
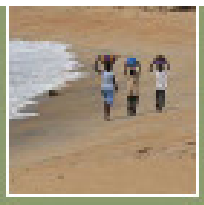
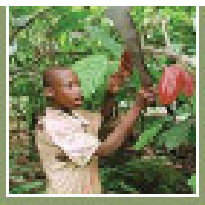
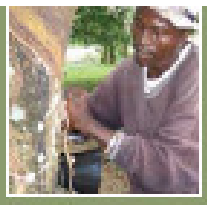

Republic of Liberia
Ministry of Agriculture
Comprehensive Assessment of the Agriculture Sector
Volume 2.2 - Sub-Sector Reports

IFAD

MINISTRY OF AGRICULTURE

COMPREHENSIVE ASSESSMENT OF THE AGRICULTURE SECTOR IN LIBERIA (CAAS-Lib)

Volume 2.2 - Sub-Sector Reports

Liberia 2007

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Liberia 2007

I. LAND AND WATER MANAGEMENT COMPONENT

EXECUTIVE SUMMARY

The Comprehensive Assessment of the Agricultural Sector of Liberia (CAAS-Lib) was launched by the Government of Liberia, with assistance from the Food and Agriculture Organization of the United Nations (FAO), the World Bank and the International Fund for Agricultural Development (IFAD), to provide a vision and policy and programme options for the agricultural sector and for food security, and also to help the sector institutions prepare themselves for the transition to nation-building after nearly 14 years of war and destruction of life and property. The review comes at a time of transition from war to peace and nation building by the recent process of democratic elections and also the Millennium Development Goal (MDG) that calls for halving of the number of poor and hungry people by 2015.

As a sub-sector report contributing to the overall review, the main tasks of this study are to: review information on the resource base and analyse the land and water sector data, bearing in mind the environmental issues; review past and present water development and management projects with regard to water control and soil conservation; analyse options for development of water and soil conservation projects as priority investments; review planned overlapping activities in the sector and formulate implementation strategies.

Located on the west coast of Africa, Liberia ($4^{o}18'$, $8^{o}30'$ north; $7^{o}30'$, $11^{o}30'$ west) occupies a land area of approximately 111 370 km^2 of which 96 160 km^2 (86 percent) is dry land. The rest, 15 210 km^2 and constituting 14 percent of the surface area, is covered by water. It shares borders with Guinea to the north, Côte d'Ivoire to the northeast and east, Sierra Leone to the northwest and the Atlantic Ocean to the south and southwest, with a coastline of about 520 km in length.

The population is estimated at approximately 3.5 million (2004 figure), 52 percent of which is rural, with an estimated total of about 230 000 farming families. It is estimated that Monrovia alone accounts for nearly 40 percent of the population, with most of the returning refugees preferring to settle in Monrovia. At a projected growth rate of 2.3 percent per annum, the population is expected to reach approximately 5 million in 2020. According to the Ministry of Agriculture (MOA; 2006), approximately 40 percent of the total population of Liberia is between the ages of 15 and 35 years.

Liberia's economy, as described by the contribution of the various sectors to the gross domestic product (GDP), can be summarized for the period 1997 to 2005 as: agriculture and forestry (64–77 percent); industry (4–10 percent); services (19–26 percent). The unstable economic environment resulted in the decline of the contribution of industry to the GDP, particularly when most of the revenues from mining were unaccounted for. The war in Liberia has rendered the country one of the poorest in the world, with a reported per capita GDP of approximately US$ 130 in 2003. Eight out of every ten people are said to be living on less than a dollar a day. The Government's strategy for poverty reduction has been first to stabilize the economy and secondly to increase resource allocation to the social sectors.

The climate of Liberia can be summarized as follows: rainfall ranges from about 1 700 mm in the north to > 4 500 mm in the south; temperature 24–28 ^{o}C; relative humidity 65–> 80 percent; sunshine duration 2–8 hours/day; evapotranspiration 3.0–4.5 mm/day. The wind

conditions are described as generally mild. The topography comprises mainly flat to rolling coastal plains running into some interior plateaus and then mountains in the northeastern part of the country. The country is made up of four physiographical units: coastal plains (0-100 m), interior hills (100–300 m), interior plateaus (300–600m) and the mountainous areas (> 600m). The country has nine major river systems, all of which are perennial, and run in a northeast to southwest direction into the Atlantic Ocean, draining about 66 percent of the country and taking their sources from neighbouring Sierra Leone, Guinea or Côte d'Ivoire. There are also short coastal water courses, draining about 3 percent of the country. The total renewable water resource is estimated at approximately 232 km^3/year, making Liberia one of the African countries with the highest *per capita* renewable water resources, about 71 000 m^3/year.

The geology of Liberia can be classified into three major rock age provinces: the Liberian age province (2.7 billion years), the Eburnean age province (2 billion years) and the Pan African age province (0.55 billion years). There are three types of soil in Liberia, namely laterites (latosols), sand (regosols) and swamp, covering 75, 21 and 4 percent, respectively, of the land surface.

Nearly 5.4 percent of Liberian land, amounting to about 600 000 ha, is said to be cultivated, and 220 000 ha of this is reported to be under permanent crop or plantation, while the rest is arable. Broadly, the land can be divided into uplands and lowlands or swamps. Swamps can be classified as mangrove, riverine grassland, floodplains or inland valleys. The level of suitability of the swamps for production is not known because they have not been characterized, but there is a general assumption that the swamps are more productive when used for growing rice.

Irrigation potential is estimated at about 600 000 ha, but only approximately 1 000 ha can be described as having a surface irrigation facility. The total water-managed area in 1987, including swamp rice control, was estimated at about 20 100 ha. This includes equipped lowlands (2 000 ha) and non-equipped cultivated swamps (18 000). Therefore, in the real sense of the word, irrigation infrastructure is virtually non-existent, despite the presence of abundant water resources in the country. Areas with good water control and having the possibility of two crops per year are limited. There are also peri-urban irrigation activities around Monrovia, but the method of irrigation is predominantly by hand.

On the issue of water ownership, control and use, there are no statutory regulations. Ownership of water running in a defined channel (e.g. a river) is not properly understood because water is generally assumed to be a free gift. Individual land ownership presupposes a riparian right on the resources that are on or underneath the land.

With regard to the beneficial uses of water, the provision of water supply and sewerage services to the public is the responsibility of the Liberia Water and Sewer Corporation (LWSC). Regulations govern the legality of connections and illegal connections are punishable by law. Also, local authorities are vested with the responsibility to prevent and remedy pollution of fresh water used by the public for drinking and domestic purposes. Unwholesome sources of water supply, whether public or private, are prohibited by law. The law allows for catchment area protection of public water supply schemes and punishes anyone whose activities within such defined boundaries will impact negatively on the water source.

Regarding the control and protection of water works, the design and construction of public water works largely appears to be the responsibility of the Ministry of Public Works (MPW). Arguably, private water supply, hydroelectric works, drainage and sewerage works and those pertaining to field water control are subject to the technical control of the MPW. A permit from the Forestry Development Authority (FDA) is required for the damming of rivers and streams within the boundaries of forest reserves and national parks.

With respect to health-related issues, the discharge of wastewater from any premises into swamps, watercourses or irrigation channels is regarded by the health legislation in force as a statutory nuisance, punishable by law. Groundwater exploitation for any purpose is subject to prior health clearance in the form of a permit from the local health authority.

It must be noted that no clear reference is made to the development and use of agricultural water resources but this is inferred from other legislation affecting water works in general and forestry issues in particular, including matters of forest water resources and catchment protection.

The development, conservation and use of the country's freshwater resources are subject to fragmentation of responsibilities among several branches of the Government and two public utility companies. A draft bill for the establishment of a Water Resources Board (WRB) draws membership from seven ministries, the LWSC and LEC (Liberia Electricity Corporation); two additional members are appointed by the Minister of Water Resources (MWR). The WRB is expected to have the following functions:

- to formulate policies for the conservation, development and best use of the water resources of Liberia;
- to coordinate all public and private projects and programmes concerning the conservation, development and use of water resources;
- to advise the Minister on measures for the implementation of water resources policies and plans and on all matters concerning the conservation, development and use of water resources.

Liberia shares international water resources with her neighbours: St John Basin (Liberia and Guinea), St Paul Basin (Liberia and Guinea), the Cestos Basin (Liberia and Côte d'Ivoire), the Cavalla Basin (Liberia and Côte d'Ivoire), the Moa Basin (Liberia, Sierra Leone and Guinea); and the Mano Basin (Liberia and Sierra Leone). Numerous bilateral treaties have successively governed the delimitation of the frontier of Liberia since 1885 on the Mano River and since 1892 on the Moa River. Some of these treaties have provided for the freedom of navigation and transit fishing and the protection of existing water use rights for the local population.

There are nine major rivers in Liberia with catchment areas varying from 4 000 (Farmington/Du) to 28 000 km^2 (Cavalla). The Mano, Lofa, St Paul, St John, Cestos and Cavalla together drain approximately 65.5 percent of the country. The river flow of the Cavalla at Nyakee in the 1960/61 water year amounted to about 13 km^3/year. The average discharge for St Paul at Mt Coffee for the 1958/66 water years amounted to about 19.2 km^3/year. A water balance study for the Du river catchments upstream of Kakata, with an area of 326 km^2, made over 4 years showed that the mean annual rainfall, runoff and evapotranspiration equalled 2 742 mm, 1 150 mm and 1 592 mm, respectively, with a runoff coefficient of 0.42. A similar study of a 0.7 km^2 area of the steep natural rainforest

catchments of Weakpor creek, based on monitoring for one year, showed annual rainfall, runoff and evapotranspiration of 2 860 mm, 1 320 mm and 1 540 mm, respectively, and the runoff coefficient was 0.46.

The Liberian hydrological year starts in April and ends in the March of the following year. The Liberia Hydrological Service (LHS), part of the Ministry of Water Resources (MWR), is responsible for the collection of hydrometeorological statistics. There were 47 hydrometeorological stations in Liberia before the war and rainfall statistics date back to 1927 at the Ganta station, for example. The stations were operational until 1989. Since 1990, there have been no new records made because of the civil strife. Practically speaking, all the meteorological stations were destroyed during the war except one in western Liberia. There is now, therefore, an urgency to establish and modernize new stations. It must also be noted that the data that were collected previously contain many gaps, and the paucity of data is worth noting. It is simply not possible currently to obtain any meaningful data from existing information, over the full range of meteorological statistics, particularly rainfall, temperature, relative humidity, wind velocity and sunshine duration, for any single station in the country.

Hydropower plants located on the St Paul River and Farmington/Du River have all been destroyed in the war and, because of the cost of building power plants, it will take a considerable time for such ventures to be undertaken to ease the power shortage in Liberia. Nine potential sites have been identified on the rivers Mano, Lofa, St Paul, St John and Cavalla for possible future power plants. This, if achieved, will greatly augment the power supplies of the country. Exploration of hydropower potential on the Lofa River has revealed that several falls and rapids between Lofa and Baha town fulfil the conditions of low-head hydropower plants, for which dams and spillways are not required.

It can be argued from a global perspective that water is not in short supply in Liberia. However, in many local areas this is not true, and a number of swamp thickets have been removed for agricultural purposes. There is evidence to suggest that minor tributaries that used to be perennial have become seasonal due to excessive removal of vegetation cover. Because there are few measured data to suggest that the river flows are reduced, we can only speculate. There is also evidence to suggest that fallow periods could be reduced, especially on upland farms, as a result of population pressure. This land use pattern can threaten water resources and it is imperative that measures are taken at the community level to reverse the trend.

There is a lack of data on groundwater resources in Liberia. There has been some exploitation of groundwater for rural water supplies but hydrogeological data is woefully lacking. Liberia can be divided into three areas according to the occurrence of groundwater, namely the soft rock areas that consist of sedimentary rocks, the fractured/fissured hard rocks and the weathered igneous and metamorphic rocks. The quaternary sediments, which constitute the younger sedimentary rocks, are shallow; they are up to about 30 m deep, 35–40 m thick and are more than 15 000 years old. The extent of the fractured hard rock areas is not known and it is important to perform exploratory investigations to establish the extent of these possible aquifers. The weathered igneous and metamorphic rocks are soft rocks with appreciable porosity and hydraulic permeability; these are over-burdened rocks, not more than 30 m deep and are also not extensive.

Soil survey and classification. Prior to 1987, surveys of a large number of small farms were carried out by the Land and Water Resources Department of the Central Research Institute

(CARI) in Suakoko and the Land Development Division of the Ministry of Agriculture in Monrovia. These surveys were designed to assist in the production of food and cash crops. Medium-scale surveys of large farms were undertaken by different bodies, and provided information on land resources for widely ranging objectives. In addition, large-scale area-oriented surveys of land capability and crop suitability were carried out by integrated agricultural development projects in Lofa, Bong and Nimba counties in northern and northeastern Liberia. In the southeastern part of the country a survey of Grand Gedeh County identified suitable areas for lowland rice and tree crops (cocoa and coffee).

The earliest survey of soils was a national exploratory survey carried out in 1951. It was based on flights over the country and observation along accessible motor routes. A national soil map was produced at a scale of 1:300 000 showing five soil "associations". The description of the soil associations provided some indication of the landforms and the report also provides some idea of the chemical status and an indication of the appropriate use of the land. Although such a survey cannot be used with any reliability for either national or regional planning, it provides the first account of the range of soils to be found in Liberia. In this survey, much of central Liberia is indicated as having very shallow soils (lithosols), but with latosols around the margins. In 1977, the Soil Division of the former Central Agriculture Experiment Station (CARES), with Geiger, established a catalogue of soil series that had been defined up to that time in Liberia. A description is given of each series together with its classification (soil taxonomy) and an indication as to its use. However, the series described were established mainly in Bong County and neighbouring areas, where most soil surveys had been undertaken.

Detailed surveys of the selected swamps and lateral slopes were conducted along trace lines spaced 100 m apart. Mapping was done at a scale of 1:2 000, with separate sheets showing soil types and land suitability for rice and for dry land cropping. Soil texture proved to be the principal factor that determines suitability in swamp areas; soil depth and gravel content were the principal determinants of suitability for dry land crops on the lateral slopes. The soil analysis results indicated that the soils have very low fertility. Infiltration rates and hydraulic conductivity are relatively high in the coarser-textured swamp soils. Five selected swamps totalling 596 ha were surveyed at a detailed level, of which 146 ha were suitable for rice and 128 ha were suitable for dry land cropping. Some 222 ha were found to be unsuitable for cropping.

In this survey two farming systems were identified within the villages, namely an upland farming system and a village farming system, the former is the principal source of the staple subsistence food (rice) and receives priority in terms of labour resources. Surplus labour, if available, is utilized on the village farms, which are oriented towards cash crops, such as tree crops (coffee and cocoa), vegetables and swamp rice. A tentative analysis of the correlation between soil mapping units and other classification systems was performed.

Land Tenure. At independence in 1850, the Government of Liberia vested all land in the state. By the time of the Land Act of 11 January 1850, all Liberians had the right to own land, if feasible, and the process of land acquisition was relatively easy. Under the Anglo-American deed system of land acquisition, Presidential assent was required. Rural land is still under some customary tenure but there is no security in the customary tenure system. According to the Government of Liberia (GOL, 1980), an environment conducive to development must, among other things, include a land tenure system that permits a farmer to feel secure in the use of land, especially where land improvements are involved.

Land in Liberia is divided into lots; 4 lots are equivalent to 1 acre. The cost of acquisition of 1 acre of land in 1850 was US$0.50 but, at present, the same area of land may sell for US$120.

There is no comprehensive policy on the acquisition of land for agricultural purposes, and GoL is silent on the payment of fees. The GOL grants leases to private investors, and land fees are negotiable. The MOA determines fees for agricultural land acquired for private use, although the Ministry of Lands, Mines and Energy (MLME) manages the process of land acquisition.

Land use and forestry. The first comprehensive land use map of Liberia was prepared in 1956 from aerial photographs taken in 1953. At the time, the map showed extensive forest vegetation in the northwest and southeast, with some agricultural areas. In 1981, another land use map was prepared from aerial photographs taken in 1979. This revealed the extensive depletion of forest cover, largely due to farming activities. Apart from the plantations (rubber, cocoa, coffee and oil-palm), which are noted for providing surface cover and minimizing soil erosion, the farming system has largely been one of shifting cultivation, with a fallow period of 9–10 years. Deforestation is said to occur at a rate of 1.5–2 percent per annum.

In 1976, the GOL passed a special Act creating the FDA as the sole institution with authority to manage Liberia's forest estate (Working Group on Liberia's Protected Area Network, 2006). For administrative purposes, Liberia is divided into four forestry regions that are managed by the FDA. These forests are said to be home to about 2 000 species of flowering plant, 150 species of mammal, 620 species of bird, 125 species of reptile and amphibian and over 1 000 described insect species. However, Liberia's forest habitat and biodiversity face increasing threats from slash-and-burn agriculture, mining, logging and the migration of rural settlements.

The FDA now proposes a sustainable forest management policy known as the 3C policy, the *conservation, community and commercial forestry* policy, where community involvement is seen as an important part of the process of management. The aim of commercial forestry is the sustainable production of forest products and the development of viable forest-based industries. Community forest management focuses more on the interests of the people who live in and on the fringes of forest areas. Alternative livelihood issues are to be considered where dependence on forest resources and products such as wildlife is crucial. The aim of forest conservation is to sustain and enhance biodiversity conservation and to maintain the other environmental functions of forests for current and future generations.

On the issue of **land conservation**, prevention and control of soil erosion, which results from human interference with natural conditions, is indirectly provided for by current forestry legislation to the extent that the use of forests is restricted and forest cover is thereby protected. The commercial exploitation of forests at large is restricted with regard to the size of trees that can be felled and additional restriction may be placed on the exercise of timber concessions from the Government. In addition, the GOL may set aside forests for controlled use of natural resources therein.

Wetlands. The wetlands of Liberia that have been designated potential Ramsar sites for conservation include Lake Piso, Marshall Mesurado, Lake Shepherd, Bafu Bay, Cestos-Senkwehn, Gbedin and Kpatawee, as shown in Table 13. It is expected that an inventory and a management plan will be developed for the sustainable management of these wetlands.

These lands are generally considered as wastelands but they are home to important biodiversity and have key economic importance for many Liberians engaged in inland fisheries and swamp rice development.

Land capability studies. These were undertaken as detailed surveys of selected swamps and exploratory semi-detailed surveys of dry land farming areas around selected villages. The semi-detailed surveys extended over the areas affected by cultivation. Maps of vegetation and land use, soils and land capability were compiled at a scale of 1:20 000. Broad patterns of soils were mapped using the "soil family" concept, and land was classified according to a modified version of the United States land capability system Large areas of the land were found to be only marginally suitable for cropping, due to shallow soil depth or excessive gravel content. The maps provide general indications of the features of the village lands and serve as a basis for future integrated development of both irrigated rice and dry land crops.

Agricultural land capability. Land types include tidal swamps, coastal beach plains, flood plains, valley swamps and low and high hills. In the case of the tidal swamps, high tides could destroy crops, requiring substantial investment in drainage if such lands are to be used for agricultural production. The coastal beach plains generally have low fertility and low organic matter content and will require some degree of fertilization when cropped. The flood plains also have the problem of potential flooding that can destroy crops, but proper timing of planting and adequate drainage can improve the situation. The valley swamps, which are potential rice fields, are also poorly drained and have low fertility and organic matter content. Adequate drainage and fertilization can improve their agricultural capability. The low hills are well drained and can be used for upland rice, vegetables and cassava but also have the problem of low fertility and are prone to soil erosion. Fertilization and long fallow periods can improve the agricultural capability of the soil.

