

Literature Review of Freshwater Ecosystem Services

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INTRODUCTION

Liberia's climate is dominated by abundant rainfall – on average 2700 mm of water falls in a year and during the rainy season (May to October) an average monthly rainfall ranges from 150 mm-350 mm (Ndehedehe et al., 2016). There are six major rivers in Liberia, which drain approximately two-thirds of the country (UNEP, 2004). The Mano, Cestos and Cavalla are shared basins between Sierra Leone and Côte d'Ivoire respectively, while the Lofa, Saint John and Saint Paul drain part of Guinea (USAID, 2008). The major rivers flow in a northeast to southwest direction due to the topography, and empty into the Atlantic Ocean. Although fresh water is not a scarce resource in Liberia, it is a vital resource important for people and the economy. Both rural and urban populations are primarily reliant upon groundwater resources for their water supply; only 62% of the Liberian population has access to protected water sources (MPEA, 2013), mainly from shallow and unregulated wells, or boreholes with hand pumps. Some communities draw water from surface water sources such as springs or harvested rainwater (UNDP, 2006). Prior to the civil conflict, 11 cities had piped water supplies including Monrovia, Gbarnga, Voinjama, and Kakata, among others (UNDP, 2006). Most water systems, including the largest system in Monrovia were based on surface water collection and treatment (UNEP, 2004) with only four systems relying on groundwater sources (USAID, 2008).

Due to the civil conflict, Liberia's infrastructure was completely destroyed and public services stopped their operation including water distribution (USAID, 2008). The rate of people without access to clean water is 61%, (MPEA, 2013). In the capital city, 64% of people get their water from one protected well, two primary bore holes and 250 shallow wells (AWF, 2007; USAID, 2008); and only 14.5% get their water from a water distribution system (GoL, 2013). The use of unsafe water sources and inadequate domestic and public sanitation facilities creates breeding grounds for mosquitoes, which in turn makes people vulnerable to malaria, one of the primary causes of mortality and morbidity in Liberia (Yarngo, 2011).

The rate of people without electricity is 95% (MPEA, 2013), which is the world's lowest rate of access to public electricity. According to the Ministry of Lands, Mines and Energy (2013), the high cost and lack of reliable access to electricity remain key obstacles to the country's stability and sustainable economic growth. Preliminary studies, based on the magnitude of the surface water flows in the country, indicate a high potential for hydroelectric power, up to 1,000 MW (MLME, 2013). In terms of agriculture, despite the abundance of land and water in Liberia, making multiple harvests per year feasible, less than 5% of the land is under permanent cultivation, and less than 1% is irrigated (MPEA, 2013).

1. FRESHWATER CONTEXT

UNEP, 2004. Desk Study on the Environment in Liberia. UNDP, Monrovia

In Liberia, direct linkages are apparent between environment and security, as well as between environment and development. Poor management and overexploitation of Liberia's natural resources has

created and fuelled civil war and conflict for the past 14 years. With the Accra Peace Agreement in place and the support of the international community, there is now an opportunity for Liberians to build an accountable, transparent, representative and effective system of governance to ensure the sustainable use and development of the country's extensive natural resources.

As with all conflicts, the biggest tragedy has been the suffering and misery of the civilian population in Liberia. Tens of thousands have been injured and killed, and many left with disabilities. One in three Liberians has been uprooted and displaced. Their basic human rights and opportunity to develop has been denied. This peace accord offers hope for a new start. However, major challenges lie ahead since the 14 years of conflict have destroyed both natural resources and manmade infrastructure in Liberia. Vital infrastructure in the energy, water, sanitation, waste management and housing sectors has been partially or totally destroyed.

For displaced people and returning refugees, the most important priority is safe drinking water and sanitation. Currently, the capital of Monrovia and many other areas are totally dependant on water trucks. The temporary wells that are being drilled under houses and in gardens face the problem of cross-contamination from sewage and waste. A wide disinfection programme is underway to prevent the spread of disease caused by unsanitary conditions, such as cholera. Safe drinking water, a functioning sewage treatment and sanitation system and proper waste management are the most urgent needs in the urban areas.

Water and Sanitation

Liberia has large potential water resources. The climate is of the tropical type, with heavy rainfall that ranges from 2 000 to 4 000 mm per year. Average annual rainfall is estimated at 2 372 mm for Monrovia. Water tables in Liberia are on average 7–13 m below ground level and easily accessible for shallow well development.

Before 1990, approximately 45 per cent of the urban population had access to safe drinking water – managed water systems or improved hand pump wells – compared to 23 per cent of the rural population. In 1991, the daily water production for Monrovia amounted to 61 000 m³/day. The water supply system included house connections and a limited number (150) of public taps to serve the low-income areas.

Due to conflict-related damage, a lack of maintenance and a shortage of electricity, the current treated water production rate in Monrovia is approximately 10 per cent (5 800 m³/day) of the production in 1990 and supply covers only a small area of the city.

