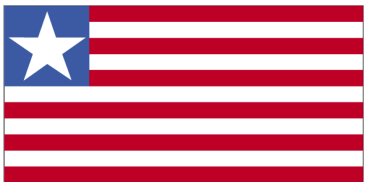

CLIMATE CHANGE ADAPTATION FOR SMALLHOLDER FARMERS IN LIBERIA

by

William J. Todd Jr.

Booker Washington Institute (BWI)

January 2016

TABLE OF CONTENTS

This document outline the following information as indicated below:

- Current situation on climate change in Liberia
- Possible causes/factors associated to climate change in Liberia
- Effects of climate change in farming communities
- Remedies/solution to climate change effects in the Liberian agricultural sectors.

Specific objectives:

- Define climate change and climate smart agriculture
- Identify the causes/factors contributing to climate change
- Analyze the impact of climate change to farmers and how farmers can adapt to the changes

INTRODUCTION:

This document is to guide students and smallholder farmers how to adapt themselves to climate change when it comes to farming in the Liberian communities. Despite the fact that Liberia is underdeveloped, to be successful farmers, there is a need for both the students and smallholder farmers to acquit themselves to the causes/effects of climate change as well as how to find application solution to enable them become a successful farmers to help the Government to have access to food security.

The Republic of Liberia is located on the west coast of Africa (between longitudes 7°30' and 11°30' west, and latitudes 4°8' and 8°30' north). It is bordered on the west by Sierra Leone, on the north by Guinea, on the east by Côte d'Ivoire, and on the south by the Atlantic Ocean (Figures 1a and b). It is Africa's oldest Republic, declared independent in 1874 under a constitution modelled on that of the United States of America. Two civil wars from 1990 to 2003 displaced hundreds of thousands of people and destroyed the economy and infrastructure. A democratic government was elected in 2005.

The current situation

Human activity and technological advisements are one of the most important attributes to climate change in Liberia. These activities associated with climatic change in Liberia that farmers have contributed to the

- Deforestation(cutting down trees)
- Indiscriminate use of agro chemicals
- Poor farming practices among farmers
- Uncontrolled bush burning
- Coal burning

The combination of the above activities have resulted into un desirable environmental effects like accumulation of green house gases in the atmosphere that leads to the following:

- Global warming
- Reduced precipitation
- Soil erosion
- Loss of soil fertility
- Unnecessary/ extreme weather conditions like droughts and flooding as most river catchment areas are destroyed and eventually affect agricultural productivity, resulting into hunger, malnutrition and death of people and other non- human components of the ecosystem.

Factors contributing to climate change in Liberia:

The table below summarizes the factors contributing to climate change and the factors contributing to climate change in Liberia.

Factor	**How/ what effect?**	**Result**
Increased population	More demand for food and land resources	Pressure on natural system
Agriculture	✓ Deforestation ✓ Wetland reclamation ✓ Bush burning to clear land	✓ Reduced precipitation ✓ Drought ✓ Global warming ✓ Loss of soil fertility

Land use in Liberia		
Land type	Area (million ha)	Percent of total land
Forest	4.9	50
Arable (upland and lowland)	4.6	47
Uplands	*4.0*	*41*
Lowlands	*0.6*	*6*
Others	0.3	3
Total Area	9.8	100
Source: CAAS-Lib, 2007.		

Population: About 53% of the population lives in rural areas, and 70% of the active population is engaged in agricultural activities; agriculture is the dominant contributor to export trade and earnings and a source of livelihood for a greater number of people than any other sector. The sector is dominated by traditional subsistence farming systems. The use of modern technology is limited. Slash-and-burn farming, where forest lands are cleared, burned and upland rice cropped together with other crops is the primary production system. Sixteen indigenous African tribes (Kpelle, Bassa, Gio, Kru, Grebo, Mano, Krahn, Gola, Gbandi, Loma, Kissi, Vai, Dei, Belle, Mandingo, and Mende) make up 95% of the population. Americo-Liberians, descendants of freed American slaves and the Congo People, freed slaves from the Caribbean make up the other 5% of the population. Liberia has 15 administrative divisions or counties.