Agricultural land and water projects. In the 1970s up to the mid-1980s, a number of large, medium and small agricultural development projects were undertaken in Liberia as part of Government efforts to feed the nation and provide certain raw materials for export. These included a number of water control projects for swamp rice development and oil-palm development.

The large projects included the Lofa County Agricultural Development Project (LCADP), the Bong County Agricultural Development Project (BCADP), the Nimba County Integrated Rural Development Projects I and II (NCIRDP I and II), the South East Rural Development Project (SERUDEP) in Grand Gedeh, Maryland and Sinoe Counties, the Central Montserrado Development Project (MDP) and the Special Rice Projects (SRP) at Zleh Town and Foya. The BF Goodrich Liberia Incorporated Rubber Concession was also undertaken to increase the export of rubber.

The medium to small projects included the SRPs in Philadelphia, Balabokree, Gbedin, Kpein, Kpatawee and Garwula-Tombe. Land areas for the projects ranged from 13 ha for the Kpatawee scheme to 2 272 ha for the Cestos scheme (Table 15). Unfortunately, these projects have deteriorated and the situation has been made worse by destruction of resources during the war and inadequate maintenance of the schemes. There is the need to reclaim these swamps in the short term and to develop additional areas in the long term. Funding for these projects was provided largely by the International Development Agency (IDA), the European Development Fund (EDF) and the African Development Bank (ADB). The Chinese Government also undertook a number of swamp projects.

Since 1994, FAO, along with several other donors, has been assisting Liberia with emergency operations, mainly supplying farmers with agricultural inputs, notably seeds and tools. It was not until February 1997, however, that Liberia expressed interest in participating in the Special Programme for Food Security (SPFS). In May 1997, an FAO exploratory mission visited Liberia to determine the nature and scope of the SPFS, which resulted in the signing of an agreement in February 2000 to implement a pilot phase of Technical Cooperation Programme (TCP) Assistance at six selected sites. The project, which aimed to demonstrate technologies for water management and control for the upland and swampland agro-ecologies, proposed to cover 50 farmers at each site for a total participating farm population of 300 farmers, 40 percent of whom were expected to be female farmers. The project was expected to cover about 600 ha for upland crops and 100 ha for swamp rice.

A number of other local and international NGOs are supporting various aspects of land and water resources projects including forestry development projects. Fauna and Flora International (FFI), the Sustainable Development Institute (SDI), Conservation International (CI) and the Global Environmental Fund (GEF) are supporting forestry projects in Liberia. Two pilot community forestry projects are proposed for implementation, and the World Bank, the FFI and GEF are currently undertaking a community forestry study for Sapo National Park. Some NGOs that are involved in water projects and supported by USAID include the Catholic Relief Service (CRS), World Vision International (WVI), the Mercy Corps, the Liberia Community Infrastructure Project (LCIP), AFRICARE, and the African Development Aid Foundation (FDA). Agencies of the UN, such as FAO, WFP, UNDP, UNICEF, UNHCR, UNEP and UNIFEM, are actively involved in postwar nation-building; some of them are channelling their resources through local NGOs. The United Nations Mission in Liberia (UNMIL), whose mandate is to keep peace in Liberia, is also involved in supporting postwar nation-building.

Agencies of the UN such as FAO have, since 2005, been supporting rehabilitation of old swamp areas in Lofa County, for example, by training ex-combatants in sustainable livelihood activities. A monthly subsistence allowance of US$30 per participant which was provided as an incentive for resettling the ex-combatants did not prove successful because most of the trainees did not go back to swamp rice cultivation. Currently such financial incentives have been discontinued and the assistance generally provided is in the form of inputs for communities, such as seeds, farming tools and training. There is also a system of food-for-work assistance being provided by the WFP but this has also run into various problems.

Agricultural water management. Managing water for agriculture starts with the assessment of the water demands made by the crop and its environment. This is referred to as crop evapotranspiration or crop water requirements. As already stated, there are few data on crop water requirements and there are insufficient data available to enable such computations to be made. The two most important food crops in Liberia that require consideration of water control and management are rice and vegetables. As reported in interviews, farmers would prefer long-duration and high-yielding rice varieties for one main crop in the rainy season to two short-duration, low-yielding varieties. Yields for the second rice crop are generally very low. It has also been concluded that crop maturity and harvest periods should not occur in September because rice consumption by birds is at its peak at this time of year.

The **swamps** are used extensively for the production of mainly rice in the rainy season and vegetables during the dry season. Other crops such as cassava are planted on mounds. These

are uprooted and stem cuttings transferred and planted on the uplands at the beginning of the rice growing season when the mounds face the danger of submergence. Mounds areconstructed by inversion of soil and burying of stubble/grass, which helps to decompose plant materials and improve soil fertility. A few swamps attempt two rice crops a year and these are mainly the perennial swamps. Drainage is generally poor.

The typical lowland rice production activity involves nursery, brushing and clearing, ploughing, pudding and transplanting, weeding, fertilizer application (if needed) and harvesting. Clearing is not a major activity in the north. Fertilizer application is almost non-existent due to its high cost and poor availability. The typical main drain/canal embankment specification is 75–100 cm crest width, 75–100 cm height and 150–200 cm base width. The field bunds have the following typical specifications: 50–70 cm crest width, 40–60 cm height and 90–150 cm base width. Most of the work carried out by the Land and Water Resources Development Division (LWRDD) of the MOA has been in lowland water management. The water control systems have generally been poorly designed and constructed, and lack of maintenance has caused the systems to deteriorate, sometimes beyond repair.

The typical lowland water control system is tedious and sometimes difficult. The water control activities include digging of canals/drains, clearing of canals/drains, bunding, flooding, drainage, ploughing and puddling, levelling, and repair of canal/drains/bunds.

The **upland** ecosystem for rice is carried out purely under rainfed conditions and the system of cultivation is shifting cultivation. This farming system is putting a lot of pressure on the country's land resources and it is feared that the fallow periods of 9–10 years may reduce if the trend is not halted. Drainage is generally good on the uplands. The typical farming activities involve brushing, felling, burning, clearing, broadcasting and ploughing, weeding and harvesting. The rice is often mixed with maize and cassava, which are all harvested at different times depending on their growing periods.

The upland soils are generally acidic, with low fertility and low water-holding capacity, and are prone to soil erosion. Unfortunately, upland soil and water management is not so much an issue for the farmers. The reason why these farmers do not pay particular attention to field soil and water conservation practices is an important area of research. The farmers, however, complain that in the recent past delays in the onset of the rainy season have led to late planting. This shows that rainfall patterns are changing and poses a new challenge to agricultural water management.

Farmers that crop land on the slopes are faced with different problems of soil water management in a typically rainfed culture. It is generally known that soil water on slopes depletes much more quickly because of faster subsurface flow induced by the generally acute slopes. There is also the risk of soil erosion and nutrient loss on the slopes. On the whole, drainage is generally good on the slopes. Little attention has been paid to the land and water management problems of this group of farmers. It must be noted that there has been little focus on these farmers in the work of the LWRDD.

Another aspect of lowland water management falls under what is known as **recession agriculture**. Practised largely during the dry season, the farmers take advantage of the residual moisture of the soil in the swamps to grow vegetables. Also, **upland irrigation** has not been seriously considered an issue in Liberia probably because of water surpluses in all the agro-ecological zones and the availability of large areas of swamp for rice and vegetable

production. **Urban and peri-urban agriculture** is also practised on a limited scale in Liberia, taking advantage of the ready market in the urban centres for vegetable crops produced through such activities. There is potential for the use of motorized pumps for irrigation from shallow wells in support of urban and peri-urban agricultural activities, especially in and around Monrovia.

Demand for rice land and water. A rice production analysis showed that, on average, coupled with upland rice production, it will require swampland expansion of approximately 10 000 ha/year to achieve the projected food self-sufficiency target. It must be noted that 4 percent of Liberian land, amounting to about 445 500 ha, are designated as swamp and 8 352 750 ha as uplands. Before the war cropped land was recorded as 600 000 ha, of which 220 000 ha was permanent cropland and the rest (380 000 ha) was arable cropland. Assuming a minimum fallow period of 10 years this implies that a total of about 464 000 ha would have to be available for upland rice production, amounting to 5.5 percent of the total upland area of Liberia. By this analysis, it will only be necessary to bring about 37 percent of the swamp under rice production over a period of 10 years to achieve self-sufficiency in rice. On the whole, at the current level of rice production, it will require an expansion of 20,000-25,000 ha of both upland and lowland rice for 10 years for Liberia to achieve self-sufficiency in rice production.

With regard to water resources, assuming 1 500 mm of water is required for the rice crop, and considering surface evaporation, drainage and other losses, a total land area of about 400 000 ha of both upland and swamp rice will require an annual renewable water supply of about 6 billion m^3 or 6 km^3/year. This is only about 2.6 percent of the total annual renewable water resource of 232 km^3/year.

In Liberia, rice research at the international level used to be undertaken by the West Africa Rice Development Association (WARDA) until the late 1980s, when it relocated to Côte d'Ivoire at the beginning of Liberian civil strife. At the local level, rice research is undertaken by the Central Agricultural Research Station (CARI) in Gbarnga and by the universities. Some of these institutions have been conducting research over many years, yet basic data such as water requirements for crops, crop coefficients, crop average rooting depth and growth periods are lacking despite the breeding of new crop varieties. Perhaps the abundance of water resources caused the researchers to put more emphasis on other production aspects of rice while neglecting research into agricultural water management. Even in the MDG development priorities for agriculture, water for agriculture does not appear to be a specific issue but is considered within the promotion of the use of improved farming methods.

Institutional set-up and capacity for land and water resource management. Within the MOA, the LWRDD was created with institutional responsibility in the following areas of agricultural development:

- soil survey and classification
- irrigation and drainage
- land evaluation
- land use planning
- cartography and remote sensing.

By implication, the LWRDD must develop and rationalize water resources and agroclimatological activities in relation to agricultural development and the agro-ecological

areas of the country, develop a national soil conservation and management programme geared towards controlling land degradation, develop a national irrigation and drainage programme geared towards reducing dependence on rainfed agriculture, and rationally develop and use agricultural water to take advantage of agroclimatic conditions in the country.

Before the war, in 1990, LWRDD was headed by a Director and a Deputy Director. There were five sectional heads in charge of the technical divisions of soil survey and classification, irrigation and drainage, land evaluation, land use and planning, and cartography and remote sensing. Staffing and human capital has deteriorated following the war.

The LWRDD, as a directorate within MOA, operates at four levels: the headquarters in Monrovia, County, District and Clan levels. During the war, agriculture was badly hit in the districts and many of the staff of MOA, including those of LWRDD, sought refuge in refugee camps and left their stations in the field. As is the case with many Government departments, LWRDD is grossly under-funded and this greatly hampers its work. There is a need to reorganize and strengthen the work of LWRDD by re-equipping it and building the capacity of its staff through pragmatic staff development programmes. It must be noted that important equipment belonging to LWRDD and valued at several thousands of dollars was also destroyed in the war. Apart from the disincentive of low salaries, the war disrupted the programmes of the department and saw the exit of many qualified staff. An example is a 5-year project on land resource assessment for land use planning, which was initiated in 1987, funded by UNDP and the GOL and executed by the FAO/MOA but was disrupted by the war.

Key Findings. Various issues have emerged from the review and analysis of the agricultural land and water sector, as listed below.

- Liberia does not have a policy document on comprehensive water resource development, although there are small pieces of legislation on land, mining, forestry and water supply that relate to water resources.
- The hydrometeorological and hydrological networks in the country are in a very poor state; some stations have been closed down due to lack of equipment and commitment of observers.
- Even though there are insufficient data to support this claim, current land-use practices are deemed to be having an effect on water resources, as suggested by the seasonality of some tributaries that used to be perennial, and changing rainfall patterns.
- There is the general notion that water resources are limitless. The country must seriously engage itself in a more pragmatic way in planning water resources management in the face of current land use practices. Issues of integrated watershed management and the joint administration of international water bodies must be dealt with. This situation requires immediate attention.
- Forest cover is reducing due to current farming practices, thus posing a threat to soil fertility, biodiversity and the water resources of the nation.
- Institutional capacity for managing agricultural land and water is weak and must be strengthened through capacity building and equipping of the water sector agencies.
- Swamp water management is difficult and makes extra demands on the farmers in terms of time, resources and energy. There is a general preference for upland farming even though rice yields are said to be about half those attainable in the lowlands. There are also problems with poor design, construction and maintenance of water control structures.

- Basic water management data for crops are not available and research in Liberia does not seem to consider this a priority, probably because of the abundance of water resources. The emphasis is more on the control of excess water in the lowlands than management of soil water in the uplands.
- Upland water management and water management on slopes are not considered critical issues in the farming community. The upland soils are generally acidic, with low fertility, low water-holding capacity and are prone to soil erosion, yet soil and water management is not so much an issue for the farmers here. The reason why farmers do not pay particular attention to field soil and water conservation practices on the uplands and the slopes is an important area for research.
- Rain-fed agriculture has seen, in recent years, late onset of the rains, which concerns farmers. Could it be that the rainfall patterns are changing due to general land use practices?
- An aspect of lowland agricultural activity, known as recession agriculture, attempts to use residual soil water for agriculture. Farmers at the periphery of water bodies, advancing and retreating depending on the water regime, take advantage of soil water for crop production. Could options such as this be exploited further?
- Conventional upland irrigation is not considered an issue in Liberia because of water surplus in all the agro-ecological zones in the country and the large area of swampland available for development.
- Shallow well irrigation farming and peri-urban irrigation also take place on a limited scale in Liberia. These activities are probably taken for granted and therefore do not receive any recognition in the plans for achieving food security.

Development potential and constraints. An analysis of the development potential and constraints is based on the following observations:

- there is a high potential risk of an irreversible degradation of land and water resources;
- there is a general lack of recognition of the close interrelationships between livelihood strategies, agriculture and the environment;
- institutional capacity in support of agricultural water development and management is weak and needs strengthening;
- other forms of agricultural water uses have potential uses, such as upland supplementary irrigation, lowland shallow well irrigation, recession agriculture and urban/peri-urban agriculture;
- the poor rural infrastructure, comprising rural roads, markets, irrigation systems, water supply, and health and educational facilities, is basic to quality of life in rural areas and is an important factor in economic development;
- poor accessibility, particularly to potentially rich areas, slows down economic activity in terms of mobility and access to important social services such as markets and health infrastructure;
- Liberia has high economic potential, which, if developed, would provide job opportunities for young people and empower women to generate income for personal family needs. The indications are that the level of deprivation is high especially in the rural areas and has been made even worse by the war, but the fact remains that the rural economic potential is high when appropriate measures are taken.

The way forward. With the main objective of seeing agriculture in Liberia becoming a major source of growth and poverty reduction, any **land and water management** interventions must be aimed at:

- enhancing agricultural production and productivity;
- improving rural infrastructure, especially in the area of accessibility;
- fostering participatory community development, recognizing the role of gender in development.

In view of the above, key project components that can be proposed, with justifications, are as follows:

Component 1: **Land and Water Sector Institutional Capacity Building (2–5 years)**
Component 2: **Land and Water Development for Swamp Rice Production (2–10 years)**
Component 3: **Land and Water Development for Upland Rice Production (2–5 years)**
Component 4: **Urban and Peri-urban Agriculture for Women and Youth Groups (3 years)**
Component 5: **Community Watershed Management (1–5 years)**

Project costs, estimated at US$53.7 million, are summarized in the table below.

N°	**Project component**	**Cost (US$)**
1	Land and Water Sector Institutional Capacity Building	2 500 000
2	Land and Water Development for Swamp Rice Production	22 100 000
3	Land and Water Development for Upland Rice Production	3 000 000
4	Urban and Peri-urban Agriculture for Women and Youth Groups	4 500 000
5	Community Watershed Management	7 500 000
	Total	**39 600 000**

It is expected that by the end of the investment phase of the proposed projects, community and individual farm incomes would substantially increase, mainly through increased net returns from improved agricultural production practices and an increase in the areas brought under rice cultivation in the swamps. Flood recession, small-scale irrigation and peri-urban irrigation for production of vegetables would also result in additional benefits. Also, key Government institutions in the water sector and many communities will benefit either directly or indirectly from the projects through investment in physical infrastructure, equipment, training, technical and/or financial support programmes. The private sector agencies that participate in these projects will not only provide jobs but will also have their capacities strengthened.

1. INTRODUCTION

The Comprehensive Assessment of the Agricultural Sector of Liberia (CAAS-Lib) was launched by the Government of Liberia (GOL) with assistance from the Food and Agriculture Organization of the United Nations (FAO), the World Bank and the International Fund for Agricultural Development (IFAD) to provide a vision and policy and programme options for the agricultural sector and for food security, and also to help the sector institutions prepare themselves for the transition to nation-building after nearly 14 years of war and the destruction of life and property.

The review comes at a time of transition from war to peace and nation-building through the recent process of democratic elections and also the Millennium Development Goal (MDG) that calls for halving of the number of poor and hungry people by 2015. The agriculture sector has been considered a major source from which a number of expectations will be met, notably availability and access to nutritious food, employment, improved income and foreign trade. In the emerging phase of recovery and development in Liberia, the sector will provide a reliable base for resettlement and employment.

In line with the above, this report is intended to provide a technical background to the land and water development and management issues necessary for the review and to propose appropriate projects that can be implemented in the short, medium and long term in line with the objective of seeing agriculture in Liberia become a major source of growth and poverty reduction.

2. TERMS OF REFERENCE

The main tasks involved in this study were to review information on the resource base and analyse the land and water sector data, bearing in mind the environmental issues; review past and present water development and management projects with regard to water control and soil conservation; analyse options for development of water and soil conservation projects as priority investments; review planned overlapping activities in the sector and formulate implementation strategies.

3. BACKGROUND

General

Located on the west coast of Africa, Liberia ($4^{o}18'$, $8^{o}30'$ north; $7^{o}30'$, $11^{o}30'$ west) occupies a land area of approximately 111 370 km^2 of which 96 160 km^2 (86 percent) is dry land. The rest, 15 210 km^2 and constituting 14 percent of the surface area, is covered by water. It shares a common border with Guinea to the north, Côte d'Ivoire to the northeast and east, Sierra Leone to the northwest and the Atlantic Ocean to the south and southwest, with a coastline about 520 km long. The population is estimated at about 3.5 million (2004 figure), 52 percent of which is rural, with an estimated total of 230 000 farming families. It is estimated that Monrovia alone accounts for nearly 40 percent of the population, with most of the returning refugees preferring to settle in Monrovia. At a projected growth rate of 2.3 percent per annum, the population is expected to reach approximately 5 million in 2020. According to the Ministry of Agriculture (MOA, 2006), approximately 40 percent of the total population of Liberia is between the ages of 15 and 35 years. Some of the core of the trained workforce that fled abroad is beginning to return home to rebuild the country.