The poor water supply has resulted in communities and families installing independent uncontrolled wells. This had led to a heavy reliance on ground water and risks to human health resulting from poor sanitation and the total breakdown in solid waste management. In addition, the water supply systems in ten urban areas outside of Monrovia have collapsed, causing supply problems. Due to the lack of supply, the international community provides supplementary water to hospitals, IDP centres and orphanages as well as public water distribution tanks. A number of organizations such as Action contre la Faim, the European Union, UNICEF, WHO and the United Kingdom's Department for International Development (DFID) also assist with regular well disinfections. In Monrovia there are currently at least 5 500 wells and in Buchanan at least 2 700. The regular chlorination of this number of wells is not sustainable in the long term.

In contrast to the urban environment, traditional rural communities in Liberia rely primarily on local watercourses for their water needs. Shallow wells are also used occasionally when surface supply levels are low. However, the conflict has disrupted these traditional methods, as in some areas the conflict has restricted access and in others streams have been diverted or polluted.

The only functioning sewerage system is in Monrovia. However, the sewage treatment plant has under-capacity and was only intended for a population of 130 000 people, whereas the current population is approximately 800 000. The plant was designed to provide sedimentation and secondary (biological) treatment with trickling filters. Although the system is designed to handle sanitary wastewaters, the influent is supplemented with storm water due to illegal connections with drains and from infiltration of ground water. The plant and the pumping stations have not functioned consistently for over ten years due to disrepair and a shortage of electricity, hence raw sewage has been frequently allowed to flow directly into lagoons, rivers and the sea. It was reported that a small number of Monrovians (1,3 per cent) still use the sewer system, causing a build-up of sewage within low-points in the pipeline. Occasionally, the mains are fractured causing outflow on to the streets or into the sea and local rivers.

The majority of the population uses either pit latrines, toilets connected to septic tanks or open defecation. In some cases faeces are put in plastic bags and disposed of in drainage channels or with domestic waste. These practices have the potential to contaminate ground and surface water and thereby pose risks to human health.

UNDP, 2006. State of the Environment Report for Liberia 2006. UNDP, Monrovia

This is the first state of the environment (SOE) report for Liberia. As required by the Environmental Protection and Management Law, the report should be produced after every five years. The state of the environment report is a guide for development planning and decision-making and is an important reference for environmental education and awareness. It is expected to serve as a monitoring tool for measuring progress against stated development goals. . Within the environmental domain, there are serious data gaps related to Liberia's biodiversity, mountains, solid waste management, and greenhouse gas emissions, among others. This needs to be urgently addressed so as to improve subsequent editions of the SOE.

This report is divided into four parts: 1) environment and economic development, 2) the state and trend of the natural resources, 3) the human environment, and 4) environmental governance. These are designed to reflect the inter-linkages between environment, development, security and good governance in Liberia and are the broad areas that Liberians will have to think about and act on during the process of reconstructing their country.

Part two provides information on the state and trends of the major natural resources of land, water and biodiversity. Land is critical for human survival and development; it supports agriculture, forestry, tourism, human settlement, wildlife and industrial development. Land resources are affected by land degradation from activities such as mining, poor agricultural practices, lack of land-use planning and the current land tenure system. Habitat degradation and loss, over-exploitation of resources through excessive harvesting or hunting, introduction of exotic species and ineffective institutional arrangements are threatening the rich biodiversity. To address the issue of biodiversity loss, 10 national forest reserves and two fully

protected areas have been gazetted. The fully protected areas are Sapo National Park and East Nimba Nature Reserve. Water resources management is weak. There is no integrated water resources management, the laws are fragmented across several agencies and there are no proper enforcement mechanisms. There is no policy governing water resources management.

USAID, 2008. Liberia Environmental Threats and Opportunities Assessment (Etoa). Final Report.

USAID/Liberia is currently transitioning from emergency relief to development. The Mission's Office of Economic Growth, which encompasses natural resource management and biodiversity activities, is crafting a new strategy to reflect the changing times. Pressures on Liberia's forests, biodiversity, natural resources and ecosystems are increasing. At the same time there are growing opportunities for USAID to collaborate with other donors, non-governmental organizations (NGOs), government agencies that are acquiring new mandates and competencies, and the private sector. These factors led the Mission to decide that an Environmental Threats and Opportunities Assessment (ETOA) was warranted. An ETOA goes beyond, yet incorporates, a 118-119 analysis. An ETOA describes the range of environmental impacts from human activities across the spectrum of sectors: green (forests, agricultural systems), brown (urban, industrial systems) and blue (marine and freshwater systems).

The ETOA report is divided into three sections; a State of the Environment Report, Actions Necessary and Planned to Conserve Tropical Forests and Biodiversity (Tropical Forests and Biodiversity Report - Foreign Assistance Act Sections 118/119), and an Environmental Data Collection, Monitoring and Adaptive Management Plan.

