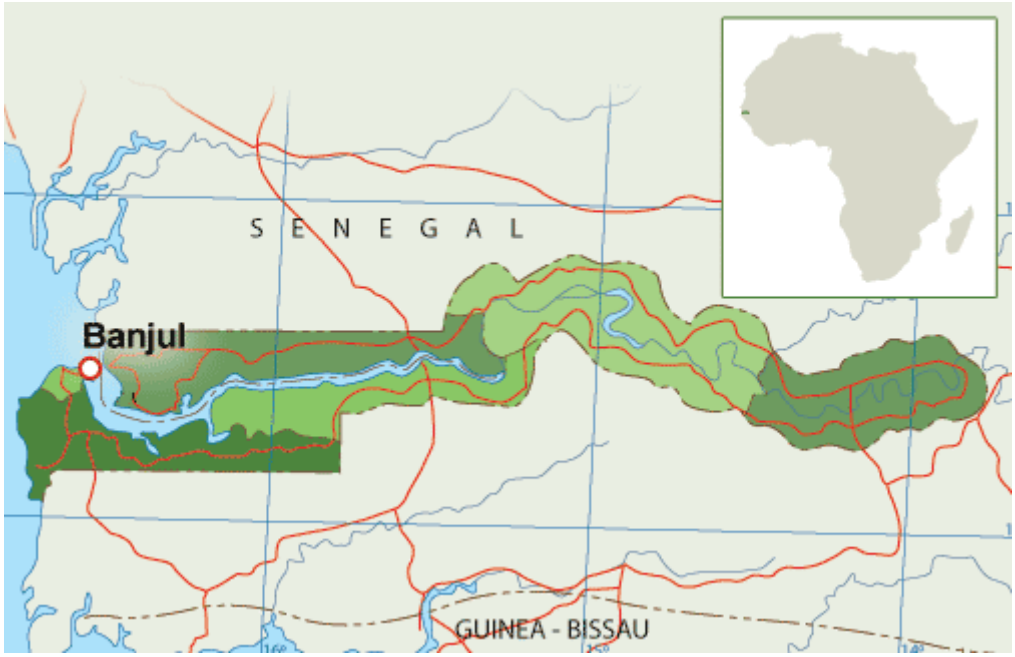

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