The resource base

Some aspects of the resource base are described in detail in section 3, but some issues will be introduced here within the physical context of the report as brief background information. The climate of Liberia can be summarized as follows: rainfall ranges from about 1 700 mm in the north to > 4 500 mm in the south, see Map 1; the temperature is 24 28 ^{o}C); relative humidity 65–>80 percent); sunshine duration 2–8 hours/day; evapotranspiration 3.0–4.5 mm/day. The wind conditions are described as generally mild. The topography comprises mainly flat to rolling coastal plains running into some interior plateaus and then mountains in the northeastern part of the country. The country is composed of four physiographical units: coastal plains (0–100 m), interior hills (100–300 m), interior plateaus (300–600m) and the mountainous areas (> 600m). The country has nine major river systems, all of which are perennial, and run in a northeast to southwest direction into the Atlantic Ocean, draining about 66 percent of the country and taking their sources from neighbouring Sierra Leone, Guinea or Côte D'Ivoire. There are also short coastal water courses, draining about 3 percent of the country. The total renewable water resource is estimated at about 232 km^3/year, making Liberia one of the African countries with the highest per capita renewable water resources, approximately 71 000 m^3/year. The water resources are further described in section 3 of this report.

The geology of Liberia can be classified into three major rock age provinces: the Liberian age province (2.7 billion years), the Eburnean age province (2 billion years) and the Pan African age province (0.55 billion years). There are three types of soil in Liberia, namely laterites (latosols), sand (regosols) and swamp, covering 75, 21 and 4 percent, respectively, of the land surface (Table 1). Alluvial deposits constitute about 2 percent of the soils in Liberia. Generally, soils in Liberia are characterized by shallow layers of humus, low organic matter content, high acidity, and are deficient in magnesium and calcium, which serve not only as plant nutrients but also neutralize the acid in the soil. The soils range from weakly developed muds and hydromorphic clays along the coast and in the inland swamps to shallow soils on the Plateau Mountains and lateritic hills and terraces in the north. Liberia is also well endowed with mineral resources, the major ones being iron ore and diamonds.

Table 1. Soils of Liberia

Soil type	Liberian classification[1]	Percentage coverage	Area[1] (ha)	Properties
Lateritic soils or latosols	Kakata, Suakoko and Voinjama Series	75	8 352 750	Reddish brown, leached 10 cm topsoil, 4–6 % OM, acidic, well-drained, productive agricultural soils
Regosols or coastal sandy soils	Claratown, Sinko and Freeport Series	20	2 227 400	Well-drained, 60 % coarse sand, very low water holding capacity, little humus and mineral nutrients, not productive agricultural soils
Alluvial soils or swamp soils	Gbelle, Ballam, Grayzohn and Cuttington Series	5	556 850	Waterlogged, grey hydromorphic soils, poor drainage, thick dark layer of loamy-peaty organic material with relatively high humus content.

Source: GOL (1983), [1]Author's Derivation (2006)

Nearly 5.4 percent of Liberian land, amounting to approximately 600 000 ha, is said to be cultivated; 220 000 ha of this area is said to be under permanent crop or plantation, while the

rest is arable (FAO, 2005). Broadly, the cultivated areas are uplands and lowlands or swamps. Swamps can be classified as mangrove swamps, riverine grassland, floodplains and inland valleys. The level of suitability of the swamps is not known as they have not been characterized. There is, however, the general assumption that the swamps are more productive lands for rice growing.

Irrigation potential is estimated at about 600 000 ha but only about 1 000 ha can be described as a surface irrigation facility. The total water managed area in 1987, including swamp rice control, was estimated at about 20 100 ha (FAO, 2005). This area included equipped lowlands (2 000 ha) and non-equipped cultivated swamps (18 000 ha). Therefore, in the real sense of the word, irrigation infrastructure is virtually non-existent because of the abundant water resources present in the country. Areas with good water control and with the possibility of two crops per year are limited. There are also peri-urban irrigation activities around Monrovia but the method of irrigation used here is predominantly manual.

4. WATER RESOURCES LEGISLATION AND ADMINISTRATION IN LIBERIA

4.1 Water resources legislation

In 1983, The United Nations Department of Technical Cooperation for Development assisted the GOL to perform a systematic review of the Liberian legislation and administration on the development, conservation and use of the country's water resources and developed a draft Water Resources (Control and Utilization) Act for consideration by the GOL. Water issues in Liberian law were referred to with regard to the creation of the Ministry of Lands, Mines and Energy (Peoples Redemption Council Decree [PRCD] 55 of 21 October 1981), the Amended Public Authorities Law (approved 30 January 1973) on the establishment of the Liberia Water and Sewer Corporation, the Amended Public Authorities Law (approved 12 July 1973) on the establishment of the Liberia Electricity Corporation with specific reference to hydropower generation, and the Public Health Law of 19 July 1976 on matters of water-related sanitation (United Nations (UN), 1983).

There are no statutory regulations regarding water ownership, control and use. The ownership of water running in a defined channel (e.g. a river) is not properly understood because water is generally understood to be a freely available resource. Individual land ownership presupposes a riparian right on the resources that are on or underneath the land. Groundwaters, which do not flow in a well defined channel and cannot therefore be assigned to surface water courses, are regarded as the absolute property of the owner of the land above, and can be withdrawn by the owner without liability to adjoining lands. The issue of reasonableness of use or proportionate sharing of withdrawal from a common source currently does not appear to be considered in water rights in Liberia. The grant of a mining concession presupposes the right to take water and use it, and such mining concerns need not secure ownership of land adjacent to water courses in order to draw water for their own purposes.

Regarding the beneficial uses of water, the provision of water supply and sewerage services to the public is the responsibility of the Liberia Water and Sewer Corporation (LWSC). Regulations govern the legality of connections and illegal connections are punishable by law. Also, local authorities are vested with the responsibility to prevent and remedy pollution of freshwater used by the public for drinking and domestic purposes. Unwholesome sources of water supply, whether public or private, are prohibited by law. The law allows for catchment

area protection for public water supply schemes and punishes by law anyone whose activities within such defined boundaries will impact negatively on the water source (UN, 1983).

Regarding the control and protection of water works, the design and construction of public water works appears to be the responsibility of the Ministry of Public Works (MPW). Arguably, private water supplies, hydroelectric works, drainage and sewerage works, and works pertaining to field water control are subject to technical control by the MPW. A permit from the Forestry Development Authority (FDA) is required for the damming of rivers and streams within the boundaries of forest reserves and national parks.

With regard to health-related water issues, the discharge of wastewater from any premises into swamps, watercourses or irrigation channels is regarded by the health legislation in force as statutory nuisance, and is punishable by law. The use of well-water for any purposes is subject to prior health clearance in the form of a permit from the local health authority.

It must be noted that no clear reference is made to the development and use of agricultural water resources but this is inferred from other legislation regarding water works in general and forestry issues in particular, with regard to matters of forest water resources and catchment protection.

4.2 Water resources administration and institutions

The development, conservation and use of the country's freshwater resources are subject to a fragmentation of responsibilities among several branches of the Government and two public utility companies.

The Ministry of Lands, Mines and Energy (MLME) is responsible for the collection and distribution of information on Liberian water resources through its sector agency the Liberian Hydrological Service. The data acquisition cuts across surface and groundwater sources and even brackish water, and this body also has responsibility for water quality monitoring. The Ministry of Health and Social Welfare (MHSW) administers health legislation, with particular reference to water quality preservation, water supply and sanitation. It is this ministry that is responsible for licensing of waste discharges from any origin into any water body, developing quality standards for drinking water obtained from a well and also undertaking urban and suburban water supply projects in some cases. The Ministry of Rural Development has primary responsibility for rural water supply and sanitation programmes, with a specific mandate to develop groundwater resources. This ministry also has oversight responsibility for licensing of ferry operations on inland waterways. The Ministry of Public Works (MPW) is responsible for the technical control of all water-related projects and structures, whether public or private. The Ministry of Planning and Economic Affairs (MPEA) shares with the Liberia Water and Sewer Corporation (LWSC) the primary responsibility for water sector planning. The Ministry of Finance (MOF), through its revenue bureau, licenses river pilots and commercial and sports fishermen for both inland and marine waters. The LWSC is a public utility company in charge of the provision of water supply and sewerage services throughout Liberia. The company has full corporate powers for the implementation of its mandate. The Liberia Electricity Corporation (LEC) is a public company with responsibility for the generation and distribution of electricity throughout Liberia, including hydropower generation; it has full corporate powers for the implementation of its policies. The MOA is engaged in studies and research on irrigation and soil conservation practices (UN, 1983).

A National Water Resources and Sanitation Board has been functioning since 1980, primarily for coordination purposes. This was in line with the United Nations declaration of a Water and Sanitation Decade at the time, which saw many developing countries, including Liberia, sign up to provide safe drinking water for all by the end of the decade. The Board draws membership from all Government departments and agencies and also the private sector; its secretarial functions are discharged by the Liberian Hydrological Service (LHS). A draft bill for the establishment of a Water Resources Board (WRB) draws membership from seven ministries, the LWSC and LEC; two additional members are appointed by the Minister of Water Resources (MWR) and the Board is expected to have the following functions (GOL, 1984):

- to formulate policies for the conservation, development and best use of the water resources of Liberia;
- to coordinate all public and private projects and programmes concerning the conservation, development and use of water resources;
- to advise the Minister on measures for the implementation of water resources policies and plans and on all matters concerning the conservation, development and use of water resources.

Liberia shares the following international water resources with its neighbours: the St John Basin (Liberia and Guinea), the St Paul Basin (Liberia and Guinea), the Cestos Basin (Liberia and Côte d'Ivoire), the Cavalla Basin (Liberia and Côte d'Ivoire), the Moa Basin (Liberia, Sierra Leone and Guinea) and the Mano Basin (Liberia and Sierra Leone). Numerous bilateral treaties have successively governed the delimitation of the frontier of Liberia since 1885 on the Mano River and since 1892 on the Moa River. Some of these treaties have provided for freedom of navigation and transit fishing and the protection of existing water use rights for the local population.

It is quite clear that although references have been made to water in connection with landholdings, mining activities, forestry and water supply, there is no clear water resources development policy in Liberia and it is important that any such policy should be sufficiently comprehensive and integrated to ensure the necessary linkages between interrelated sectors. Likewise, the importance of energy, water and sanitation to poverty alleviation and its implications for the building of peace and stability make it all the more necessary to address the energy, water and sanitation situation with utmost urgency and as a framework for policy formulation and implementation. The issue of water for agriculture should be clearly spelt out in any such policy document.

Within the MOA, the Land and Water Resources Development Division (LWRDD) was created with institutional responsibility for the following areas of agricultural development:

- soil survey and classification;
- irrigation and drainage;
- land evaluation;
- land use planning;
- cartography and remote sensing.

By implication, the LWRDD must develop and rationalize the water resources and agroclimatological activities in relation to agricultural development and the agro-ecological

areas of the country, develop a national soil conservation and management programme geared towards controlling land degradation, develop a national irrigation and drainage programme geared towards reducing dependence on rainfed agriculture, and rationally develop and use agricultural water to take advantage of agroclimatic conditions in the country.

Before the war, in 1990, LWRDD was headed by a Director and a Deputy Director. There were five sectional heads in charge of the technical divisions of soil survey and classification, irrigation and drainage, land evaluation, land use and planning, and cartography and remote sensing. Before the war, there were five holders of higher degrees, three holders of first degrees and ten technicians (Table 2a). Currently there are two holders of higher degrees, two holders of first degrees and three technicians (Table 2b).

Table2a. Technical staff of LWRDD before 1990

Technical division	**Number of staff in post before 1990**		
	Higher degree holders	**First degree holders**	**Technicians**
Soil Survey and Classification	2	1	4
Irrigation and Drainage	2	1	
Land Evaluation	1		1
Land Use Planning		1	3
Cartography and Remote Sensing			2
Total	**5**	**3**	**10**

Source: Farnga (2006)

Table2b. Technical staff of LWRDD in 2006

Technical division	**Number of staff in post in 2006**		
	Higher degree holders	**First degree holders**	**Technicians**
Soil Survey and Classification		1	2
Irrigation and Drainage	1		
Land Evaluation	1		1
Land Use Planning		1	
Cartography and Remote Sensing			
Total	**2**	**2**	**3**

Source: Farnga (2006)

The LWRDD, as a directorate in MOA, operates at four levels: the headquarters in Monrovia, and County, District and Clan levels. During the war, agriculture was badly hit in the districts and many of the staff of MOA, including those of LWRDD, sought refuge in refugee camps and left their stations in the field. As is the case with many Government departments, LWRDD is grossly underfunded and this greatly hampers its work. There is the need to reorganize and strengthen the work of LWRDD by re-equipping it and building the capacity of staff through pragmatic staff development programmes. It must be noted that important equipment belonging to LWRDD and valued at several thousands of dollars was also destroyed in the war. Apart from the disincentive of low salaries, the war disrupted the programmes of the department and saw the exit of many qualified staff. For example, a 5-year project on land resource assessment for land use planning, which was initiated in 1987,

funded by the United Nations Development Programme (UNDP) and the GOL and executed by the FAO/MOA was disrupted by the war.

4.3 Agricultural water management

Managing water for agriculture starts with the assessment of the water demands made by the crop and its environment. This is referred to as crop evapotranspiration or crop water requirements. As already stated, there are very few data on crop water requirements, and there is insufficient data available to enable such computations to be made. Secondary data on rice water requirements are shown in Table 3. The two most important food crops with regard to water control and management in Liberia are rice and vegetables. As reported during interviews, farmers would prefer long-duration and high-yielding rice varieties for one main crop in the rainy season to two short-duration, low-yielding varieties. Yields for the second rice crop are generally very low. It has also been concluded that crop maturity and harvest periods should not occur in September because rice consumption by birds is at its peak at this time of the year. This implies that the growing period should be timed such that harvesting falls in late October and beyond.

Table 3. Crop water requirements for selected stations

County	Project	[1]Crop	Transplanting date	Harvesting date	Crop water requirements (mm)
Nimba	Gbedin	Rice	Early March	Early July	448
Grand Gedeh	Zlehtown	Rice	Early January	Late April	449
Cape Mount	Gawula Tombe	Rice	Late February	Early June	431
Bong	Kpatawee	Rice	Early July	Early November	445
Maryland	Philadelphia	Rice	Late March	Late July	440

Source: Derived and modified from Farnga (1988); [1]Rice water requirement does not include water for nursery, land preparation and soil percolation. If these are included, the figures will increase by between 1.5 and 2.5 times.

Irrigation requirements have also been computed. Even for the same crops, the water requirement is generally higher in the drier than in wetter regions. Total rainfall amounts are always higher than the crop water requirements but rainfall distribution can be a problem. Moreover, standard values were assumed for the crop coefficient because there are no such data available for Liberia.

The upland soils are generally acidic, with low fertility and low water holding capacity, and they are prone to soil erosion. Unfortunately, upland soil and water management is not generally an issue considered by farmers. The reason why farmers do not pay particular attention to field soil and water conservation practices is an important research problem. The farmers, however, complain that during the recent past, delay in the onset of the rainy season has led to late planting. This shows that rainfall patterns are changing and poses a new challenge to field water management.

Farmers that crop on the slopes are faced with different problems of soil water management in a typically rainfed culture. It is generally known that soil water on slopes is depleted much more quickly because of faster subsurface flow induced by the generally acute slopes. There is also the risk of soil erosion and nutrient loss on the slopes. Drainage is generally good on the slopes. Little attention has been paid to these groups of farmers with regard to land and

water management. It must be noted that the work of the LWRDD is not generally focused on farmers in these areas.

Another aspect of lowland water management falls under what is known as **recession agriculture**. This is practised largely during the dry season, when the farmers take advantage of the residual moisture of the soil in the swamps to grow vegetables. Also, **upland irrigation** has not been seriously considered to be an issue in Liberia, probably because of the water surplus in all agro-ecological zones and the availability of large areas of swamp for rice and vegetable production. **Urban and peri-urban agriculture** is also practised on a limited scale in Liberia, taking advantage of the ready market in the urban centres for vegetable crops produced through such activities. There is potential for the use of motorized pumps for irrigation from shallow wells to support urban and peri-urban agricultural activities, especially in and around Monrovia.

As an initiative for good governance and to minimize some of its institutional bottlenecks, the GOL is embarking on a decentralization exercise for all Government ministries, including MOA, with increased participation of NGOs and CBOs in agricultural development at the community level.

4.4 Hydrometeorology

The Liberia Hydrological Service (LHS) is responsible for the collection of hydrometeorological statistics. There were 47 hydrometeorological stations in Liberia before the war and rainfall statistics date back to 1927 at the Ganta station, for example. The stations were operational until 1989. Since 1990, there have been no new records made because of the presence of civil strife. Practically speaking, all the meteorological stations were destroyed during the war except one in western Liberia. There is therefore now an urgent need to establish and modernize new stations. It must also be noted that even the data that were previously collected hads many gaps, and the paucity of such data is worth noting. It is simply not possible at present to obtain any meaningful data from existing information over the full range of meteorological statistics, particularly rainfall, temperature, relative humidity, wind velocity and sunshine duration, for any single station in the country. In order to improve the meteorological database, and as part of the LHS modernization plan, 15 new synoptic stations are to be located, one in each county, at all the provisional airstrips in the country.

The paucity of meteorological data in Liberia renders it impossible for any station to have a consistent database covering rainfall, temperature, relative humidity, wind velocity and sunshine duration. In fact many of the stations have no data on any meteorological parameter other than rainfall. There are stations for which the rainfall data cover a period of more than 30–50 years, but these are few and the data frequently show gaps. Table 4 shows rainfall data for Liberia. The average annual rainfall ranges from about 1 687 mm in Suakoko in the north to about 4 614 mm in Robertsport in the south. Overall, 80–95 percent of the rainfall is received between June and October but the number of months in which water surplus occurs varies from –five to eight depending on the location. Reliable rainfall figures computed on the assumption of 20, 50 and 80 percent probability of exceedance for Firestone Harbel are 3 442, 2 950 and 2 723 mm, respectively. Similar figures computed on the assumption of 20, 50 and 80 percent probability of exceedance for Robertsville are 4 189, 3 430 and 3 096 mm, respectively (Table 6). There are very few data on evapotranspiration available, but some scanty information chanced upon for Firestone Harbel for the period June–December 1977 ranged between 95.2 and 120.3 mm/month for the period (Table 7). For the same period,

there was a water surplus of approximately 242 mm/month. Generally, there is a water deficit in the dry months of November to February, when evapotranspiration exceeds rainfall. The reported mean annual potential evapotranspiration amounted to 1 329 mm and 1 318 mm for Firestone Harbel and Robertsfield respectively (United Nations Department of Technical Cooperation, 1987). There is also evidence to suggest that rainfall patterns are changing and perhaps the amount of rainfall is diminishing because of the removal of large areas of vegetation due to the farming practice of shifting cultivation. Even for stations such as Firestone Harbel and Robertsfield, consistent data could only be obtained for the period 1977 to 1982 and they are not complete (Table 5).