The State of the Environment (SOE) Report identifies threats to terrestrial, coastal/marine and freshwater ecosystems and examines the potential effects of climate change on these ecosystems. It also assesses environmental and natural resource hazards and degradation in urban and rural areas. The SOE includes an analysis of policy and institutional issues impacting the environment, natural resources and ecosystems. Drawing on these assessments, the SOE identifies the underlying causes of environmental degradation and analyses approaches and interventions used by all institutions (e.g., NGOs, government, private sector) to address these causes and the results obtained, with particular emphasis on enabling conditions including the legal and regulatory environment. The SOE concludes with an analysis of opportunities and constraints associated with all environmental elements, recommendations for indicators of environmental damage/health and potential monitoring systems, and a brief analysis of key links between economic growth, health and governance activities and environmental threats and opportunities.

The Actions Necessary and Planned to Conserve Tropical Forests and Biodiversity Report was prepared to provide information and analysis required by the U.S. Congress, and stipulated in the U.S. Foreign Assistance Act (FAA) of 1961. Sections 118 and 119 of the FAA require USAID Missions to examine issues of tropical forests and biodiversity conservation when preparing strategies for development assistance.

The Environmental Data Collection, Monitoring and Adaptive Management Plan Report identifies environmental spatial data gaps, assesses the capacity of Liberian institutions to collect and manage data, analyses monitoring and adaptive management use of data and information by Government of Liberia,

USAID and key partners, and provides recommendations for strengthening data collection and management.

Threats To Freshwater Ecosystems

There are six major rivers in Liberia. These flow from mountains in the north and empty into the Atlantic Ocean. Most of the rivers are navigable up to 20 miles from the coast, except for Cavalla, which is navigable up to 50 miles. Together, these basins drain approximately 65% of the country. The Mano and Cavalla are shared basins between Sierra Leone and Côte d'Ivoire respectively, while the Lofa, Saint John and Saint Paul drain part of Guinea. Numerous micro watersheds or sub-watersheds also exist.

- **Potential Threats to Inland Fisheries—Over Fishing.** The value and production of inland fisheries is not known but it is an important seasonal subsistence activity. BNF estimates that there are an estimated 8000 boats on Liberia's inland river system with only about 200 registered. According to BNF, there is little control over net mesh size and there is wide use of organic and chemical pesticides, and dynamite. BNF has little capacity to monitor inland fisheries.
- **Wetlands.** There are approximately 600,000 ha of freshwater swampland in Liberia with only about 3% (20,000) ha under cultivation. Although there appears to be very few threats to Liberia's freshwater wetlands, very little is known about the value of freshwater wetlands, from their role in providing medicinal plants and other products, to their role in providing ecosystems services such as water quality enhancement, flood control, and provision of habitat.
- **Water Hyacinth.** Water hyacinth occurs in several waterways but there is no data on its extent and/or its impact on the ecosystem.

Impact Of Climate Change

While there is a substantial lack of data concerning climate change and its implications for Liberia's ecosystems, current models suggest that agriculture crops grown in the tropics, exhibit immediate yield decline with even the slightest warming, and that there will more than likely be a subsequent increase in crop pests and diseases. In terms of forest ecosystems, all climate change models project that even in extreme scenarios, direct deforestation will impact tropical forests before climate-driven dieback.

Although there has been little research on the possible impact of climate change on biodiversity, most specialists agree that as with tropical forests, loss of habitat through anthropogenic factors will impact biodiversity long before any possible impact from climate change. The exception to this would be for migratory animals. Rising sea levels linked to global warming would more than likely pose the biggest threat. A one meter rise could result in the loss of about 95 km² of land in the coastal zone to inundation, the destruction of the majority of mangroves and have a significant effect on fisheries through changes in hydrology and aquatic ecology.

2. WATER SUPPLY AND SANITATION

African Water Facility-AWF 2007. Liberia: Monrovia Expansion and Rehabilitation Of Three County Capitals Water Supply And Sanitation Project Appraisal Report. African Development Bank

The purpose of the Water Supply and Sanitation for Monrovia and the three county capitals Project is to a) study economically, technically, environmentally and socially viable water supply and sanitation systems to meet 2025 demands in Monrovia and three county capitals of Kakata, Zwedru and Buchanan, where the Liberia Water and Sewerage Corporation is responsible for services production, and b) develop water sources, abstraction, water conveyance and transmission, water treatment facilities, water distribution network, and sanitation facilities in Metropolitan Monrovia, Kakata, Zwedru and Buchanan as well as efficient water metering and billing systems utilizing appropriate, affordable and least cost technology, and c) mobilize adequate resources for LWSC to implement the expansion and rehabilitation of the WSS systems.

The project is to undertake three stage studies consisting of: Stage 1: Feasibility study; Stage 2: Detailed designs for the study area WSS systems, engineering and preparation of tender documents; and Stage 3: Resource Mobilization.

the project will contribute towards alleviation of poverty in the study areas through the provision of clean and affordable and sustainable water and sanitation services and also supports in promoting more efficient use of available WSS services. The project is consistent with the country's MDGs Action Plan for water and sanitation, the Interim Poverty Reduction Strategy (IPRS) and in line with the Government policy of rehabilitating infrastructure and utilities for urban dwellers in Liberia on priority basis. Monrovia, Kakata, Zwedru and Buchanan have been selected for the study, because their WSS infrastructure needs urgent rehabilitation, replacements and extensions, since during the civil war infrastructure has not been properly maintained, and in addition, suffered severe damages.