Table 4. Rainfall in Liberia

Station	Period	Annual rainfall (mm)
Robertsport	1952–73	4 614
Monrovia	1945–73	4 590
Greenville	1952–73	4 229
Lamco Buchanan	1959–80	3 945
Robertsfield	1949–80	3 740
Goodrich	1956–80	3 388
Bomi Hills	1952–76	3 161
Firestone Harbel	1936–80	3 133
NIOC	1960–80	3 061
LAC	1961–80	2 790
Pinetown	1952–73	2 696
Bong Mines	1962–80	2 543
Firestone Cavalla	1928–80	2 492
Salala Rubber Corp	1961–80	2 475
Voinjama	1953–73	2 426
Sanniquellie	1952–80	2 356
Ganta	1927–73	2 201
Cocopa	1950–80	2 047
Zwedru	1952–73	1 933
Tappita	1952–73	1 931
Suakoko	1952–72	1 687

Source: Liberia Hydrological Service

Table 5. Meteorological data for Firestone Harbel and Robertsfield

Year	Firestone Harbel Latitude: 6°23' north Longitude: 10°25' west					Robertsfield Latitude: 6°14' north Longitude: 10°22' west				
	Rainfall (mm)	Temp (°C)	Relative humidity (%)	Wind velocity (km/day)	Sunshine duration (hours)	Rainfall (mm)	Temp (°C)	Relative humidity (%)	Wind velocity (km/day)	Sunshine duration (hours)
1977	2764	26.2	83	29.4	4.0	2926	25.9	88	131.4	3.7
1978	2856	26.0	84	27.9	3.7	na	25.8	88	135.2	3.6
1979	3161	26.3	83	28.8	4.1	3065	26.0	88	142.2	3.7
1980	3231	26.2	83	29.8	4.0	2426	26.2	88	135.6	3.3
1981	na	26.2	80	27.7	4.3	na	26.2	87	133.0	3.6
1982	na	26.2	81	28.0	4.1	na	25.9	84	114.1	3.9

Source: Liberia Hydrological Service (2006)

Table 6. Rainfall frequency analysis for Firestone Harbel and Robertsfield

Station	Period	Reliable annual rainfall (mm)		
		f = 20 %	f = 50 %	f = 80 %
Firestone Harbel	1941–80	3 442	2 950	2 723
Robertsfield	1961–77	4 189	3 430	3 096

Source: Author's estimates (2006); f = probability of exceedance

Table 7. Water balance for Firestone Harbel (1977)

Month	Rainfall (mm)	Evapotranspiration (mm)	Water surplus/deficit (mm)
June	477.8	108.3	369.5
July	359.9	95.2	264.7
August	732.5	98.9	633.6
September	526.5	86.4	440.1
October	272.5	120.3	152.2
November	41.7	110.7	–69.7
December	9.1	104.5	–95.4

Source: Liberia Hydrological Service; Author's estimates (2006)

4.5 Surface water

The Liberian hydrological year starts in April and ends in March of the following year. Surface water hydrological statistics for Liberia are collected by the LHS of the Ministry of Water Resources (MWR). Before the war there were 45 hydrological stations but by 2003 only one, in western Liberia, was intact. Small amounts of information can be obtained from published texts but the current situation is that the information database has been destroyed. It is therefore imperative that measures are taken to re-equip the water sector institutions to improve the hydrostatistical base. The Liberia Water Company (LWC) also collects some hydrological data but this pertains to their own water supply activities only.

There are six major rivers in Liberia with catchment areas varying from 4 000 (Farmington/Du) to 28 000 km^2 (Cavalla). The Mano, Lofa, St Paul, St John, Cestos and Cavalla together drain about 65.5 percent of the country. The river flow of the Cavalla at Nyakee in the 1960/61 water year amounted to about 13 km^3/year. Average discharge for St Paul at Mt Coffee for the 1958/66 water year amounted to about 19.2 km^3/year (Table 8; Table 9). A water balance study performed over 4 years for the Du river catchment upstream of Kakata, with an area of 326 km^2, reported that the mean annual rainfall, runoff and evapotranspiration equalled 2 742 mm, 1 150 mm and 1 592 mm, respectively, and the runoff coefficient was 0.42. A similar study of an 0.7 km^2 area of the steep catchments of Weakpor creek based on monitoring over one year showed annual rainfall, runoff and evapotranspiration of 2 860 mm, 1 320 mm and 1 540 mm, respectively, with a runoff coefficient of 0.46 for natural rainforest. Another water balance study of a 2.5 km^2 area of the flat catchment of Cassava creek showed annual rainfall, runoff and evapotranspiration of 3 115 mm, 2 090 mm and 1 025 mm, respectively, and the runoff coefficient was 0.67 for farmland (United Nations Department of Technical Cooperation and Development (UNDTCD), 1987). The flow process in Liberia is characterized by high variability because of the effects of the wet and dry seasons. The UNDTCD (1987) reported that for catchment areas smaller than 10 km^2, low flows could be as low as 2–4 litres/m^2/s and high flows could be as high as 2 000–4,000 litres/m^2/s. The important lakes in Liberia are Lake Piso and Lake Shepherd, and have been identified as important wetlands for conservation.

All the Liberian rivers flow in the northeast to southwest direction and into the Atlantic Ocean through the coastal plain region. Earlier estimates suggest that the total renewable water resources of Liberia could amount to approximately 232 km^3/year, amounting to a per capita supply of about 71 000 m^3/year, and making Liberia one of the best endowed countries in Africa in terms of water resources. Total water withdrawal in 2000 was estimated at 106.8 million m^3, of which agriculture took 57 percent and was followed by the domestic sector with 28 percent and industry with 15 percent (FAO, 2005).

Hydropower plants located on the St Paul River and Farmington/Du River have all been destroyed in the war and because it is costly to build a power plant, it is going be a considerable time before such ventures can be undertaken to ease the power supply problems in Liberia. Nine potential sites have been identified on the rivers Mano, Lofa, St Paul, St John and Cavalla for possible future power plants. This, if achieved, will greatly augment the power supplies of the country. Exploration of the hydropower potential of the River Lofa revealed that several falls and rapids between Lofa and Baha town fulfil the conditions for low-head hydropower plants, for which dams and spillways are not required.

Table 8. Major river systems in Liberia

River Basin	Catchment area (km^2)		Main tributaries	Highest elevation (m *asl*)	Hydropower plant	
	Total	Within Liberia			Existing	Proposed
Mano	7 500	6 000	Morro/Mano	750	0	1
Lofa	11 000	9 600	Lawa/Mahe	1 200	0	2
St Paul	20 500	11 500	Via/Tuma	Not known	1	3
Farmington/Du	4 000	4 000		600	1	0
St John	15 500	14 000	Zor Creek/Ya Creek/Mani R	1 000	0	2
Cestos	14 000	11 500	Gwen Cr/Nuon R	1 500	0	0
Cavalla	28 000	11 500	Duobe R	1 500	0	1
Sehnkwehn	4 460	4 460			0	0
Sinoe	3 000	3 000			0	0

Source: Hydrological Service of Liberia. *asl*, above sea level.

It can therefore be argued from a global perspective that water is not in short supply in Liberia. However, that cannot be said from the perspective of local areas where a number of swamp thickets have been removed for agricultural purposes. There is evidence to suggest that minor tributaries that used to be perennial have become seasonal due to excessive removal of vegetation cover. Because there are very few measured data to document whether the river flows are in fact reducing, we can only speculate. There is also evidence to suggest that fallow periods could be reduced, especially on the upland farms, as a result of population pressure. This land-use pattern can threaten water resources and it is imperative that measures are taken at the community level to reverse this trend.

4.6 Groundwater

There are few data on the groundwater resources in Liberia. There has been some exploitation of groundwater for rural water supply but hydrogeological data are woefully lacking. Liberia can be divided into three areas according to the occurrence of groundwater, namely the soft rock areas, which consist of sedimentary rocks, the fractured/fissured hard rocks and the weathered igneous and metamorphic rocks. The sedimentary formations occur mainly in the Pan African age rocks in the Robert Basin along the coast. Unconsolidated

sediments are said to be widespread, especially in Bushrod Island, New Georgia, New Kru Town and Virginia (UNDTCD, 1987). These are fairly extensive aquifers. The quaternary sediments, which constitute the younger sedimentary rocks, are shallow and are up to about 30 m deep, 35–40 m thick and are more than 15 000 years old (UNDTCD, 1987). The extent of the fractured hard rock areas is not known and it is important to perform exploratory investigations to establish the extent of these possible aquifers. The weathered igneous and metamorphic rocks are soft rocks with appreciable porosity and hydraulic permeability; they are over-burdened rocks, not more than 30 m deep and also not extensive.

The hydraulic properties, such as porosity, permeability, transmissivity, storativity and yield, of the possible aquifers in Liberia are not yet known.

Table 9. Discharge of selected rivers in Liberia

River and *location*	**Time of obser vation**	**Mean discharge (m^3/s)**											
		April	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Zeliba Cr *Voinjama*	74–76	115	95	175	150	240	300	260	200	150	130	90	80
Mano R *Mano Mines*	59–79	45	100	165	260	460	620	490	275	120	55	35	30
Lofa R *Duogamay*	73–76	10	15	35	45	125	170	110	50	20	10	5	5
Lawa R *Luyema*	73–76	5	5	10	15	30	40	50	20	10	5	5	5
St. Paul R *Walkerbridge*	59–77	65	125	200	285	445	775	550	320	165	85	60	60
St. Paul R *Mt. Coffee*	58–66	150	340	656	850	1 105	1 615	1 220	750	345	165	105	110
Du R *Firestone*	59–61	10	20	30	65	55	80	40	20	15	10	5	10
Farmington R *Owensgrove*	46–50	40	75	140	195	180	340	370	170	80	55	30	70
St. John R *Baila*	59–76	40	60	110	140	130	110	120	150	70	40	30	60
St. John R *Fallo*	59–68 &71	65	215	265	510	905	1 645	1 255	380	190	95	30	50
Cestos R *Sawolo*	63–76	25	35	65	80	90	135	115	70	40	25	20	15
Senkwehn R *Bafu Bay*	60–61	125	155	145	125	115	145	110	140	100	135	95	90
Double R *Zwedru*	75–76	10	15	25	10	10	45	20	5	5	5	5	5
Cavallo R *Nyaake*	60–61	205	205	250	205	475	990	935	860	315	165	110	195

Source: Liberian Hydrological Service

5. LAND RESOURCE ASSESSMENT AND MANAGEMENT IN LIBERIA

5.1 Land resources assessment

Land tenure. This is the subject of a separate review within CAAS-Lib and only a partial view is presented here. At independence in 1850, the Government of Liberia vested all land in the state. By the time of the Land Act of 11 January 1850, all Liberians had a right to own land, if feasible, and the process of land acquisition was relatively easy. Land in Liberia is

divided into lots, where 4 lots is equivalent to 1 acre. The President of the Republic of Liberia signed the land title deeds for the acquisition of land for any purpose. Under the Anglo-American deed system of land acquisition, Presidential assent was required. The cost of acquisition of 1 acre of land in 1850 was US$0.50; currently the same piece of land would sell for US$120. Rural land is still under some customary tenure but there is no security in the customary tenure system. According to the GOL (1980), an environment conducive to development must, among other things, include a land tenure system that permits a farmer to feel secure in the use of land, especially where land improvements are involved. The Government can acquire rural land through the local authorities for projects in the public interest. The administration of land in Liberia is carried out by the Ministry of Lands, Mines and Energy (MLME), which has oversight responsibility for sector agencies such as the National Lands Commission (NLC) and the Surveyors Board (SB) (Julu, personal Communication, 2006). There is no comprehensive policy on the acquisition of land for agricultural purposes and the Government is silent on the payment of fees. The GOL grants leases to private investors and land fees are negotiable. The MOA determines fees for agricultural land acquired for private uses even though the MLME manages the process of land acquisition.

Soil survey and classification. Prior to 1987, surveys of a large number of small farms were carried out by the Land and Water Resources Department of the Central Research Institute (CARI) in Suakoko and the Land Development Division of the MOA in Monrovia. These surveys were designed to assist in the production of food and cash crops. Medium-scale surveys of large farms were undertaken by different bodies, and provided information on land resources for widely ranging objectives. However, large-scale area-oriented surveys of land capability and crop suitability were carried out by integrated agricultural development projects in Lofa, Bong and Nimba counties in north and northeast Liberia. In the southeastern part of the country a survey of Grand Gedeh County identified suitable areas for lowland rice and tree crops (cocoa and coffee). All the extensive surveys were carried out by foreign consultants. Table 10 below highlights major soil or land resource surveys undertaken in Liberia and a summary of these surveys is presented in subsequent paragraphs.

Table 10. Major soil/land resource surveys undertaken in Liberia between 1951 and 1990

Author: year of publication	Type of Survey	Purpose
Reeds, W.E: 1951	Reconnaissance soil survey	Soil associates and landforms
Subramanian, V.S: 1970	Reconnaissance soil survey	Plantation crop development
Fanfant, R: 1970	Reconnaissance soil survey	Lowland rice development
Slusher, D.F: 1970	Soil survey programme	Soil survey programme for Liberia
Fanfant, R: 1972	Reconnaissance soil survey	Lowland rice cultivation
Agra Und Hydrotechnik: 1974	Feasibility of upper LCADP	Plantation & food crop development
Subramanian, V.S: 1975	Reconnaissance soil survey	Lowland rice & tree crop development
SATMACI: 1975/76	Soil and land capability survey	Land suitability for coffee and cocoa
Agra Und Hydrotechnik: 1976	Feasibility of upper NCRDP	Plantation & food crop development
Geiger, I.C: 1977	Soil survey & classification	Soil series description & classification
Soil Division (MOA) & USAID	Soil survey of CARI, Suakoko	Soil series description & classification
Agra Und Hydrotechnik: 1978	Exploratory/reconnaissance	Plantation & food crop development
Van Mourik: 1979	Regional reconnaissance land resource survey	Reconnaissance appraisal for agricultural purposes
Veldkamp, W.J: 1980	Soil series description & classification	Land resource survey for Mano River Union Project areas
Arup Ireland International: 1986	Land capability of Grand Gedeh	Swamp rice and tree crop production
Project LIR/87/010, MOA/FAO: 1987–1990	Land resources assessment for land use planning	To produce a unified soil map of Liberia and standardize the methodology used in Liberia for land resources surveys, soil classification, land evaluation and land use planning

The earliest survey of soils was a national exploratory survey carried out by Reeds (1951). It was based on flights over the country and observation along accessible motor routes. A national soil map was produced at a scale of 1 : 300,000 showing five soil "associations". The description of the soil associations provided some indication of the landforms and the report also provided some idea of chemical status and an indication of appropriate use of the land. Although such a survey cannot be used with any reliability for either national or regional planning it provides the first account of the range of soils to be found in Liberia. In this survey, much of central Liberia is indicated as having very shallow soils (lithosols), but with latosols around the margins.

Subramanian (1975) undertook a survey in the Zlehtown area (northeast of Grand Gedeh) to select areas suitable for plantation crops, especially oil-palm, coffee and cocoa. He described the area as being a dissected plateau with steep, eroded land, hillocks and low-lying areas. Much of the upland had concretionary soils with the concretions often being tightly packed. These were considered to be unsuitable for development. Deeper and less gravelly soils were found on the lower slopes – such soils were considered to be suitable for tree crops, although it was thought that cocoa might be sensitive to acidity. The swamps were generally of a sandy nature but were considered to have development potential for rice. Subramanian (1975) pointed out that the soil had been found under forest and that changing land use and forest clearing is likely to have number of effects. Amongst these are the following:

- a reduction in top soil organic matter;
- a risk of hardening of plinthite through increased wetting;
- an increased risk of soil erosion, indicating a need for soil and water conservation;
- an adverse effect on soil structure and infiltration.

SATMACI (1975/76) undertook a soil and land capability survey of eight areas in Liberia to determine their suitability for coffee and cocoa. The areas surveyed were Grand Gedeh, Bong, Lofa, Nimba, Grand Bassa, Sinoe, Cape Mount, Maryland and Montserrado counties. The survey report provides background data on the physical conditions in Liberia and a more detailed account of the soils and land capability in the Grand Gedeh sites (1 772 ha). Two maps, for soils and their crop suitability, at a scale of 1:10 000 were produced.

Soils were classified according to the ORSTOM system. Two soil classes dominated in the survey: ferrallitic soils on the interfluves and hydromorphic soils in the depressions. The suitability of a soil type for coffee and cocoa crops was judged from the physical condition of the soil, in particular texture, gravel/stone content (including concretions), wetness/drainage, and soil depth. Nearly 50 percent of the areas surveyed were classified as moderately suitable, good and/or very good. Neither the map legend nor the tables within the text subdivided the suitability classes according to the limitations that were defined, but reference to the text suggests that high gravel content is the major limitation of these soils. The soils were found to be very low in natural fertility.

In 1976 the MOA commissioned a report for oil-palm and coconut projects in Grand Gedeh and Maryland counties. Three maps at a scale of 1:10,000 were produced, for soil type, morphology and vegetation. Again, the soils were classified according to the ORSTOM system, and were predominantly leached ferrallitic soils that were subdivided on the basis of colour, drainage and gravel content. Stoniness (gravel and concretion), the presence of indurated horizons, and extremes of texture were found to be the main limiting factors.

Fanfant also carried out a series of land resource surveys for lowland rice development in the early 1970s. Geiger (1977) subsequently laid the foundation for a national soil classification system based on soil series. Extensive reconnaissance land resource surveys were carried out in the Mano River Union area between the St Paul River and the border with Sierra Leone (land resources of western Liberia) by Van Mourik (1979), in Nimba County (Agrar and Hydrotechnik, 1978) and in Grand Gedeh County (Arup Ireland International, 1986).

The survey reported by Van Mourik in 1979 was aimed at providing data to assist planners in identifying projects and in regional planning. This was the first major regional reconnaissance land resources survey to have been undertaken in Liberia. In this study, the lands systems approach was used, in which the survey area of some 27 000 km^2 was divided into land systems from interpretation of aerial photographs. These were used as mapping units and formed the basis for field sampling and land suitability mapping.

The constituent land facets of each land system were described in terms of area, landform, soils, and vegetation and land use. An evaluation was then made of the suitability of each facet for various crops including coffee, cocoa, rubber, oil-palm, upland rice and lowland rice. Three maps were presented at the scale of 1 : 500,000 that included vegetation and land use, and land systems. Land suitability was found to be in the range permissible for Oxisols. The authors therefore proposed a new subgroup of Aquoxic Paleudults to accommodate these soils.

In 1977, the Soil Division of the former Central Agriculture Experiment Station (CARES), with Geiger, established a catalogue of soil series defined up to that time in Liberia. A description is given of each series together with its classification (soil taxonomy) and an indication as to its use. However, the series described were established largely in Bong County and neighbouring areas where most soil surveys had been undertaken. Table 11 below suggests a tentative correlation between soil classification systems.

Table 11. Tentative correlations between soil classification systems

Soil unit	Liberian soil series (Soil Division, 1977)	Soil Taxonomy (Soil Survey Staff, 1975)	FAO/UNESCO, 1974
D1	Kollieta	Typic Paleudult Plinthic Paleudult	Orthic Acrisol Planthnic Acrisol
D2	Gbaokele	Plinthic Paleudult Typic Paleudult	Planthnic Acrisol Orthic Acrisol
D3	Gbaokele	Plinthic Paleudult Typic Paleudult	Planthnic Acrisol Orthic Acrisol
D4	Sinyea	Plinthic Paleudult	Planthnic Acrisol
D5	Sinyea	Typic Paleudult	Orthic Acrisol
D6	Sinyea	Plinthic Paleudult	Planthnic Acrisol
D7	Sinyea	Plinthic Paleudult	Planthnic Acrisol
D8	Suakoko	Plinthic Paleudult	Planthnic Acrisol
L1	Kpatawee	Typic Paleudult	Dystric Nitosol
L2	Samukata	Typic Dystropept	Dystric Cambisol
L3	Kitoma	Plinthaquic Paleudult	Planthnic Acrisol
L4	Kitoma	Typic Tropaquult	Gleyic Acrisol
W1	Gbelle	Typic Tropaquult	Gleyic Acrisol
W2	Grayzohn	Typic Tropaquult	Gleyic Acrisol
W3	Ballam	Acric Tropaquult	Gleyic Acrisol
W4	Cuttington	Typic	Dystric Gleysol

Arup Ireland International (1986) undertook a land capability survey of Grand Gedeh County aimed at identifying specific village areas suitable for intensification and improvement of agricultural production. This was followed by more detailed surveys of five selected

areas/sites and the preparation of outline development plans for irrigated rice schemes in swamps, and improvements to a range of tree and food crops in surrounding areas. The survey was also intended as a pilot project to develop appropriate methods for extending surveys to other village areas in the southeast region.

For the reconnaissance survey, regional and land use maps were presented at a scale of 1:250 000, based on field surveys and interpretation of aerial photographs and satellite imagery. The report pointed out that some 70 percent of the area was found to be forest-covered, with 29 percent comprising a mosaic of secondary regrowth and small scale slash-and-burn cultivation. Most of the area was reported to comprise a gently undulating pen plain on relatively uniform and strongly weathered parent material. The report also indicates which differences in soils and land capability proved to be more significant, in terms of agricultural potential at the level of the individual slope sequence rather than at regional level.

Land capability studies. These were undertaken as detailed surveys of selected swamps and exploratory semi-detailed surveys of dry land farming areas around selected villages. The semi-detailed surveys extended over the areas affected by cultivation. Maps of vegetation and land use, soils and land capability were compiled at a scale of 1:20,000. Broad patterns of soils were mapped using the "soil family" concept and land was classified according to a modified version of the United States land capability system. Large areas of the land were found to be only marginally suitable for cropping, due to shallow soil depth or excessive gravel content. The maps provide general indications of the features of the village lands and serve as a basis for future integrated development of both irrigated rice and dry land crops.

Detailed surveys of the selected swamps and lateral slopes were conducted along trace lines spaced 100 m apart. Mapping was done at a 1 : 2 000 scale, with separate sheets showing soils and land suitability for rice and for dry land cropping. Soil texture proved to be the principal factor that determined suitability for agriculture in the swamp areas; soil depth and gravel content were the principal determinants of suitability for dry land crops on the lateral slopes. The results of soil analysis indicate that the soils have very low fertility. Infiltration rates and hydraulic conductivity are relatively high in the coarser-textured swamp soils. Five selected swamps totalling 596 ha were surveyed at a detailed level; of these 146 ha were suitable for rice and 128 ha were suitable for dry land cropping. Some 222 ha were unsuitable for cropping.

In this survey two farming systems were identified within the villages, namely an upland farming system and a village farming system. The former is the principal source of the staple subsistence food (rice) and receives priority in terms of labour resources. Surplus labour, if available, is utilized on the village farms, which are oriented towards cash crops, such as tree crops (coffee and cocoa), vegetables and swamp rice. A tentative correlation between soil mapping units and other classification systems is given in Annex 3 (Dominant Soil Characteristics).

These previous surveys have yielded a considerable amount of information on the land resources of the country. However, as different individuals and organizations carried them out for widely ranging objectives, they differ in the presentation of their findings. The early surveys of Reeds (1951) and Fanfant (1970), which are on too small a scale to be of any practical application and which lack any interpretation of land capability or suitability for particular crops, do not together give a complete picture of the land resources of Liberia. The

need for a coordinated national service for soil surveys was stated as long ago as 1970 by Slusher, but there has been little or no progress subsequently, either in national land resource mapping or in standardizing the survey methodology and data interpretation techniques.

Soils were not mapped, but Van Mourik's report pointed out some of the difficulties of applying the soil taxonomy and FAO/UNESCO classifications (FAO/UNESCO, 1974; Soil Survey Staff, 1975) in the field. It is difficult to recognize diagnostic horizons, because of the exhaustive laboratory and micromorphological analysis that is often required to correctly identify horizons, and because of anomalies in the application of the definitions under Liberian conditions. Thus an approach on the basis of soil "families" was favoured, in which the classification centred on four concepts: i) texture and gravel content of the soil profile (25–100 cm depth), ii) stage of profile development, iii) parent materials and iv) colour.

These features were found to be readily recognized in the field during routine soil surveys and were considered to be directly relevant to assessment of land capability and crop suitability. The families were correlated with subgroups of soil taxonomy and units of the FAO/UNESCO Soil Map of the World.

Land resources assessment for land use planning. The information produced by the various surveys of soil/land resources needed improvement in terms of criteria, standardization of methodology and coordination. As a result, a requirement for a coordinated national land resources survey was recognized as early as 1975. In 1985 the GOL, realizing the need for a nationally coordinated database fundamental to planning and the rational use of its land resources to cater for a rapidly expanding population, made available its counterpart contribution to the project for land resource assessment for land use planning.

The Project, LIR/87/010 "Land Resource Assessment for Land Use Planning", was financed by UNDP and executed by FAO. The project appraisal and formulation mission were carried out in 1985, resulting in a project document proposing a project of five years' duration, with an agreement reached among UNDP, FAO and the GOL in March 1987. The MOA was designated as the Government counterpart agency responsible for project implementation. The Government contributed L$797 600 and the UNDP contribution, as finally revised, was $US2 186 197.

The project became operational on 28 August 1987. However, towards the end of the third year of the project, implementation was interrupted because of political instability in the country. It must be noted that the objectives of this project at that time, compilation of an inventory of soil resources, mapping, computerization, capacity building of staff and development of guidelines for land use, are as relevant now as ever.

Land use and forestry. The first comprehensive land use map of Liberia was prepared in 1956 from aerial photographs taken in 1953. At the time, the map showed extensive forest vegetation in the northwest and southeast with some farmed areas. In 1981, another land use map was prepared from aerial photographs taken in 1979 (GOL, 1983). This revealed the depletion of extensive forest cover, largely due to farming activities. Apart from the plantations (rubber, cocoa, coffee and oil-palm), which are noted for providing surface cover and minimizing soil erosion, the farming system has largely been one of shifting cultivation, with a fallow period of 9–10 years. This farming method involves felling/slashing, burning and planting. For the steep and rolling hills, removal of vegetation cover leads to increased soil erosion. In addition, the communities have found charcoal production very rewarding

financially. Bushmeat, a major source of protein in the diet of Liberians, has put more pressure on forest resources because catching the game sometimes requires the burning of vegetation, thus giving rise to loss of biodiversity and soil fertility.

The forestry sub-sector has been recently reviewed in detail and development proposals made as part of the Liberian Forestry Initiative (GOL, 2004) but a brief review in the context of catchment protection is presented here. In 1976, the GOL passed a special Act creating the Forestry Development Agency (FDA) as the sole institution with authority responsible for managing Liberia's forest estate (Working Group on Liberia's Protected Area Network, 2006). For administrative purposes, Liberia is divided into four forestry regions managed by the FDA. The first forestry region covers Nimba, River Cess, Bong, Margrebi and Grand Basseh counties. The second forestry region covers Grand Gedeh, a portion of Sinoe, Maryland, River Gee and Grand Kru counties. The third covers Cape Mount, Bomi, Gbarpula, Lofa and Montserrado counties. The fourth forestry region covers the rest of Sinoe County. Currently, protected forest covers an area of about 14 200 km^2 (Table 12). These forests are said to be home to about 2 000 species of flowering plant, 150 species of mammal, 620 species of bird, 125 species of reptile and amphibian and over 1 000 described insect species (UNEP, 2004). Liberia's forest habitat and biodiversity face increasing threats from slash-and-burn agriculture, mining, logging, and the migration of rural settlements. According to GOL (2004)[1], forest cover declined from 4.1 million ha in 1992 to about 3.48 million ha in 2001/02 and the MDG target is to reverse deforestation by at least maintaining the current forest cover levels. It is also expected that the land area protected to maintain biodiversity, which stood at 192 000 ha in 2003, will be increased to at least 534 000 ha by 2015. Deforestation is reported to be occurring at the rate of 1.5 to 2 percent per annum.

The FDA now proposes a sustainable forest management policy known as the 3C policy: the *conservation, community and commercial forestry* policy, in which community involvement is seen as an important part of the process of forest management. The aim of commercial forestry is the sustainable production of forest products and the development of viable forest-based industries. Community forest management focuses more on the interests of people who live in and on the fringes of forest areas. Alternative livelihood issues are to be considered where dependence on forest resources and products such as wildlife is crucial. The aim of forest conservation is to sustain and enhance biodiversity conservation and maintain the other environmental functions of forests for current and future generations. The Liberia forest initiative aims to develop a comprehensive land use plan by creating a buffer zone system for farming in order to minimize conflicts with human communities. In fact the Protected Forest Areas Act of 2003 outlines categories for ten protected areas in Liberia, namely buffer zone, communal forest, cultural site, conservation corridor, game reserve, national forest, national park, nature reserve, multiple sustainable use reserve and strict nature reserve (Working Group on Liberia's Protected Area Network, 2006).

With regard to the issue of land conservation**,** prevention and control of soil erosion that results from human interference with natural conditions is indirectly provided for by current forestry legislation to the extent that the use of forests is restricted and forest cover is thereby protected.

Table 12. National forest reserves

Forest Reserve	Area (ha)
Krahn-Basa	513 962
Grebo	260 462
Gola	206 995
Kpelle	174 828
Yoma	2 649
Lorma	71 226
South Lorma	43 506
Gbi	32 930
Gio	66 969
East Nimba	28 966
West Nimba	12 950
Total	**1 415 443**

Source: GOL (2004)[2]

The commercial exploitation of forests is restricted with regard to the size of trees that can be felled and additional restriction may be placed on the exercise of timber concessions from the Government. In addition, the GOL may set aside forests for the controlled use of natural resources therein.

Wetlands. The wetlands of Liberia that have been designated as potential Ramsar sites (IUCN - International Union for the Conservation of Nature) for conservation include Lake Piso, Marshall, Mesurado, Lake Shepherd, Bafu Bay, Cestos-Senkwehn, Gbedin and Kpatawee, as shown in Table 13. These sites are not only home to important biodiversity but also important fishing grounds for many Liberians. It is expected that an inventory and a management plan will be developed for the sustainable management of these wetlands.

Table 13. Wetlands of Liberia named as potential Ramsar sites

Wetland	Type	Area (ha)	Conservation status
Lake Piso	Coastal lacustrine	76 091	Proposed nature reserve
Marshall	Inland riverine	12 168	Proposed nature reserve
Mesurado	Coastal lacustrine	6 760	None
Lake Shepherd	Coastal lacustrine	na	None
Bafu Bay	Coastal lacustrine	na	None
Cestos-Senkwehn	Inland riverine	na	Proposed nature reserve
Gbedin	Inland swamp	8	None
Kpatawee	Inland riverine	na	None

Source: UNEP (2004)

These lands are generally considered as wastelands but they have key economic importance to inland fisheries and swamp rice development.

Agricultural land capability. From previous soil studies, a broad classification of land capability has been developed. Land types include tidal swamps, coastal beach plains, flood plains, valley swamps, and low and high hills (Table 14). In the case of the tidal swamps, high tides could destroy crops, requiring substantial investment in drainage if such lands are to be used for agricultural production. The coastal beach plains generally have low fertility and low organic matter content and will require some degree of fertilization when cropped. The flood plains also have the problem of potential flooding that can destroy crops, but proper timing and adequate drainage can improve the situation. The valley swamps, which are potential rice fields, are also poorly drained and have low fertility and organic matter content. Adequate drainage and fertilization can improve their agricultural capability. The

low hills are well drained and can be used for upland rice, vegetables and cassava but also have the problem of low fertility and are prone to soil erosion. Fertilization and long fallow periods can improve the agricultural capability of the soil.

Table 14. Agricultural land capability

Agro-ecology	Drainage	Crop suitability	Constraints	Improvement measures
Tidal swamps	Poor	Intensive lowland rice	High tide destroys crops	Adequate drainage
Coastal beach plains	Poor to well drained	Unsuitable for most crops except cassava, coconut, oil-palm	Low fertility, low organic matter (OM)	Fertility management
Flood plains	Poor to well drained	Cocoa, oil-palm, upland rice, irrigated rice possible	Potential flooding	Proper timing of cropping activities, adequate drainage
Valley swamps	Poor	Lowland rice	Water-logging, low nutrients, low OM	Adequate drainage, fertility management
Low hills	Well drained; foot slopes poorly drained	Upland rice, vegetables, cassava	Low fertility, erosion	Fertility management, adequate fallow

Source: GOL (1983)

5.2 Review of some agricultural land and water projects

From the 1970s to the mid-1980s, a number of large, medium and small agricultural development projects were undertaken in Liberia as part of Government efforts to feed the nation and provide certain raw materials for export. These included a number of water control projects for swamp rice development and oil-palm development.

The large projects included the Lofa Country Agricultural Development Project (LCADP), the Bong County Agricultural Development Project (BCADP), the Nimba County Integrated Rural Development Projects I and II (NCIRDP I and II), the South East Rural Development Project (SERUDEP) in Grand Gedeh, Maryland and Sinoe counties, the Central Montserrado Development Project (MDP) and the Special Rice Projects (SRP) at Zleh Town and Foya. The BF Goodrich Liberia Incorporated Rubber Concession was also undertaken to increase the export of rubber (GOL, 1983).

The medium to small projects included the Special Rice Projects (SRPs) in Philadelphia, Gbedin, Kpein, Kpatawee and Garwula-Tombe. Land areas for the projects range from 13 ha for the Kpatawee scheme to 2 272 ha for the Cestos scheme (Table 15). Unfortunately, these projects have deteriorated, and the situation has been made worse by the destruction during the war and inadequate maintenance of the schemes. There is the need to reclaim these swamps in the short term and to develop additional areas in the long term. In order to do this, there will be the need to evaluate the performance of these projects. Swamp development costs are said to range between US$350 and US$1 000/ha on average. Funding for these projects was provided largely by the International Development Agency (IDA), the European Development Fund (EDF) and the African Development Bank (ADB). The Chinese Government also undertook a number of swamp projects.

Table 15. Irrigated agricultural development projects in Liberia

County	Scheme	Area (ha)	Crop	Water control method
Nimba	Gbedin	833	Rice	Basin
Grand Gedeh	Zleh Town	233	Rice	Basin
Grand Gedeh	Cestos	2 272	Rice	Basin
Grand Gedeh	Zwedru	50	Rice	Basin
Cape Mount	Gawula Tombe	142	Rice	Basin
Bong	Kpatawee	13	Rice	Basin
Lofa	Foya 1	156	Rice	Basin
Lofa	Foya 2	150	Rice	Basin
Lofa	Foya 4	155	Rice	Basin
Lofa	Foya 5	130	Rice	Basin
Lofa	Foya Tenga	132	Rice	Basin
Lofa	Foya Fagunda	134	Rice	Basin
Maryland	Philadelphia	24	Rice	Basin

Source: Farnga (1988)

Since 1994, FAO together with various other donors has been assisting Liberia with emergency operations, mainly supplying farmers with agricultural inputs such as seeds and tools, but it was not until February 1997 that Liberia expressed interest in participating in the Special Programme for Food Security (SPFS). In May 1997, an FAO exploratory mission visited Liberia to determine the nature and scope of the SPFS, resulting in the signing of an agreement in February 2000 to implement a pilot phase of Technical Cooperation Programme (TCP) Assistance for six selected sites (Table 16). The project, which aimed at demonstrating technologies for water management and control for the upland and swampland agro-ecologies, proposed to cover 50 farmers at each site for a total participating farm population of 300 farmers, 40 percent of whom were expected to be female farmers. The project was expected to cover about 600 ha for upland crops and 100 ha for swamp rice (MOA/FAO, 2000) but implementation was disrupted by the civil strife.

Table 16. SPFS pilot agricultural water projects

N°	County	District	Clan	Site
1	Bomi	Klay Dowein	Tek Gbarvon	Zordee Gbobeh
2	Grand Bassa	Compound No. 2 Compound No. 3	Mobli Zeowein	Kpaweeto Tubmanville
3	Nimba	Sanniquellie-Ma Saclepea-Ma	Sehyi Gbannoi	Sehkinpa Kpein

Source: FAO/MOA (2000)

A number of local and international NGOs are supporting various aspects of land and water resources projects including forestry development projects. Fauna and Flora International (FFI), the Sustainable Development Institute (SDI), Conservation International (CI) and the Global Environmental Fund (GEF) are supporting forestry projects in Liberia. Two pilot community forestry projects are proposed for implementation and the World Bank, the FFI and GEF are currently undertaking a community forestry study for Sapo National Park. Some NGOs that are involved in water projects and supported by USAID include the Catholic Relief Service (CRS), World Vision International (WVI), Mercy Corps, the Liberia Community Infrastructure Project (LCIP), AFRICARE, and the African Development Aid Foundation (FDA). Agencies of the UN, such as FAO, WFP, UNDP, UNICEF, UNHCR, UNEP and UNIFEM, are actively involved in postwar nation-building; some of them are

channelling their resources through local NGOs. The United Nations Mission in Liberia (UNMIL), whose mandate is to keep peace in Liberia, is also involved in supporting postwar nation-building.

The UN agencies, such as FAO, among other objectives, are supporting rehabilitation of old swamp areas by training ex-combatants in sustainable livelihood activities; this has been occurring since 2005 in Lofa County, for example. A monthly subsistence allowance of US$30 per participant, which was provided as an incentive for resettling the ex-combatants, did not prove successful because most of the trainees did not go back to swamp rice cultivation (Koiwuo, personal communication, 2006). Currently, such financial incentives have been discontinued and the assistance generally provided is in the form of inputs for communities such as seeds, farming tools and training. There is also food-for-work assistance being provided by the WFP, but these programmes have also run into various problems.

The International Committee of the Red Cross (ICRC), which claimed to be offering assistance to about 40 000 community groups, provided seeds and tools. The Food Support for Local Initiatives (FSLI) group also provided seeds, tools and food-for-work in assistance to the communities. The German Technical Cooperation Agency (GTZ) also provided assistance in the multiplication of tuber crops, plantain and vegetables. The Pentecostal Ministries Union (PMU) is also assisting the communities in vegetable production. The United Methodist Committee on Relief (UMCOR) also provides assistance in swamp rice development and seed multiplication. The Sustainable Agricultural Services Union (SASU), in collaboration with FAO, implemented training for communities in crop, livestock and fisheries production. The NGO CONCERN is implementing FAO support for 1 500 beneficiaries in swamp and upland rice production. The local NGO ADA provides assistance to farmers in the form of farming inputs and food-for-work in Foya, Gbedin and Kpatawee, for example, but did not appear to be well accepted by the beneficiary farmers. The water control headworks at these three sites are damaged and need to be repaired urgently. The FAO and WFP, as part of the agricultural sub-sector assistance, are also assisting ex-workers of the Central Agricultural Research Institute (CARI) in the form of seeds, tools and food-for-work to undertake rice seed multiplication on the abandoned research fields that cover 6.5 ha of swamps and 4.2 ha of upland. Some of the ex-workers will be re-engaged when CARI resumes full operation as the country's main research institute. Rice varieties such as New Rice for Africa (NERICA) are being multiplied at CARI with the assistance of WARDA.

At Zuluyee (Sanniquellie District) and Mowulahun (Kolahun District), for example, traditional swamps are being developed by a group of farmers, even though the land areas involved are small in proportion to the number of participating farmers. However, the demonstration of self-help spirit is notable and commendable.