The outcomes of the project will consist of adequate resources mobilized based on proposals and designs for water supply and sanitation facilities, which will, when implemented, provide reliable services for the people in Monrovia (1,500,000 people) , Kakata (25,000 people), Zwedru (10,000 people) and Buchanan (35,000 people). This in turn will have a multiplier effect on health and productivity of the people, and will subsequently support poverty reduction efforts on the national level.

Government of Liberia, 2013. Water Sanitation and Hygiene (WASH), Sector Performance Report.

Water, Sanitation and Hygiene are fundamental to everyday life and have been recognized by the UN as basic Human Right. It is the responsibility of the Government of Liberia to provide, regulate and facilitate the services that will allow every citizen of Liberia to enjoy a better quality of life.

There are many organizations and projects that are striving to improve WASH services across Liberia and for the first time, a Sector Performance Report (SPR) has been prepared to capture and present sector efforts, with particular focus on the activities and outcomes in 2013. This report was collated and written by staff from a range of government ministries, agencies and non-government organizations and represents a major step forward in how the WASH sector in Liberia monitor and report. The 2013 SPR reports on progress on a number of key areas in the WASH Sector:

Progress on the Sector Strategic Plan has been incremental with progress in some areas, but a number of constraints in others, which are detailed in this report:

- 17 activities have been completed (up from 13 in 2012)

- 80 activities on-going
- 46 activities are yet to commence

Water Resources, although not extensively covered in the Sector Strategic Plan, is included because it sets the context for WASH in Liberia. The focus has been on the St Paul River watershed, which supplies the Liberia Water and Sewer Corporation Monrovia piped water system and will supply the hydroelectric power station at White Plain, when its refurbishment is complete. While rainfall, and river level monitoring is being improved, data remains scarce across the country. Measuring water quality remains problematic. There are no centralized, systematic records on groundwater levels. This lack of data will impede any future attempts to implement Integrated Water Resource Management and to regulate the mining sector, which is suspected of causing pollution. The rainfall data does show a high potential for improving rural water supplies through rainwater harvesting.

Collating information on the financing of WASH in Liberia has been a challenge because of the many organizations involved and because it is not always easy to separate WASH from other budgeted activities. However, data from the national budget and the Aid Management Unit has been collated. In 2012/13 1.2% of the government budget was allocated to WASH. For 2013/14 it is lower, at 0.4%. From external donors, WASH funding accounted for 1.9% of the total Aid budget for fiscal year 2012/13 at USD 12 million. In the second half of 2013, USD 2.5million was spent on WASH by NGOs, many sector NGOs operating did not submit reports, so the true figure is likely to be substantially higher.

Rural Water Access has been steadily improving from 56% in 2007 to 66% in 2011 (based on national survey data). There is a challenge around data because there are several sources with differing definitions. However, the data available does show some major concerns:

- While 65% of the rural population obtain their drinking water from protected wells, 23% drink from surface water, which will almost certainly be unsafe.
- The proportion of people who are travelling for more than 30 minutes to fetch drinking water has increased from 7% to 18% between 2007 and 2011.
- Only 60% of Over 10,000 improved water points mapped nationally were fully functional in 2011.

Urban Water and Sanitation is dominated by the situation in Monrovia, however Liberia Water & Sewer Corporation also has the mandates to service the 14 County capitals and other towns with a population of more than 5,000. This accounts for a third of the country's population. In urban areas, 64% of people get their water from a protected dug well, and only 14.5% get their water from a piped system.

In Monrovia, there are large areas of the city not served by the piped supply system nor the sewerage system, including central areas of the city near Mamba Point. The existing infrastructure has not yet been restored to its pre-war capacity, which in itself is inadequate because of the expansion of the city over the past decades. Most people in all urban areas defecate in the open or use the limited number of communal or household latrines.

Data on water supply quantities and billing is limited to that from audit report from 2012. This shows that the only 74% of the water billed for was actually paid. The seriousness of the situation has been recognized and three urban water schemes are being implemented with support from the African Development Bank and three with support from USAID.

Monrovia City Corporation is collaborating with donors and NGOs to pilot the introduction of tiger worm household latrines, which do not require de-sludging and the residue can be used as a fertilizer. In 2013, 65 tiger worm toilets were piloted in 11 communities across Monrovia.

Testing of Drinking Water Quality shows that the majority of water points sampled had contamination that made them unsafe to drink. While monitoring of water quality is improving, there are still challenges and stronger regulation of water vendors and more public education is needed.

Community-Led Total Sanitation (CLTS) is a way of getting people within communities to work together to stop open defecation in their towns and villages. Natural leaders get community members involved to trigger behavior change and latrine building so that the community as a whole can be declared Open Defecation Free (ODF). CLTS has been introduced into 15 counties in Liberia. By the end of 2013, 666 communities had been ‘triggered’ and of those 320 have achieved ODF status.