The United Methodist Church Agricultural Project (UMCAP) and USAID are supporting the rehabilitation of an improved swamp rice farm covering 2 ha to produce some food for the inmates of a leprosarium in Ganta. Supported by the LCIP/USAID as part of the Demobilization, Disarmament, Rehabilitation and Reintegration (DDRR) programme, 480 ex-combatants and farmers were also assisted by the local NGO CATALYST, which provided seeds, tools and technical assistance. In an 8-month programme, CATALYST implemented 27.6 ha of swamp rice development in six villages in Bong County, which they described as successful. The assisted communities have continued the work even without further outside assistance.

Also between 1996 and 1998, 20 ha of swamp rice development was implemented by the local NGO Zao Development Council Incorporated (ZADC) for five communities in Nimba County, with financial assistance from CRS and FAO. As usual, the assistance came in the form of planting material, tools and technical assistance in capacity building. BANBATT 10 of UNMIL also assisted the Kpein community, under what was known as the Nimbanian Bangladeshi Friendship Agricultural Project (NIBAFAP), in the rehabilitation of a 4.5 ha upland rice project in Nimba county. Earlier assistance provided by FAO under the SPFS in the construction of water control headwork for the development of additional swamps at Kpein did not turn out to be successful but the farmers, on their own initiative, are engaged in swamp rice development activities. Vegetable crops such as peppers, eggplant and bitter ball are also produced at Kpein, where irrigation is done by hand. Also at Saclepea, the Nimba County Rural Development Project (NCRDP) and Community Union for Productivity (CUP) have initiated swamp rice projects. Lessons learned from all these experiences are discussed later.

6. EMERGING ISUES IN THE LAND AND WATER SECTOR

Various issues have emerged from the land and water sector review and analysis.

- Liberia has no comprehensive policy document relating to water resources development but there are small portions of the legislation on land, mining, forestry and water supply that relate to water resources.
- The hydrometeorological and hydrological networks in the country are in a very poor state; some stations have been closed down due to lack of equipment and commitment of observers.
- Although there are insufficient data to support this claim, current land-use practices are deemed to be having an effect on water resources, as suggested by the seasonality of some tributaries that used to be perennial, and the changing rainfall patterns.
- There is the general assumption that water resources are limitless. The country must seriously engage itself in a more pragmatic way in planning its water resources in the face of current land use practices. Issues of integrated watershed management and the joint administration of international water bodies must be dealt with. This situation requires immediate attention.
- Forest cover is reducing due to current farming practices, thus posing a threat to soil fertility, biodiversity and the water resources of the nation.
- Institutional capacity for managing agricultural land and water is weak and must be strengthened through capacity building and the equipping of the water sector agencies.
- Swamp water management is difficult and makes extra demands on farmers in terms of time, resources and energy. There is a general preference for upland farming even though rice yields are reported to be about half those attainable in the lowlands. There are also problems with poor design, construction and maintenance of water control structures.
- Basic water management data for crops are not available and research in Liberia does not seem to consider this a priority, probably because of the abundance of water resources. The emphasis seems to be on the control of excess water in the lowlands rather than management of soil water in the uplands.
- Upland water management and water management on slopes are not considered to be critical issues in the farming community. The upland soils are generally acidic, with low fertility and low water-holding capacity, and are prone to soil erosion yet soil and water management is not generally considered by the farmers. It is necessary to investigate why

farmers do not pay particular attention to field soil and water conservation practices on the uplands and the slopes.

- Rainfed agriculture has seen, in recent years, late onset of the rains, which is of concern to the farmers. Could it be that the rainfall patterns are changing due to general land use practices?
- A system of lowland agricultural activity known as recession agriculture attempts to use residual soil water for agriculture. Farmers at the periphery of water bodies, advancing and retreating depending on the water regime, take advantage of soil water for crop production. Could options such as this be exploited further?
- Conventional upland irrigation is not considered to be an issue in Liberia because there are water surpluses in all the agro-ecological zones in the country and large areas of swamps available for development.
- Small, shallow well irrigation farming and peri-urban irrigation also take place on a limited scale in Liberia. These activities are probably taken for granted and therefore do not receive any recognition in the plans for achieving food security.

7. DEMAND FOR RICE LAND AND WATER

In this section an estimate of the land area and water resources needed to achieve self-sufficiency in production of the staple food crop is presented (Table 17). The projected population (P) was computed using 2004 as the baseline year, assuming an annual growth rate of 2.3 percent for the period 2006–2015 (10 years). Assuming the per capita consumption of rice to be 124 kg, the domestic rice required (DRRq) for the entire population over the ten year period was computed. Assuming that rice imports will progressively decrease over the same period, a progressively declining rice import factor (RIF) was applied to determine the total rice imported (TRI). This includes commercial imports and food aid. The total domestic rice produced (TDRP) over the period was computed by subtracting the TDRP from DRRq. It was further assumed that there are three different production systems: upland rice (UpR), traditional swamp rice (TSR) and improved swamp rice (ISR), contributing 50, 30 and 20 percent respectively to the domestic rice produced. The factors were applied to compute the UpR, TSR and ISR. The land areas required to grow the UpR, TSR and ISR were computed by assuming average rice yields of 1.2, 1.5 and 2.0 MT/ha respectively. The results indicate that a total swamp land (TSL) area of approximately 167 000 ha and an upland area (UpRL) of 232 000 ha will be required by 2015, if a consistent rice policy is implemented over the period, making a total of nearly 400 000 ha of both types of land. If double cropping is done each year in the swamps, the swampland area could be halved to achieve the same result.

On average, coupled with upland rice production, it will require swampland expansion of about 10 000 ha/year to achieve the food self-sufficiency target projected. It must be noted that 4 percent of Liberian land, amounting to about 445 500 ha, are said to be swamp and 8 352 750 ha are uplands. Before the war cropped land was reported to measure 600 000 ha, of which 220 000 ha was permanent cropland and the rest (380 000 ha) was arable cropland. Assuming a minimum fallow period of 10 years this implies that a total of approximately 464 000 ha would need to be available for upland rice production, amounting to 5.5 percent of the total upland area of Liberia. By this analysis, it will require only about 37 percent of the swamp area to be brought under rice production over a period of 10 years to achieve self-sufficiency in rice. On the whole, at current rice production levels, it will require an

expansion of 20 000–25 000 ha of both upland and lowland rice for 10 years for Liberia to achieve self-sufficiency in rice production.

Table 17. Rice production analysis

Year	P (million)	DRRq (MT)	RIF	TRI (MT)	TDRP (MT)	UpR (MT)	TSR (MT)	ISR (MT)	UpRL (ha)	TSRL (ha)	ISRL (ha)	TSL (ha)
2006	3.663	454 194	0.45	204 387	249 806	124 903	74 942	49 961	104 086	49 961	24 981	74 942
2007	3.747	464 640	0.40	185 856	278 784	139 392	83 635	55 757	116 160	55 757	27 878	83 635
2008	3.833	475 327	0.35	166 364	308 962	154 481	92 689	61 792	128 734	61 792	30 896	92 689
2009	3.921	486 259	0.30	145 878	340 381	170 191	102 114	68 076	141 826	68 076	34 038	102 114
2010	4.012	497 443	0.25	124 361	373 082	186 541	111 925	74 616	155 451	74 616	37 308	111 925
2011	4.104	508 884	0.20	101 777	407 108	203 554	122 132	81 422	169 628	81 422	40 711	122 132
2012	4.198	520 589	0.15	78 088	442 500	221 250	132 750	88 500	184 375	88 500	44 250	132 750
2013	4.295	532 562	0.10	53 256	479 306	239 653	143 792	95 861	199 711	95 861	47 931	143 792
2014	4.394	544 811	0.05	27 241	517 571	258 785	155 271	103 514	215 654	103 514	51 757	155 271
2015	4.495	557 342	0.00	0	557 342	278 671	167 203	111 468	**232 226**	111 468	55 734	**167 203**

Source: Author's estimates (2006)

With regard to water resources the situation is as follows: assuming 1 500 mm of water requirements for the crop, considering surface evaporation, drainage and other losses, a total land area of about 400 000 ha of both upland and swamp rice will require an annual renewable water supply of about 6 billion m^3 or 6 km^3/year. This is only approximately 2.6 percent of the total annual renewable water resource of 232 km^3/year.

8. LAND AND WATER DEVELOPMENT CONSTRAINTS AND POTENTIAL

An analysis of the development potentials and constraints is based on the following observations.

- There is a high potential risk of an irreversible degradation of land and water resources. The abundance of natural resources in Liberia cannot be overemphasized. With regard to water resources, it is true that Liberia is one of the few West African nations which are endowed with adequate supplies. Whereas there are few scientific data to describe the extent of the water resource, physical observation alone attests to the fact that this resource is substantial. As stated earlier, it is estimated that the country possesses about 232 km^3 of renewable water resource per annum. The statistics also show that deforestation is at the rate of 2–5 percent per annum. There is concrete scientific evidence to suggest that when forest cover diminishes, water resources also dwindle, thereby increasing the risk of perennial streams becoming seasonal. The country must as a matter of urgency move away from the notion that water resources are limitless and must seriously engage itself in a more pragmatic way in planning the management of water resources in the face of current land use practices. This situation requires immediate attention.

- There is a general lack of recognition of the close interrelationships between livelihood strategies, agriculture and the environment. The population of Liberia is intimately integrated into the landscape of river systems, lakes and mangrove swamps. The rural people earn their livelihood through the cultivation of food crops, fishing, extensive husbandry of livestock, collecting fuel wood, producing vegetables, growing tree crops such as cocoa and coffee and through other non-agricultural activities. Under the right conditions, these people should invest in the long-term health and productivity of their

land, water, tree and livestock resources. The most important conditions influencing these investments are profitability, power and certainty. Quite often bottlenecks exist with regard to uncertainties over the rights to land. Land users need to be sure that investments in the land will yield good future returns and they must be certain that they will be able to reap what they sow (ICRAF, 2001). This calls for an integrated approach to basin management to be able to derive livelihoods from the larger environment on a sustainable basis. Improved resource management in all basins requires input from many agencies and sectors, along with more collective action by local community groups. There is the need to empower legitimate local authorities and community groups to develop and enforce regulations on resource use and to exert control over catchment areas. Community regulation of resource use is very important for maintaining the integrity of the resource base and for stimulating private investment in resource management (Agodzo, 2003).

- Institutional capacity in support of agricultural water development and management is weak, largely due to the destruction that occurred during the war and underfunding of the sector. A highly centralized institution, LWRDD lacks key equipment and personnel to provide the needed services at the community level. The concentration of resources in Monrovia, as with all Government departments, also makes it difficult for district and community level work to be carried out. Government is in the process of reforming the agricultural sector by decentralizing services to the grassroots level. When governments try to do too much via the civil service, they end up not doing anything well. Current global trends involve private sector participation in service delivery, thus leaving the civil service to concentrate on providing the enabling environment and control for entrepreneurship development. It should be possible for the private sector to participate in some aspects of the land and water management work, by providing such services as training for staff and farmers.

- Basic water management data for crops are not available and research in Liberia does not seem to consider this to be a priority, probably because of the abundance of water resources. The emphasis appears to be on the control of excess water in the lowlands rather than management of soil water in the uplands. Upland water management and water management on slopes are not considered to be critical issues in the farming community. The upland soils are generally acidic, with low fertility, low water-holding capacity and are prone to soil erosion, yet soil and water management is not thought to be an issue for these farmers. Rain-fed agriculture has seen, in recent years, late onset of the rains, which is of concern to farmers. Could it be that the rainfall patterns are changing due to general land use practices? No link has as yet been scientifically established between the changing rainfall patterns and general land use practices. The reasons why farmers do not pay particular attention to field soil and water conservation practices on the uplands and the slopes require investigation.

- Swamp rice water control is very difficult. Labour for swamp water control is generally expensive. Labour gangs operate in certain areas, where farm work is rotated among gang members. There is an arranged form of payment in kind for labour. However, there can be labour shortages at the peak of the farming season and the cost of hiring labour can be high. Studies showed, for example, that in neighbouring Sierra Leone, 70–80 percent of farmers abandoned swamp farms for the uplands when the Government made investments in developing swamps using conventional water control systems (Kandeh, 2003). There are still problems with swamp rice production because of difficulties in water control and

the extra demand it makes on time, energy and resources of the farmers. However, there is also evidence that rice yields in swamps can be up to twice those obtained on the lowlands. Opportunities exist to improve water control in the lowlands and to continue to train farmers in techniques of water control.

- The potential exists for development of other forms of agricultural water use, such as upland supplementary irrigation, lowland shallow well irrigation, recession agriculture and urban/peri-urban agriculture. There are hardly any statistics on the extent of these activities and how much they are contributing to the food sector of the economy. The cost implications of upland supplementary irrigation will definitely be higher (about US$5 000–8 000/ha), but there is also evidence that the returns are equally high when properly managed. It is understood that peri-urban farmers would rather grow vegetables to generate income to buy the rice they eat than grow rice themselves. For urban/peri-urban agricultural activities, simple pumping technologies with capacities of 1.0 m^3/hour, and capable of irrigating 100 m^2/hour of land area at an assumed irrigation depth of 10 mm, could be promoted. It is believed that the potential exists for simple forms of agricultural water use to achieve food security in Liberia. Those advocating water control interventions currently promoted by GOL to achieve food security must also consider these interventions.

- The rural infrastructure is generally poor. Rural infrastructure, comprising rural roads, markets, irrigation systems, water supply, and health and educational facilities, is basic to the quality of life in rural areas and is an important factor in economic development. Although the statistical reporting systems are weak, there is evidence to suggest that the key rural infrastructure necessary to accelerate economic growth is generally below the levels that will promote adequate levels of economic activity. Many dwellings were destroyed and/or abandoned during the war. Only 4 percent of rural households are reported to have access to safe drinking water. Only about 4.5 percent of villages in some districts have access to functional markets. The road network is estimated to be 70 km per 1000 km^2, making it one of the worst in sub-Saharan Africa. The level of destruction of life and property during the 14 years of war has made the situation worse, so that even finding the money for postwar reconstruction is becoming a problem. This suggests that the level of deprivation is high, especially in rural areas.

- Poor accessibility, particularly to potentially rich areas, slows down economic activity in terms of mobility and access to important social services such as markets and health infrastructure. Rural roads are considered a fundamental factor for the development of agriculture. Scientific evidence suggests that production levels increase, input costs reduce and even farm wages increase when road accessibility is good. The road infrastructure, worsened by the civil war, is generally poor and most roads become flooded during the rainy season because of poor drainage. In fact, there were long years of neglect of the feeder roads even before the war, thus making accessibility to markets and other social services difficult in the rural areas. PARKBATT (Pakistani Battalion) and BANBAT (Bangladeshi Battalion) engineers from the United Nations Mission in Liberia (UNMIL) have been involved in the rehabilitation of some major road links in the country. One other problem of poor accessibility is that residents of potentially rich agricultural areas near to the borders of neighbouring countries may engage illegally in smuggling in order to dispose of their commodities at good prices, partly because of lack of access to the important internal markets. It is therefore vital that potentially rich

agricultural areas be linked up to the key market centres in order to boost trade within the country.

- Liberia has high economic potential, which, if developed, would provide job opportunities for young people and empower women to generate income for personal family needs. Whereas diamonds have become the symbol of wealth in Liberia, it is becoming increasingly clear that the country needs to face up to the reality of the times and invest more in agriculture not only to provide jobs in the agribusiness chain but also to improve the food security situation in the country. The indications are that the level of deprivation is high, especially in rural areas, and has been made even worse by the war, but the fact remains that the rural economic potential is high when appropriate measures are taken.

9. POTENTIAL LAND AND WATER INVESTMENT ACTIVITIES

With the main objective of seeing agriculture in Liberia become a major source of growth and poverty reduction, any **land and water management** interventions must be aimed at:

- enhancing agricultural production and productivity;
- improving rural infrastructure, especially in the area of accessibility;
- fostering participatory community development, recognizing the different roles of the two genders in development.

In view of the above, key project components that can be proposed, with justifications, are given below.

9.1 Proposed projects

Component 1: **Land and Water Sector Institutional Capacity Building (2–5 years).** Made worse by war, such important institutions as the Land and Water Resources Development Division (LWRDD), the Liberia Hydrological Survey (LHS), the Water and Sanitation Department (WSD) and the Liberia Water Company (LWC) in the business of water resources development and swamp rice development in Liberia urgently need to be strengthened and to support agricultural and other sectoral developments in the country. Useful data have all been destroyed during the war.

The project should support the following activities:

1. land use assessment of Liberia (**5 years**);
2. detailed study of the water sector (**2 years**);
3. development of a comprehensive national water policy (**2 years**);
4. establishment of a water resources commission (**2 years**);
5. improvement in the meteorological and hydrological networks (**5 years**);
6. staff training in the management of the hydrological and meteorological network and capacity building of the staff of the water sector (**5 years**).

The Liberia Hydrological Surveys (LHS), for example, is the sole agent responsible for generating meteorological, surface hydrological and geohydrological data. Out of the 47 meteorological stations that existed before the war, only one is currently intact. Of the

45 hydrological stations that existed before the war, only one is intact. The future requires that the water sector institutions are assisted to provide the necessary data for development planning. A proposed Water Resources Commission (WRC), as present in many countries, would require start-up funding but must generate income from royalties paid by water users to meet part of its recurrent expenditure.

During the implementation of the project, LWRDD is expected to be the lead institution that facilitates and manages the project. In collaboration with other sector institutions, LWRDD and the LHS will procure and install key meteorological and hydrological equipment and also improve such networks. Capacity building for the various categories of staff in the water sector institutions is to be undertaken by private consultants. At least 20 key staff selected from all the water sector institutions are to be trained in local and foreign institutions. Mechanisms for the joint management of international water bodies must be put in place. There must also be strong support for tertiary education and research in water resources engineering.

Component 2: **Land and Water Development for Swamp Rice Production (2–10 years).** Land under swamp rice was lost during the war. In the short term, this land area needs to be brought back into production by rehabilitation of these swamps to bring them up to the pre-war figures, as a short-term measure to meet the country's cereal requirements. There are already ongoing swamp rice reclamation projects scattered over Liberia, either as community-initiated postwar activities or as initiatives for resettling ex-combatants. There is the need to bring more of the improved swamps into sustained production and also to provide support for traditional swamp rice production efforts in order to help achieve the objective of food security. This project will also support the expansion of community involvement in the restoration of priority swamps at a rate of about 10 000 ha/annum over a period of 5 years; the initiation of farmer field schools in land and water management in swamp rice production; and will equip farmers to sustain production.

The project activities should include the following:

1. assessment of the potential of swamps and inland valleys and their characterization for agricultural development (**2 years**);
2. support for improved swamp rice production (**10 years**);
3. support for traditional lowland rice production (**10 years**);
4. capacity building in the construction and management of water control structures (**10 years**);
5. research trials in swamp rice production (**10 years**).

Support for improved swamp rice production will include reclamation of old improved swamps lost during the war and the development of new improved swamps. Support for traditional lowland rice production will include the reclamation of old traditional swamps lost during the war and the development of new traditional swamps. These could take the form of technical, credit and input support for the participating farmers.

The LWRDD shall be the agency responsible for the implementation of the project in collaboration with NGOs and faith-based organizations (FBOs).

Component 3: **Land and Water Development for Upland Rice Production (2–5 years).** Conventional rice cropping in Liberia occurs on the uplands. Although the exact area out of the estimated 380 000 ha of arable land that is involved is not known, it is estimated that this

activity occupies a large proportion of the arable lands of Liberia. Although it has been scientifically proven that the swamps are more productive per unit area than the uplands, it is equally true that there is less work involved in upland rice cultivation. Moreover, it allows for more crop diversification through intercropping with other staples. Therefore, upland rice production will remain a major production activity for a long time despite the relatively low yields. The farming system in Liberia is one of shifting cultivation on predominantly rolling to steep slopes; unprotected slopes lend themselves to soil erosion, thus leading to rapid soil degradation. The soils are generally acidic due to the high rainfall. The need to conserve soil and maintain soil fertility on such slopes thus becomes paramount in this type of farming system.

It is assumed here that most of the intervention required will be in the form of input support and farmer training/field schools in soil and water conservation strategies. A conservative figure for a pilot area of 100 ha is proposed initially and will be expanded gradually in the long term.

The project will focus on identifying suitable technical options for intensification, and increased efficiency of upland rice development and management, allowing for intercropping as well as for soil conservation.

The project activities should include:

1. providing support services in terms of credit, farm tools, seeds and agrochemicals to approximately 500 female farmers and 300 young farmers in 50 groups, potentially those involved in subsistence production activities (**2 years**);
2. capacity building in soil and water conservation strategies on uplands (**5 years**);
3. expansion of new upland farms at 10 000 ha/annum (**10 years**);
4. research trials on upland rice intercropped with other staples (**5 years**).

It is expected that the project will be managed by the LWRDD in collaboration with NGOs and CBOs.

*Component 4***: Urban and Peri-urban Agriculture for Women and Youth Groups (3 years)**. Urban and peri-urban agricultural activities are increasing in Liberia because of the high demand for produce by the rapidly increasing urban population. It is believed that Monrovia alone now accounts for nearly 40 percent of the Liberian population because most refugees returning home do not move to their county of origin but rather choose to settle in Monrovia. The proximity to input and output markets and the relatively better market infrastructure compared with rural-based agriculture gives this type of agriculture an advantage. Amongst the genuine and promising developments in Liberia is the emergence of civil society groups and several theme-focused youth groups. Youth groups seeking to undertake ventures in agriculture need to be encouraged and mechanisms should be put in place to facilitate their engagement in replicable productive enterprises. Furthermore, there is a wide range of small-scale service and business activities in the agrifood chain that could profitably be picked up by organized youth groups.

This project will focus on the following activities:

1. assessing the potential and benefits of urban and peri-urban agriculture (**0.5 year**);

2. providing support services in terms of credit, farm tools, seeds and agrochemicals to approximately 1000 female farmers and 600 young farmers in 50 groups, potentially those involved in market-oriented production, input supply and post-harvest activities (**3 years**);
3. capacity building in urban/peri-urban production and post-harvest activities (**3 years**);
4. construction and equipping of shallow wells with motorized pumps for irrigation of urban/peri-urban farms (**3 years**).

The project is to be managed by MOA with strong linkages maintained with women's and youth groups as well as with appropriate NGOs and CBOs. The activities of the project could be incorporated into similar projects that are already in train.

Component 5: **Community Watershed Management (1–5 years).** The presence of an agrarian economy suggests that economic activity is land-based. There is evidence to suggest that some small tributaries of the main rivers that used to be perennial have become seasonal because of the removal of swamp thickets for agricultural production. The general assumption in Liberia is that water is limitless. Buttressed by the fact that the country does not have a water policy to regulate, use and protect its water bodies, the situation calls for re-examination of the general land-use practices in relation to water resources. As stated earlier, there is a need to empower legitimate local authorities and community groups to develop and enforce regulations on resource use and to exert control over catchments. Community regulation of resource use is very important for maintaining the integrity of the resource base and for stimulating private investment in resource management. The best option will be a community-based approach to conservation of river basin resources, at the same time allowing the development of livelihoods on a sustainable basis.

The project will focus on the following activities:

1. assessing past and current land use practices at the community level (**1 year**);
2. assessing the extent of degradation in the various river basins using geographical information systems (GIS) and other appropriate tools (**1 year**);
3. detailed hydrological studies of all river basins, including the development of hydrological maps for all river basins in Liberia (**2 years**);
4. development of detailed land use maps (**2 years**);
5. development of detailed soil and soil suitability maps for agricultural planning (**2 years**);
6. undertaking community needs assessment in environmental conservation programmes (1 year);
7. design and implementation of community-based watershed management projects (**5 years**).

It must be noted that the International Center for Research in Agroforestry (ICRAF), which is based in Nairobi, has over the years been involved in successful community resource conservation activities, from which examples can be adopted for implementation in Liberia.

Although the project should assume a national character, pilot schemes can be started in the three most vulnerable districts in three small watersheds ($\leq$ 100 km^2). While the LWRDD of the MOA will play the role of facilitator in implementation of the project, the private sector should be contracted to undertake the tasks listed above under the supervision of the appropriate government agencies. A project heading in this direction should be inter-sectoral, involving the LHS, the Forestry Development Agency (FDA) and the Wetlands Division.

9.2 Project costs

Project costs (Annex 1), estimated at US$39.6 million are summarized in Table 18.

Table18. Cost summary for water management and irrigation sector

N°	**Project component**	**Cost (US$)**
1	Land and Water Sector Institutional Capacity Building	2 500 000
2	Land and Water Development for Swamp Rice Production	22 100 000
3	Land and Water Development for Upland Rice Production	3 000 000
4	Urban and Peri-urban Agriculture for Women and Youth Groups	4 500 000
5	Community Watershed Management	7 500 000
	Total	**39 600 000**

9.3 Project benefits

It is expected that by the end of the investment phase of the proposed projects, community and individual farm incomes would substantially increase, mainly through increased net returns from improved agricultural production practices and incremental areas brought under rice cultivation in the swamps. Flood recession, small-scale irrigation and peri-urban irrigation for production of vegetables would result in additional benefits. Also, key GOL institutions in the land and water sector and many communities will benefit either directly or indirectly from the project investment in physical infrastructure, equipment, training, and technical and/or financial support programmes. The private sector agencies that participate in these projects will not only provide jobs but will also have their capacities strengthened. Specific benefits are shown in Table 19.

Table 19. Project expected benefits

N°	**Project component**	**Expected benefits**
1	Land and Water Sector Institutional Capacity Building	• Skill improvement for key staff in the public sector • Operational efficiency improvement in the land and water sector • Modernization of equipment and hydrostatistics management • Mapping of the resources of Liberia for operational planning
2	Land and Water Development for Swamp Rice Production	• Increasing productive land area to pre-war levels • Strengthening private sector participation in design and construction of water control structures • Improvement in the water management skills of farmers • Provision of jobs
3	Land and Water Development for Upland Rice Production	• Intensification of upland rice production • Skills improvement for farmers in upland rice production • Increasing income of farmers • Provision of jobs
4	Urban and Peri-urban Agriculture for Women and Youth Groups	• Intensification of dry season vegetable production • Skills improvement for farmers in upland and peri-urban irrigation • Increasing income of farmers and empowering women • Provision of jobs
5	Community Watershed Management	• Increased environmental consciousness • Strengthening private sector participation in design of watershed management interventions • Development of detailed resource maps for planning • Sustainable use of land and water resources in line with community livelihood activities • Provision of jobs

9.4 Project management

Specific roles are recommended for the implementation of the projects as detailed in Table 20. The principle used in assigning roles is that, while LWRDD (representing central Government) creates the enabling environment for business and ensures smooth running of the projects, the actual work should be the responsibility of the private sector and community-based organizations (CBOs).

Table 20. Organization and management of water management and irrigation projects

N°	**Project component**	**Institutional responsibility**	**Expected role**
1	Land and Water Sector Institutional Capacity Building	LWRDD/LHS	Project facilitation/management; procurement and installation of equipment
		Private consultants/local and foreign institutions	Capacity building
2	Land and Water Development for Swamp Rice Production	LWRDD	Project facilitation/management
		Private consultants	Feasibility study and scheme design
		Private contractors	Scheme construction
		Farmer-based organizations	Beneficiary participation in all stages of implementation
3	Land and Water Development for Upland Rice Production	LWRDD	Project facilitation/management
		Private consultants	Geophysical study and well design
		Private contractors	Well construction; pump and accessories procurement
		Farmer-based organizations	Beneficiary participation in all stages of implementation
4	Urban and Peri-urban agriculture with Women and Youth Groups	LWRDD	Project facilitation/management
		Private consultants	Feasibility study, scheme design, farmer training
		Private contractors	Scheme construction
		Farmer-based organizations	Beneficiary participation in all stages of implementation
5	Community Watershed Management	LWRDD	Project facilitation/management
		Private consultants	Feasibility study; project design; application of GIS tools in preparation of various resource maps; LWRDD extension staff training in watershed management techniques
		Community-based organizations	Beneficiary participation in all stages of implementation

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ANNEX 1

CAAS-Lib – Investment proposal

Name of project	**Land and Water Sector Institutional Capacity Building (2–5 years)**
Institutional responsibility	Liberia Hydrological Surveys (LHS) and Land and Water Resources Development Division (LWRDD)
Aim(s) of project	To build the capacity for the land and water sector institutions for strategic planning and management of land and water resources to support agricultural and other sectoral development.
Description of the project	Made worse by war, such important institutions as the Land and Water Resources Development Division (LWRDD), Liberia Hydrological Surveys (LHS), Water and Sanitation Department (WSD) and the Liberia Water Company (LWC) in the business of water resources development and swamp rice development in Liberia urgently need to be strengthened and to support agricultural and other sectoral developments in the country. Useful data have all been destroyed during the war. The project will support the following activities: • land use assessment of Liberia • detailed study of the water sector • development of a comprehensive national water policy • establishment of water resources commission • improvement in the meteorological and hydrological networks • staff training in the management of the hydrological and meteorological network and capacity building of the staff of the land and water sector.
Expected result(s)	• skills improvement for key staff in the public sector • operational efficiency improvement in the water sector • modernization of equipment and hydrostatistics management • key Government institutions in the water sector will either directly or indirectly benefit from the project investment in physical infrastructure, equipment, training, technical and/or financial support programmes • mapping the resources of Liberia for operational planning.
Impact on food security, poverty reduction & economic development	This project will directly impact on natural resources planning and management, which will indirectly lead to the efficient use of such resources to improve agricultural production, food security and consequently the general economic growth.
Implementation procedures	Hydrological studies, forecasting and mapping; procurement and installation of hydrostatistical equipment and monitoring; local and foreign training for selected staff of the water sector institutions, establishment of the Water Resources Commission, detailed mapping of the land resources of Liberia.
Period of execution	July 2007–July 2012
Estimated cost	US$2 500 000

Name of project	**Land and Water Development for Swamp Rice Production (2–10 years)**
Institutional responsibility	Land and Water Resources Development Division (LWRDD)
Aim(s) of project	To increase rice production through the reclamation of swamps lost during the war and expansion of new ones with the aim of improving household food security, nutrition and income.
Description of the project	Land under swamp rice was lost during the war. In the short term, this land area needs to be brought back into production by rehabilitation of these swamps to bring them up to the pre-war figures as a short-term measure to meet the country's cereal requirements. There are already ongoing swamp rice reclamation projects scattered throughout Liberia, either as community-initiated postwar activities or as initiatives for resettling ex-combatants. There is a need to bring back more of the improved swamps into sustained production and also to provide support for traditional swamp rice production efforts in order to help achieve the objectives of food security. This project will also support the expansion of community involvement in the restoration of priority swamps; the initiation of farmer field schools in land and water management in swamp rice production; and equipping farmers to sustain production. The project activities shall include the following: • assessment of the potential of swamps and inland valleys and their characterization for agricultural development; • expansion of community involvement and participation in restoration of priority swamps by initiating small farmer field schools in land and water management in swamp rice production and equipping farmers to sustain production; • expansion of new swamp areas for improved water control at 5 000 ha/annum; • expansion of new swamp areas for traditional water control at 5 000 ha/annum; • capacity building in the construction and management of water control structures • research trials in swamp rice production. Support for improved swamp rice production will include reclamation of old improved swamps lost during the war and the development of new improved swamps. Support for traditional lowland rice production will include the reclamation of old traditional swamps lost during the war and the development of new traditional swamps. This could take the form of technical, credit and input support for the participating farmers.
Expected result(s)	• skills improvement for farmers in the construction and management of water control structures for swamp rice production; • expansion of traditional and improved swamp rice production; • development and improvement of improved rice varieties for the swamplands.
Impact on food security, poverty reduction & economic development	This will positively impact on household food security and nutrition and improve household income and consequently the agrarian and the national economy.
Implementation procedures	Evaluation of pre-war swamp development activities; identification of old swamps for reclamation; identification of new swamps for development; capacity building for LWRDD staff and farmers in swamp rice cultivation; credit and input support for organized farmer groups.
Period of execution	July 2007–July 2017
Estimated cost	US$22 100 000

Name of Project	**Land and Water Development for Upland Rice Production (2–5 years)**
Institutional responsibility	Land and Water Resources Development Division (LWRDD)
Aim(s) of project	To increase rice yields on the uplands through sound field management practices with the aim of conserving soils and maintaining soil fertility on slopes and to identify suitable technical options for intensification and increased efficiency of upland rice development and management, allowing for intercropping as well as for soil conservation.
Description of the project	Conventional rice cropping in Liberia occurs on the uplands. Even though it is scientifically proven that the swamps are more productive per unit area than the uplands, it is equally true that there is less work involved in upland rice cultivation. Moreover, it allows for more crop diversification through intercropping with other staples. Therefore, upland rice production will remain a major production activity for a long time despite the relatively low yields. The farming system in Liberia is one of shifting cultivation on predominantly rolling to steep slopes; unprotected slopes lend themselves to soil erosion, thus leading to rapid soil degradation. The soils are generally acidic due to the high rainfall. The need to conserve soil and maintain soil fertility on such slopes thus becomes paramount in this type of farming system. It is assumed here that most of the intervention required will be in the form of input support and farmer training/field schools in soil and water conservation strategies. A conservative figure for a pilot area of 100 ha is proposed initially and will be expanded gradually in the long term. The project will focus on identifying suitable technical options for intensification and increased efficiency of upland rice development and management, allowing for intercropping, as well as for soil conservation. The project activities will include: • providing support services in terms of credit, farm tools, seeds and agrochemicals to approximately 500 female farmers and 300 young farmers in 50 groups potentially involved in subsistence production activities; • capacity building in soil and water conservation strategies on uplands for LWRDD staff ; • expansion of new upland farms at 10 000 ha/annum; • research trials in upland rice intercropped with other staples.
Expected result(s)	• skills for soil erosion control and water conservation on upland slopes will be acquired by LWRDD staff and farmers; • capacity building of farmers in field water management techniques for intercropped upland rice.
Impact on food security, poverty reduction & economic development	This will also positively impact on household food security and nutrition and improve household income and consequently the agrarian and national economy.
Implementation procedures	Site selection for on-farm trials; farmer field schools in intercropped upland rice development and management; capacity building for soil and water conservation techniques on upland slopes.
Period of execution	July 2007–July 2012
Estimated cost	US$3 000 000

Name of project	**Urban and Peri-urban Agriculture for Women and Youth Groups (3 years):**
Institutional responsibility	Land and Water Resources Development Division (LWRDD)
Aim(s) of project	To build the capacity for urban and peri-urban agriculture for women and youth groups with the aim of providing jobs and incomes and meeting the urban market demand for fresh vegetables.
Description of the project	Urban and peri-urban agricultural activities are increasing in Liberia because of the high demand for the produce by the rapidly increasing urban population. It is believed that Monrovia alone now accounts for nearly 40 percent of the Liberian population because most refugees returning home do not move to their county of origin but chose to settle in Monrovia. The proximity to input and output markets and the relatively better market infrastructure compared with rural-based agriculture gives this type of agriculture an advantage. Among the genuine and promising developments in Liberia is the emergence of civil society groups and several theme-focused youth groups. Youth and women's groups seeking to undertake ventures in agriculture need to be encouraged and mechanisms should be put in place to facilitate their engagement in replicable productive enterprises. Furthermore, there is a wide range of small-scale service and business activities in the agrifood chain that could profitably be picked up by organized youth groups. This project will focus on the following activities: • assessing the potentials and benefits of urban and peri-urban agriculture; • capacity building in urban/peri-urban production and post-harvest activities for LWRDD staff, women and young people; • providing support services in terms of credit, farm tools, seeds and agrochemicals to approximately 1 000 female farmers and 600 young farmers in 50 groups potentially involved in market-oriented production, input supply and post-harvest activities; • constructing and equipping shallow wells with motorized pumps for irrigation of urban/peri-urban farms.
Expected result(s)	• meeting urban market demands for fresh vegetables at competitive prices; • job creation for youth and women's groups in the urban and peri-urban areas; • skills acquired in shallow well construction and irrigation of vegetable crops.
Impact on food security, poverty reduction & economic development	This will directly impact on natural resources planning and management, which will indirectly lead to the efficient use of such resources to improve agricultural production, food security and consequently general economic growth.
Implementation procedures	Feasibility studies, identification and registration of youth and women's groups that engage in agriculture; training, credit and input support for youth and women's groups in urban and peri-urban irrigated agriculture.
Period of execution	July 2007 – July 2012
Estimated cost	US$4 500 000

Name of project	**Community Watershed Management (1–5 years)**
Institutional responsibility	Liberia Hydrological Surveys (LHS) and Land and Water Resources Development Division (LWRDD)
Aim(s) of project	To build the capacity for the land and water sector institutions for the strategic planning and management of the land and water resources to support agricultural and other sectoral developments.
Description of the project	The agrarian economy suggests that economic activity is land-based. There is evidence to suggest that some small tributaries of the main rivers that used to be perennial have become seasonal because of the removal of swamp thickets for agricultural activity. The general notion in Liberia is that water is limitless. Buttressed by the fact that the country does not have a water policy to regulate, use and protect its water bodies, the situation calls for re-examination of general land-use practices in relation to water resources. There is a need to empower legitimate local authorities and community groups to develop and enforce regulations on resource use and to exert control over catchments. Community regulation of resource use is very important for maintaining the integrity of the resource base and for stimulating private investment in resource management. The best option will be a community-based approach to conservation of river basin resources, at the same time deriving livelihoods on a sustainable basis. The project will focus on the following activities: • assessing past and current land use practices at the community levels; • assessing the extent of degradation in the various river basins using GIS and other appropriate tools; • detailed hydrological studies of all river basins, including the development of hydrological maps for all river basins in Liberia; • development of detailed land use maps; • development of detailed soil and soil suitability maps for agricultural planning; • undertaking community needs assessment in environmental conservation programmes; • designing and implementing community-based watershed management projects. It must be noted that the International Center for Research in Agroforestry (ICRAF), based in Nairobi, has over the years been involved in successful community resource conservation activities, from which examples can be adopted for implementation in Liberia. Although the project should assume a national character, pilot schemes can be started in the three most vulnerable districts in three small watersheds ($\leq$100 km^2).
Expected result(s)	• Increased environmental consciousness. • Strengthening public–private sector participation in the design of watershed management interventions. • Development of detailed resource maps for planning. • Sustainable use of land and water resources in line with community livelihood activities.
Impact on food security, poverty reduction & economic development	This will also directly impact on natural resources planning and management, which will indirectly lead to the efficient use of such resources to improve agricultural production, food security and consequently general economic growth.
Implementation procedures	Field studies of land and water resources; land and water resources mapping using GIS and remote sensing techniques; identification of small catchments for pilot community watershed management projects; capacity building of CBOs in community watershed management.
Period of execution	July 2007–July 2012
Estimated cost	US$7 500 000