3. MODELLING

Schuol, J., Abbaspour, K.C (2007). Using monthly weather statistics to generate daily data in a SWAT model application to West Africa. Ecological modelling 2007

Most hydrologic models require daily weather data to run. While this information may be abundant in some parts of the world, in most parts such data is not available on daily basis. Distributed hydrologic models are particularly adversely affected by the lack of daily data or the existence of very inaccurate data as they impart large uncertainties to the model prediction. In this study we developed a daily weather generator algorithm (dGen) that uses the currently available 0.5 monthly weather statistics from the Climatic Research Unit (CRU). We tested dGen in two ways. First, we made a direct comparison of the measured and generated precipitation and maximum-minimum temperatures by looking at some long-term statistics in a few stations in West Africa. Second, we ran the model “Soil and Water Assessment Tool” (SWAT) with dGen-generated and measured daily weather data to simulate 25 years of annual and monthly river discharges at some gauging stations. The simulated river discharges were then compared with the measured ones. It was seen that using the dGen simulated daily weather data resulted in a much better match with the measured discharge data than the measured daily weather data in combination with the SWAT internal weather generator WXGEN. WXGEN is used in SWAT to fill missing data using monthly statistics, which must be calculated from the existing daily data. For annual and monthly hydrological simulations, dGen-generated daily rainfall and temperature data appears to have a high degree of reliability.

Schuol, J., Abbaspour, K.C, Srinivasan, R., Yang, H. (2007). Estimation of freshwater availability in the West African sub-continent using the SWAT hydrologic model. Journal of Hydrology (2008) 352, 30– 49

Accurate knowledge of freshwater availability is indispensable for water resources management at regional or national level. This information, however, has historically been very difficult to obtain because of lack of data, difficulties in the aggregation of spatial information, and problems in the quantification of distributed hydrological processes. The currently available estimates of freshwater availability by a few large international organizations such as FAO and UNESCO are often not sufficient as they only provide

aggregated rough quantities of river discharge and groundwater recharge (blue water) at a national level and on a yearly basis. This paper aims to provide a procedure to improve the estimations of freshwater availability at subbasin level and monthly intervals. Applying the distributed hydrological model “Soil and Water Assessment Tool” (SWAT), the freshwater availability is quantified for a 4-million km² area covering some 18 countries in West Africa. The procedure includes model calibration and validation based on measured river discharges, and quantification of the uncertainty in model outputs using “Sequential Uncertainty Fitting Algorithm” (SUFI-2). The aggregated results for 11 countries are compared with two other studies. It was seen that for most countries, the estimates from the other two studies fall within our calculated prediction uncertainty ranges. The uncertainties are, in general, within reasonable ranges but larger in subbasins containing features such as dams and wetlands, or subbasins with inadequate climate or landuse information. As the modelling procedure in this study proved quite successful, its application for quantification of freshwater availability at a global scale is already underway. There are, however, two limitations in the West African model: (1) not all the components of the water balance model such as soil moisture or deep aquifer recharge could be directly calibrated because of lack of data and (2) the full capabilities of the SWAT model could not be realized because of the lack of local water and agricultural management information.

Ndehedehe, C., Awange, J., Agutu, N., Kuhn, B.H. (2016). Understanding changes in terrestrial water storage over West Africa between 2002 and 2014. *Advances in Water Resources* 88 (2016) 211–230

With the vast water resources of West Africa coming under threat due to the impacts of climate variability and human influence, the need to understand its terrestrial water storage (TWS) changes becomes very important. Due to the lack of consistent in-situ hydrological data to assist in the monitoring of changes in TWS, this study takes advantage of the Gravity Recovery and Climate Experiment (GRACE) monthly gravity fields to provide estimates of vertically integrated changes in TWS over the period 2002–2014, in addition to satellite altimetry data for the period 1993–2014. In order to understand TWS variability over West Africa, Principal Component Analysis (PCA), a second order statistical technique, and Multiple Linear Regression Analysis (MLRA) are employed. Results show that dominant patterns of GRACE-derived TWS changes are observed mostly in the West Sahel, Guinea Coast, and Middle Belt regions of West Africa. This is probably caused by high precipitation rates at seasonal and inter-annual time scales induced by ocean circulations, altitude and physiographic features. While the linear trend for the spatially averaged GRACE-derived TWS changes over West Africa for the study period shows an increase of 6.85 ± 1.67 mm/yr, the PCA result indicates a significant increase of 20.2 ± 5.78 mm/yr in Guinea, a region with large inter-annual variability in seasonal rainfall, heavy river discharge, and huge groundwater potentials. The increase in GRACE-derived TWS during this period in Guinea, though inconsistent with the lack of a significant positive linear trend in TRMM based precipitation, is attributed to a large water surplus from prolonged wet seasons and lower evapotranspiration rates, leading to an increase in storage and inundated areas over the Guinea region. This increase in storage, which is also the aftermath of cumulative increase in the volume of water not involved in surface runoff, forms the huge freshwater availability in this region. However, the relatively low maximum water levels of Kainji reservoir in recent times (i.e., 2004/2005, 2007/2008, and 2011/2012) as observed in the satellite altimetry-derived water levels might predispose the Kainji dam to changes that probably may have a negative impact on the socio-economic potentials of the region. GRACE-derived TWS is not well correlated with TRMM-based precipitation in some countries of West Africa and apparently indicates a lag of two months over much of the region. On

the other hand, the regression fit between GLDAS-derived TWS and GRACE-derived TWS shows R² of 0.85, indicating that trends and variability have been well modeled.