ANNEX 2

Crop water requirements for rice

Table B1. Net irrigation requirement for Gbedin Rice Project

Month	Decade	ETcrop mm/day	Perc. mm/day	L.Prep mm/day	Eff.Rain mm/dec	IRReq Mm/day	Tot.IRReq mm/dec
Mar	1	0.51	2.2	5.6	11.5	9.47	94.7
Mar	2	2.39	4.4	5.6	27.6	9.70	97.0
Mar	3	3.82	5.0	0.0	31.8	5.64	56.4
Apr	1	4.55	5.0	0.0	32.5	6.30	63.0
Apr	2	4.52	5.0	0.0	33.2	6.20	62.0
Apr	3	4.49	5.0	0.0	35.6	5.93	59.3
May	1	4.46	5.0	0.0	37.9	5.67	56.7
May	2	4.44	5.0	0.0	40.3	5.41	54.1
May	3	4.18	5.0	0.0	43.7	4.81	48.1
Jun	1	3.92	5.0	0.0	47.1	4.21	42.1
Jun	2	3.66	5.0	0.0	50.6	3.61	36.1
Jun	3	3.42	5.0	0.0	51.0	3.32	33.2
Jul	1	3.01	2.5	0.0	25.7	2.92	14.7
Total		**448.0**	**535.0**		**445.4**		**537.6**

Source: Farnga (1988)

Table B2. Net irrigation requirement for Zlehtown Rice Project

Month	Decade	ETcrop mm/day	Perc. mm/day	L.Prep mm/day	Eff.Rain mm/dec	IRReq Mm/day	Tot.IRReq mm/dec
Jan	1	0.12	1.3	6.0	4.6	7.90	94.7
Jan	2	o.74	2.9	6.0	2.8	9.36	93.6
Jan	3	2.59	4.3	0.0	8.0	6.11	61.1
Feb	1	4.43	5.0	0.0	13.8	8.06	80.6
Feb	2	4.66	5.0	7.5	18.3	15.33	153.3
Feb	3	4.65	5.0	8.3	22.2	15.76	157.6
Mar	1	4.68	5.0	8.3	26.1	15.40	154.0
Mar	2	4.71	5.0	0.0	30.1	6.70	67.0
Mar	3	4.76	5.0	0.0	33.1	6.45	64.5
Apr	1	4.77	5.0	0.0	36.1	6.16	61.6
Apr	2	4.75	5.0	0.0	39.2	5.84	58.4
Apr	3	4.86	5.0	0.0	35.6	6.30	56.7
Total		**449.0**	**492.0**		**261.0**		**858**

Source: Farnga (1988)

Table B3. Net irrigation requirement for Gawula Tombe Rice Project

Month	Decade	ETcrop mm/day	Perc. mm/day	L.Prep mm/day	Eff.Rain mm/dec	IRReq Mm/day	Tot.IRReq mm/dec
Feb	3	0.38	2.0	6.0	4.8	7.90	79.7
Mar	1	1.96	4.3	6.0	12.6	10.96	109.6
Mar	2	3.57	5.0	0.0	17.6	6.81	68.1
Mar	3	4.53	5.0	0.0	22.6	7.27	72.7
Apr	1	4.64	5.0	0.0	27.5	6.89	68.9
Apr	2	4.80	5.0	0.0	32.5	6.55	65.5
Apr	3	4.80	5.0	0.0	39.4	5.86	58.6
May	1	4.79	5.0	0.0	46.3	5.17	51.7
May	2	4.74	5.0	0.0	53.2	4.42	44.2
May	3	4.50	5.0	0.0	58.2	3.68	36.8
Jun	1	4.40	5.0	0.0	63.3	3.08	30.8
Total		**431.0**	**513.0**		**378.0**		**686**

Source: Farnga (1988)

Table B4. Net irrigation requirement for Kpatawee Rice Project

Month	Decade	ETcrop mm/day	Perc. mm/day	L.Prep mm/day	Eff.Rain mm/dec	IRReq Mm/day	Tot.IRReq mm/dec
Jul	1	1.49	1.9	7.5	16.5	12.48	149.8
Jul	2	3.09	3.9	7.5	28.6	11.69	116.9
Jul	3	3.81	4.9	0.0	35.9	5.07	50.7
Aug	1	3.89	5.0	0.0	37.1	5.18	51.8
Aug	2	3.76	5.0	0.0	37.6	5.00	50.0
Aug	3	3.89	5.0	0.0	42.2	4.66	46.6
Sep	1	4.00	5.0	0.0	48.9	4.11	41.1
Sep	2	4.12	5.0	0.0	54.5	3.67	36.7
Sep	3	4.18	5.0	0.0	49.2	4.26	42.6
Oct	1	4.27	5.0	0.0	43.2	4.94	49.4
Oct	2	4.36	5.0	0.0	37.6	5.60	56.0
Oct	3	4.18	5.0	0.0	35.9	3.09	30.9
Nov	1	3.88	2.5	0.0	25.0	3.88	27.2
Total		**445.0**	**508.0**		**459.0**		**450.0**

Source: Farnga (1988)

ANNEX 3

Dominant soil characteristics

Soil group and map symbol	Topographic location	Colour	Texture	Depth to limiting layer (cm)	Structure	Mottles	Drainage	Flooding	Geology
D1	Upland – gentle slopes and plateau location	Dark greyish brown over yellowish brown over strong brown to yellowish red	LS (or SL) over SCL over SC/C	100+	Granular and crumb over moderate SAB	Occasionally few orange	Good	None	Gneiss and granites
D2	Upland – slope sites	Dark yellowish brown over yellowish brown to strong brown	LS/SL over gravelly-(iii) SCL or SC	50 to 100	Granular and crumb over weak to moderate SAB	Occasionally few orange	Good	None	Gneiss and granites
D3	Upland – slope sites	Ditto	LS/SL over gravelly-(iii) SCL or SC	25 to 50	Granular over weak SAB	Rarely, few to common, fine, faint to distinct orange mottles	Good	None	Gneiss and granites
D4	Upland – often steeper slopes sites	Ditto	Gravelly LS or SL over gravelly SCL	< 25	Granular over loose SAB	None	Good	None	Gneiss and granites
D5	Upland – gentle slopes and plateaus	Dark greyish brown over brown to pale brown and yellowish brown	LS over SL (sometimes slightly gravelly below 60 cm)	100+	Granular and crumb over weak SAB	Occasionally few greyish or yellowish below 60 cm	Good	None	Gneiss and granites
D6	Upland – slopes of undulating terrain	Dark brown over yellowish brown	LS over slightly to moderately gravelly SL or SCL (often weathering bedrock within 1 m)	100+	Granular and crumb over weak SAB	Usually common red mottles below 60 cm	Good	None	Gneiss and granites

Soil group and map symbol	Topographic location	Colour	Texture	Depth to limiting layer (cm)	Structure	Mottles	Drainage	Flooding	Geology
D7	Upland – slope of undulating terrain	Dark brown over yellowish brown to strong brown	LS over slightly to moderately gravelly SCL or SL (often weathering bedrock within 1 m)	100+	Granular and crumb over weak SAB	Usually common red mottles below 60 cm	Good	None	Gneiss and granites
D8	Upland – slope of undulating terrain	Dark brown over yellowish brown to strong brown	LS over SL (sometimes slightly gravelly below 60 cm within weathering bedrock w)	100+	Granular and crumb over weak SAB	Usually common red mottles below 60 cm	Good	None	Gneiss and granites
L1	Lowland – gentle slope sites	Dark greyish brown over yellowish brown to strong brown	LS/SL over SCL or SC	100+	Granular and crumb over moderate SAB	Few to many, fine and medium, faint to distinct orange below 80 cm	Moderately well or well drained	Low risk of short term flooding during wet season	Colluvium
L2	Lowland – level sites	Dark yellowish brown over light yellowish brown to yellow	Fine S to SL throughout	100+	Single grain or granular throughout	None	Well to excessively well drained	Very low risk of flooding	Course alluvium
L3	Lowland	Dark brown over pale or olive brown over gray/greenish gray	LS/ SL over SCL/ZCL or finer or SC	100+	Granular or crumb over weak to moderate SAB	Common to many, distinct, medium pale brown and grey	Moderate to poor	Liable to flood in wet season	Colluvium
L4	Swamp triangle sites – flat to gently sloping	Dark greyish brown over grey	LS over S to course SL	100+	Weak granular and single grain	Few, faint, and distinct, fine yellow	Moderate to poor	Liable to flood in wet season	Colluvium -Alluvium
W1	Swamp	Dark brown over grey, light grey or greenish grey	Fine-dominantly C, CL, ZC. And fine SC in top meter	100+	Crumb over SAB	Few to many, faint to prominent, medium and course , yellow brown to orange	Poor to very poor	Regularly or permanently flooded in wet season	Colluvium -Alluvium

Soil group and map symbol	**Topographic location**	**Colour**	**Texture**	**Depth to limiting layer (cm)**	**Structure**	**Mottles**	**Drainage**	**Flooding**	**Geology**
W2	Swamp	Dark (greyish) brown over grey or greenish grey	Fine to medium dominantly ZCL, CL/SC fine SCL in top meter	100+	Crumb over SAB	Few to common distinct, medium, yellow brown, yellow and orange	Poor to very poor	Regularly or permanently flooded in wet season	Colluvium -Alluvium
W3	Swamp	Dark brown over grey to light grey or greenish grey	Medium to course: dominantly course SC, SCL and SL in top meter	100+	Crumb over SAB	Few to common, faint to distinct, medium orange and yellow	Poor to very poor	Regularly or permanently flooded in wet season	Colluvium -Alluvium
W4	Swamp	Dark brown over grey to light grey, dark grey (when organic staining occurs) or white	Course: dominantly course LS and S with associated course quartzite stones in top meter	100+	Granular over single grain	Occasionally, few, distinct, fine to medium grey or light brown at depth	Poor to very poor	Regularly or permanently flooded in wet season	Colluvium -Alluvium

NOTES:
SAB=Sub-angular blocky
SL = Sandy loam
SC = Sandy clay
CL= Clay loam
ZC= Silty clay
LS = Loamy sand
SCL= Sandy clay loam
S= Sand
ZCL= Silty clay loam
C= Clay

ANNEX 4

CAAS-Lib Land and Water Sector Field Study

Field trip itinerary

Personnel	**Driver and vehicle**	**Itinerary (8-16 August 2006)**
Land and Water Management Group S.K. Agodzo P.K. Farnga	Oliver Cooper UN 486	Monrovia–Cape Mount–Monrovia Monrovia–Bong–Lofa–Monrovia Monrovia–Nimba–Monrovia
Personnel	**Driver and vehicle**	**Itinerary (7-16 September 2006)**
Southeastern Field Trip P.K. Farnga	UN Shuttle Flight John UN 61	Springgs–Zwedru–Spriggs Zwedru–Zlehtown–Zwedru; Zwedru–Behtown–Zwedru; Zwedru–Ziatown-Zwedru; Zwedru–Fishtown–Zwedro

List of persons contacted

Personnel	**Designation**	**Location/address**
Mr Julu Johnson	Assistant Minister	Bureau of Lands and Survey, Ministry of Lands, Mines and Energy (MLME), Monrovia
Mr George Saa	Director	Agriculture Section, Ministry of Planning & Economic Affairs (MPEA)
Mr Saye H. Gwaikolo	Director	Liberia Hydrological Survey, (LHS), MLME, Monrovia
Mr Jeffery W .Wallace	Assistant Director	Liberia Hydrological Survey, (LHS), MLME, Monrovia
Mr Anthony D. Kpadeh	Hydrometeorologist	Liberia Hydrological Survey, (LHS), MLME,- Monrovia
Mr Carton Miller	Director	Liberia Geological Survey, (LGS), MLME, Monrovia
Mr Chea Garley	Technical Coordinator	Department of Technical Services, Ministry of Agriculture (MOA), Monrovia
Mr Edward Fatoma	Deputy Director	Livestock Division, MOA, Monrovia
Mr Nathaniel Ketter	Statistician	Department of Planning and Evaluation, MOA, Monrovia
Mr Alexander Pearl	Director	Conservation International (CI), Monrovia
Mr Nathaniel B. Walker	Programme Coordinator	Conservation International (CI), Monrovia
Mr Ralph A. Woods	Head	Wetland/Ramsar focal point, Environmental Protection Agency (EPA), Monrovia
Mr George Yango	Acting Minister	Ministry of Rural Development (MRD), Monrovia
Mr Theo Freeman	Technical Manager	Forest Conservation, Forestry Development Authority (FDA), Monrovia
Mr Moses Biah	Head	Wildlife Management and training, FDA, Monrovia
Tarnue Koiwu	National Consultant	FAO TCP, Voinjama, Lofa County
Mr Francis Woiwor	County Agriculture Officer	Department of Extension and Research, MOA, Voinjama
Mr Henry Saa	District Agriculture Officer	Department of Extension and Research, MOA, Voinjama
Mr Benjamin Gobeh	Contact person	Africa Development Aid (ADA), Kolahun, Lofa County

Personnel	**Designation**	**Location/address**
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Mr Varnie Kanneh	Project Coordinator	Concern Agriculture Section, Zorzor, Lofa County
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Mr Gertie Sulonteh	County Coordinator	Department of Extension and Research, MOA, Bong County
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Daniel Gbegbe	Supervisor	FAO, TCP, CARI, Bong County
Alfred Vah	County Agriculture Officer	Department of Extension and Research, Nimba County
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Ms Yah Suah	Farmer	Gbedin Rice Project, Nimba County
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Mr J. Gonkanue Gueslah	Project Management	Catalyst Project, Nimba County
Mr Josiah Gasser	Administrative Manager	Zawu Development Council (ZADC), Ganta, Nimba County
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Ms Josephine Kawee	Chairperson	Kpein Agriculture Project, Kpein, Nimba County
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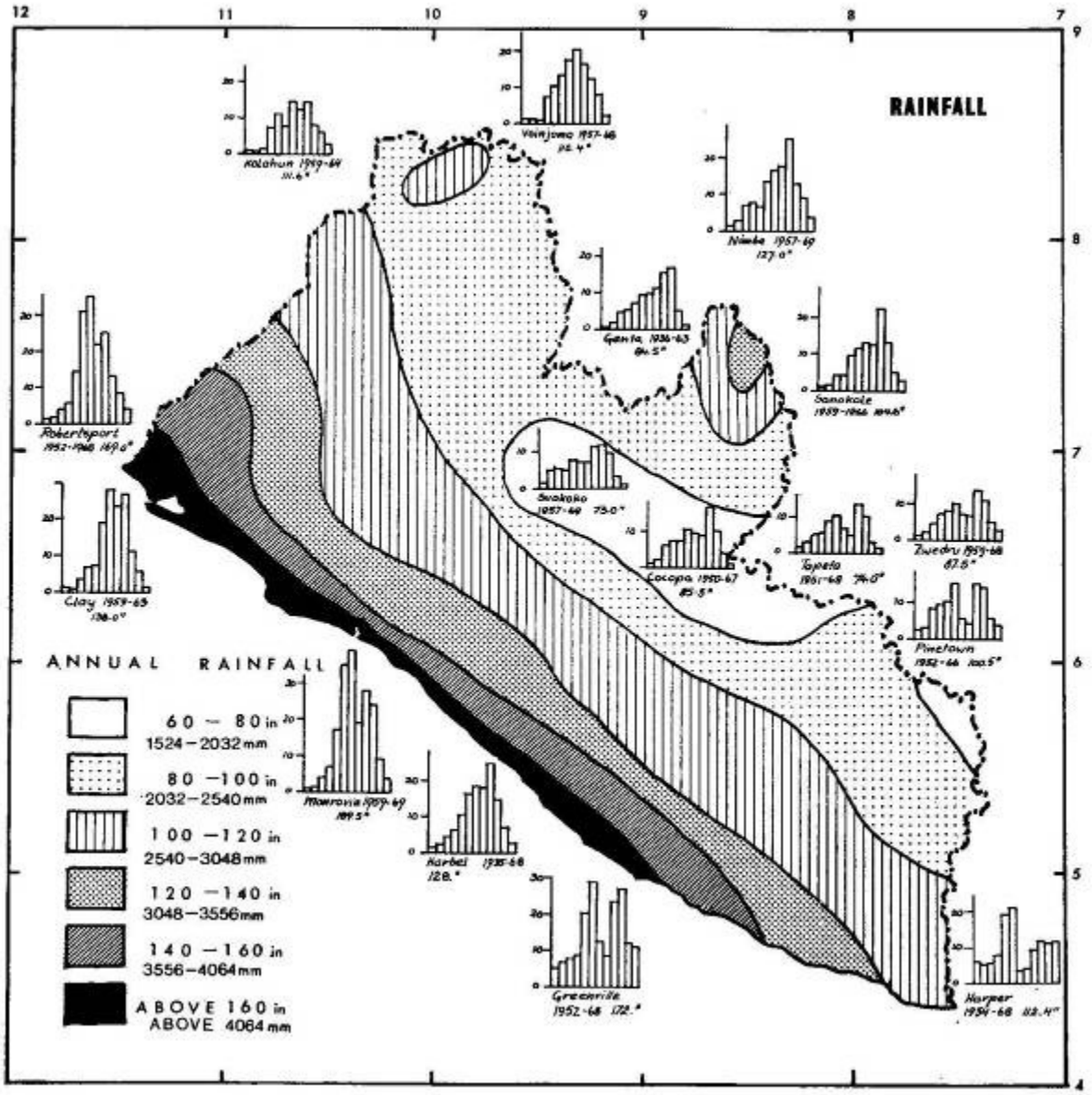
Mr Amara Konneh	Chairman	Memba Farmer Cooperative Society, Zleh Town, Grand Gedeh County
Mr Jeffrey George	Secretary	Memba Farmer Cooperative Society, Zleh Town, Grand Gedeh County
Ms Christina Williams	Member	Memba Farmer Cooperative Society, Zleh Town, Grand Gedeh County
Mr Steffen Schulz	Chief Agriculture Officer	German Agro Action(GAA), Zwedru, Grand Gedeh, County

Personnel	**Designation**	**Location/address**
Mr Isaac Stevenson	Deputy Chief Agriculture Officer	German Agro Action(GAA), Zwedru, Grand Gedeh, County
Ms Hannah Solo	Agriculture Officer	German Agro Action(GAA), Zwedru, Grand Gedeh, County
Mr Forkpa Padeye	Agriculture Officer	German Agro Action(GAA), Zwedru, Grand Gedeh, County
Mr Osman Kenneh	Chairman	Work and See Farmer Cooperative Society, Zwedru, Grand Gedeh County
Mr Anthony George	Fishery Technician	CBO Aquatic Rehabilitation Project, Zwedru, Grand Gedeh County
Mr Alex B. Sanpee	Executive Director	Land Agency for National Development (LAND)
Mr Harris Kanniah	Executive Director	CBO, Amounnou Farmer Cooperative Society, Beh Town Grand Gedeh County
Ms Esther Wisseh	Field Officer	Humanitarian Coordinating Office, Zwedru, Grand Gedeh County
Mr Teemart Williams	Agriculture Officer	German Agro Action(GAA), Fish Town, River Gee, County
Mr Boakai Kandakai	WATSAN Officer	CARITAS, Fish Town, River Gee, County

ANNEX 5

Maps of Liberia

Map 1: Rainfall map of Liberia



Map 1: Rainfall map of Liberia showing distribution of precipitation

Map 2: Drainage map of Liberia