4. POLICY

Ministry of Lands, Mines and Energy- MLME, 2009. Water Supply and Sanitation Policy. Ministry Of Lands, Mines And Energy, The Republic Of Liberia

In conformity with the Government's Poverty Reduction Strategy (PRS) 2008 – 2011, and the National Integrated Water Resources Management Policy, Liberia's vision of the Water Supply and Sanitation Policy shall be: using clean water supply and safe sanitation as a vehicle for reducing the water supply and sanitation related disease burden, increasing productivity, promoting human welfare and setting the nation on a path towards long term sustainable growth, development, and poverty reduction.

Policy objective

The objective of the Liberian Water Supply and Sanitation Policy shall be: to provide guidance and direction in institutional, economic and legal reforms that will lead to improved water governance at national, local and community levels, and improved access to safe water supply and adequate sanitation, in an affordable, sustainable and equitable manner, to all the peoples of Liberia.

Guiding principles

The guiding principles of Liberia's Water Supply and Sanitation Policy are based on a holistic approach incorporating considerations for equity, efficiency, environmental and service sustainability and recognize international WSS principles such as those articulated in the 1992 Dublin Principles³. These guiding principles include:

1. Fresh water is a finite and vulnerable resource which is essential to sustain life, development, and the environment.
2. The protection and conservation of the environment is essential to the sustainable utilization of water and to water security.
3. Water has an economic value and is a social good.
4. Development should be demand-driven and community based.
5. Access to safe drinking water and sanitation is a basic human right.
6. Safe water, hygiene practices and sanitation are directly linked to improved public health, especially for vulnerable groups such as children.
7. Priority in the planning and allocation of public funds will be given to those who are presently inadequately served ('some for all' rather than 'all for some').
8. There should be an equitable geographical allocation of development resources.
9. Users should pay for the services they get. Pro-poor approaches should be adopted wherever applicable.
10. The Government has a role as an enabler in a participatory approach to development.
11. Women have an essential role in the provision, management and safeguarding of water.
12. The private sector has an important role in water and sanitation service provision.

13. There is a need for an integrated approach covering water, sanitation and hygiene promotion.
14. Attention must be paid to water quality, rehabilitation, and the effective operation and maintenance of existing facilities.
15. Developments in technology and in other sectors shall be harnessed for serving the people.
16. Water and sanitation development is not possible in isolation of development in other sectors.
17. Political will is imperative for effective policy implementation.

Key policy statements and strategies

An estimated 39% of Liberia's population live in urban settlements of over 5000 people and 59.5% live in rural settlements of less than 2000 people. Keeping in view the differences inherent in the service provision/ facilitation in these different contexts, the following policy statements and strategies are enunciated in two parts: rural and urban.

- **Rural water supply and sanitation (WSS) policy statements and strategies :**

Rural areas contribute to 73.4% of poverty in Liberia and pose particular challenges to service provision and poverty reduction that require strategies that are both simple and sustainable.

1. Basic services for all
2. Improved health through an integrated water, sanitation and hygiene promotion approach
3. Commitment through cost sharing 4: Service sustainability through community ownership

- **Urban water supply and sanitation (WSS) policy statements and strategies**

1. Basic services for all
2. Adoption of pro-poor approaches
3. Service sustainability through full cost recovery
4. Development of the private sector in service provision

Community well-being through social and environmental considerations

Ministry of Planning and Economic Affairs- MPEA, 2013. Liberia's Medium Term Economic Growth and Development Strategy (2012-2017). Republic of Liberia Agenda for Transformation: Steps for Liberia Rising 2030

The Agenda for Transformation (Aft) is the Government of Liberia's five-year development strategy. It follows the Lift Liberia Poverty Reduction Strategy (PRS), which raised Liberia from post-conflict emergency reconstruction and positioned it for future growth. The Aft in itself will—in its five year timeframe—not be able to achieve all that Liberia is poised to do. Rather it is the first step in achieving the goals set out in Liberia Rising 2030, Liberia's long-term vision of socio-economic development. The Aft sets out precise goals and objectives that Liberia will achieve in the next five years in order to take the necessary steps toward its long-term goals, which are to become a more prosperous and a more inclusive society. This Aft supports the principles of the Paris Declaration, Accra Action Plan, and the New Deal for Engagement in Fragile States, to which Liberia is a signatory of these three donor frameworks.

WATER, SANITATION AND HYGIENE (WASH)

The already weak water, sanitation and hygiene (WASH) infrastructure in Liberia suffered deep destruction and collapse in many areas during the civil war. In Monrovia, household connections to piped water fell to one tenth of pre-conflict levels. With some recovery since 2003, an estimated 62 percent of the Liberian population now has access to protected water sources, mainly wells or boreholes with hand pumps, springs and harvested rainwater. Only a third of the population has access to water sources with adequate yield all year round, however. Water safety is also threatened by unsafe storage practices, with an estimated 63 percent of households storing water in open containers, risking contamination.

The situation for sanitation is worse, with only 25 percent of households (53 percent urban and 17 percent rural) having access to improved sanitation. This threatens the gains from access to protected water sources. The prevalence of open defecation (77 percent of rural households and 30 percent of urban households) and lack of solid waste disposal or sewerage systems, poor drainage and poor disposal of garbage all pose contamination threats to drinking water. This has intensified the sense of squalor and poor quality of life, particularly for Liberians living in urban slum areas. Also, 43 percent of households in Liberia do not practice hand washing with soap, while 62 percent do not wash hands after using the toilet and a further 68 percent reported that they do not wash hands before eating. These trends put the health of communities at risk (especially under-5 children and the elderly) and erode the quality of life for Liberians through the following: lack of clean water for drinking and personal hygiene; the debilitating impact of water-borne diseases; the time spent (by women and girls) in fetching water; and the general malaise of living in environmental squalor.

In Monrovia a solid waste disposal program has made reasonable progress, including establishment of an environmentally acceptable landfill, but the rest of the country has no disposal program. It will be critical to develop a comprehensive policy on solid waste for Liberia, as well as to set up a National Water Resources and Sanitation Board to address the fragmentation in this sector.

In 2011, Liberia issued its official WASH Compact: Water and Sanitation for All: A Global Framework for Action, on which this section is based.

Goal: To increase access to safe water supply and sanitation and improve hygiene practices.

Constraints: Lack of financing for infrastructure investments has hindered improvement of water supply, waste disposal, garbage disposal and drainage. There is limited human resource and technical capacity in WASH, and there is no board or similar body to coordinate the operations of the sector. Service coverage needs to be multi-dimensional so that advances in an area like water supply are not compromised by negative trends in other areas like solid waste disposal or hygiene behavior. Many communities are resistant to change of health habits and practices; they adhere to unsafe hygiene practices due to cultural traditions and lack of means to change. When people lack clean water, soap or solid waste disposal, they find it difficult to change their hygiene behavior, even when they are aware of good practices.

Strategic objectives: 1) Manage, expand and sustain Liberia's WASH services through a clear, functional and inclusive WASH governance structure and with strengthened operational guidelines, training and financing. 2) Expand equitable access to environmentally-friendly and sustainable water, sanitation services and solid waste management—including for the poorest and most vulnerable communities. 3) Increase safe hygiene practices (e.g., hand washing and reduced open defecation), and strengthening

community organizations and schools. 4) Improve WASH sector capacity and engagement with stakeholders, and strengthen WASH monitoring and information management systems. The following are based on the four commitments in Liberia's 2011 WASH Compact: Establish and strengthen institutional capacity; ensure equity and prioritized service provision; develop a monitoring system; and improve sector financing mechanisms.

Agents and process for change: The government will establish and make functional the National Water Resource and Sanitation Board (NWRSB), which will implement sector policy and provide technical support to municipalities and rural water and sanitation boards. The NWRSB will coordinate WASH sector activities of Liberia Water and Sanitation Commission, MPW, MOE and MOLME, and will work with them on institutional capacity building. Further, NWRSB will strengthen its own M&E units and will establish information management systems that feed information to the national WASH Information Center. The NWRSB will also work with MOE, the Liberia Water and Sewer Corporation (LWSC), CSOs and municipalities to educate households on safe hygiene practices. CSOs will advocate for sufficient attention and funding for the sector.

Outcome Indicators by 2017: A major increase in the share of households, institutions and communities both urban and rural that have access to improved WASH facilities. Infection rates from water-borne diseases, malaria and other environment-related diseases will decline. Disposal of solid waste in unmanaged sites (like streams and backyards) will decline. Priority interventions: The NWRSB will be established with a clear mandate, adequate personnel, appropriate training and sustainable financing. The NWRSB and its subsidiaries (National Water, Sanitation and Hygiene Promotion Committee, Water Supply and Sanitation Commission, Rural Water Supply and Sanitation Bureau, and Directorate of Community Mobilization and Hygiene Promotion) will implement and monitor appropriate WASH standards and regulation protocols. At national and county levels, government will establish and implement a prioritized sector investment plan to increase water and sanitation services (including for liquid and solid waste). Government in collaboration with donors will establish a pooled funding mechanism for the sector. It will strengthen the entities and institutions responsible for providing WASH services, especially at the municipal level. It will also support WASH services in schools and health facilities, including information and advisory services to improve hygiene behaviors.

5. BENEFICIARIES

Abdulai Jalloh, A., Harold Roy-Macauley, H., Sereme, P. (2012). Major agro-ecosystems of West and Central Africa: Brief description, species richness, management, environmental limitations and concerns. *Agriculture, Ecosystems and Environment* 157 (2012) 5– 16

The West and Central Africa (WCA) sub region covers a total area of over 11.5 million km² with a population of over 318 million. Most of the rural population in WCA are poor and food insecure and about 70% of the people in the region depends on agriculture, which accounts for over 35% of Gross Domestic Product (GDP) and over 40% of its export. The agroecological zones of WCA are closely related to the agro climatic zones of the region with rainfall decreasing from the southern coast in the forest region to the sub humid and semi arid Sahelian region in the north. The major agroecosystems of WCA include the semi arid, sub humid, humid forest, and swamp. Growing populations, inappropriate agricultural practices and changing climate in the region are influencing the composition and ability of agroecosystems in providing much

needed ecosystem services. Coordinating efforts to tackle these challenges and leverage opportunities for sustainable agricultural production while ensuring conservation of the diverse ecosystems in the region is therefore a major preoccupation of the West and Central African Council for Agricultural Research and Development (CORAF/WECARD).

Ministry of Lands, Mines and Energy- MLME, 2013. Liberia Investment Plan for Renewable Energy. Rural and Renewable Energy Agency. Ministry of Lands, Mines and Energy, Republic of Liberia

The Liberia Investment Plan for Renewable Energy (IPRE) aims to support the government's objective of increasing access to electricity and so accelerate the country's reconstruction and economic revitalization. The IPRE is fully aligned with the government's Agenda for Transformation, which aims to transform Liberia into a more prosperous, inclusive, middleincome society.

The high cost and lack of reliable access to electricity remain key obstacles to the country's stability and sustainable economic growth. As of 2013, Liberia has what is likely the world's lowest rate of access to public electricity—1.6 percent nationwide and 6.7 percent in the capital city, Monrovia. To assess the investment required to close the electricity gap and support economic development, the government is preparing a Least Cost Power Development Plan that aims to identify the scale and type of investments required to achieve 70 percent household coverage in greater Monrovia and to indicate the options to reach 35 percent in the rest of the country by 2030.

Complementing the Least Cost Power Development Plan, the IPRE focuses on off-grid areas where extending the main grid will not be cost-effective in the near future. It provides a road map for scaling up renewable energy interventions to increase access, reduce overreliance on imported fossil fuels and strike a balance between rural and urban areas in electricity provision. The IPRE will provide financial support and technical assistance to implement and test several business models for delivering renewable energy services outside greater Monrovia and will help create an enabling environment to attract the private sector in the medium and long term. International development partners are essential to help implement the plan.

In a country where fuel delivery is a major logistical and costly challenge, exploitation of local renewable energy resources offers a way to bring electricity services sooner and at lower costs to more remote communities.

Therefore, the Liberian government, with support from the international community, commits to adopting an aggressive and responsive access agenda by increasing the share of renewable energy in the provision of electricity.

Renewable energy development status

Renewable energy resources play a key role in meeting energy demand in a sustainable and affordable manner.

Large Hydropower Generation

Liberia has six major rivers, which drain two-thirds of the country's water.¹⁵ This intensive drainage pattern indicates considerable potential for hydroelectric power in Liberia of up to 1,000 MW. But with no elevated terrain, the preferred technological option is run-of-river plants. Additionally, Liberia's

hydrological resources for power generation vary greatly between seasons. Thus large-scale hydropower generation will require a combination of upstream reservoirs as well as thermal power generation.

Feasibility studies in 1976–83 identified 11 sites larger than 20 MW in the six main rivers and eight sites of 10–20 MW. Four sites (Table 3.1) have been further analyzed at prefeasibility level but will require in-depth analysis to assess the potential environmental and social impact, particularly the Via Reservoir, which offers a more even distribution of water throughout the year. The scale (617 MW in all) and links between these sites suggest a sequential implementation that will have to be studied in further detail, taking into account the country and region’s demand for power, improved hydrological data, more advanced designs and cost estimates, as well as the environmental and social impacts.

The MLME is leading the rehabilitation of the Mount Coffee hydropower plant, which will provide around 80 MW of continuous hydropower in the wet season and about 20 MW in the dry season. Its commissioning is expected by the end of 2015. The rehabilitation cost, around \$230 million, is being financed by the Liberian government, the Norwegian government, the European Investment Bank and Kreditanstalt für Wiederaufbau (KfW). The MLME is leading the prefeasibility study of the Via Reservoir with support of the European Commission.

Small Hydropower Generation

Two desk reviews—DECON (1983) and Geoscience (1998)—identified 31 sites for small hydroplants (Annex 3; Annex 4 presents a list of renewable energy pilots of all types). Before the war, only two sites had been developed: Firestone Plantation has a 4 MW hydropower plant in operation, providing electricity to its factories and several other villages, and a 60 kW micro-hydro in Yandohun in Bong County, which was destroyed during the war.

Table 3.2 displays information on the first mini-grid pilots based on small and micro-hydro. The Yandohun micro-hydro, implemented by RREA and financed by the World Bank, involved the rehabilitation of 60 kW to serve 240 households and was commissioned in May 2013. It is the country’s first community-owned power system. The Mein River Hydropower Project in Suakoko District, financed by USAID through the Liberia Energy Sector Support Project (LESSP), and the Nimba County project, supported by UNIDO and aiming to install multipurpose mini-hydro infrastructure, are still at the feasibility stage.