Agriculture contributed: 42% of the national Gross Domestic Product (GDP) in 2008 (CBL, 2009). The food crops sub-sector dominates agriculture's contribution to the national GDP. Rice is the main staple food grown by over 74% of the population on uplands (CFSNS, 2008). Cassava is the second most important food

crop grown by about 62% of the population (CAAS-Lib, 2007). Paddy rice and cassava production and area harvested increased by more than 3% per annum during the period 2001-2009 (Table 2). Rice and cassava contributed 22% and 23% of the agricultural GDP respectively (CBL, 2009).

Tree crops: Especially rubber, cocoa and coffee make an important contribution to the economy, accounting for 34% of the agricultural GDP in 2008 (CBL, 2009). Rubber is the most important cash crop and revenue from rubber export increased from US$ 150 million (95% of the total export revenue) in 2006 to US$ 206 million or 86% of the total export earnings in 2008 (CBL, 2009).

Agricultural output is derived from three types of farms: traditional, commercial and concession. The traditional farming systems involve production of food and export crops (mainly coffee and cocoa, and recently, rubber), plus oil palm both for home consumption and for the market. The commercial farms are mainly owned and operated by Liberians engaged in the production of fruits, coffee, oil palm, cocoa and poultry and pigs. The third model is the foreign-owned concession plantations that produce mostly rubber and palm oil (CAAS-Lib, 2007). They are owned and operated by foreign firms.
The country is within the tropical rain forest belt of West Africa and occupies about 43% of the remaining Upper Guinea Forest (CASS-Lib, 2007). In 2008, forestry contributed 19% of the national GDP, totalling US$ 97.5 million (CBL, 2009).

Paddy rice and cassava production trends in Liberia

	Year				Annual growth rate (%)
Crop/Area	1988	2001	2008	2009	2001-2009
Paddy rice					
Production (1000 metric tonnes)	299	219	279	293	3.1
Area harvested (1000 ha)	236	170	223	248	5.1
Cassava					
Production (1000 metric tonnes)	410	373	496	493	3.6

Area harvested (1000 ha)	52	48	57	63	3.5
Source: LSGIS, 2009b					

Livestock: The livestock sub-sector plays a minimal role in the Liberian economy, accounting for about14% of the agricultural GDP. Most of the animals are owned by traditional farmers who use local, less productive animal breeds and inappropriate techniques.

Thus household-based chicken, goats, ducks, pigs, sheep and cattle rearing predominates. These farmers have access to few inputs, and receive limited or no government support services. No dairy production is undertaken in Liberia for commercial purposes.

Total Livestock Units declined during the civil war from 1990-2003, but the numbers had more than recovered by 2010. Demand for livestock products greatly outstrips domestic supply; as a result imports of livestock products and live animals are high. An estimated 19,580 heads of cattle (N'Dama and Zebu), 750 Sahel goats and 1500 sheep are imported from Guinea, Cote d'Ivoire and Mali annually for slaughter (Koikoi, 2011). In 2009, some 11 million metric tons of meat valued at about US$ 4.3 million were imported (according to FAOSTAT imports of 9.6 M tonnes of meat were valued at 9.7 M US$ in 2009).

The country has enormous marine and fresh water fishery resources. There are about 20 000 km^2 of marine fishing grounds, as well as over 1 800 kilometres of rivers, and countless perennial swamps and inland water bodies with potential for inland fisheries and aquaculture (CAAS-Lib, 2007). Liberia's fishery sub-sector consists of an established marine fishery involving industrial and artisanal fishing activities, exclusively artisanal inland fishery, and aquaculture practiced in rural areas through fishpond culture. The fishery sub-sector provides about 3% of the national GDP (CBL, 2009). Over 80% of the population directly depends on fish for animal protein supply.

Land: Land ownership is governed by statutory and customary laws. Inconsistencies in these laws have resulted in several types of land holding arrangements with different levels of tenure security. These range from deed holders with a comparatively high degree of tenure security to squatters with no security. Three main types of land ownership prevail: state or public land, individual proprietorship, and common/tribal ownership rights based on customs.

Customary ownership, under which chiefs are custodians of the land, is the dominant form of land tenure. A Land Commission has recently been established to propose, advocate, and coordinate reforms of land policy, laws, and programs.

Soil and Topography

The 4 main Liberian soil types and their properties.

- The soils range from weakly developed muds and hydromorphic clays along the coast and the inland swamps, to shallow soils on the plateaus and mountains and lateritic hills and terraces in the north.
- The soil patterns are determined by differences in age, parent material, physiography, and present and past climatic conditions.
- Latosols are the most widespread soil type, followed by lithosols, regosols and alluvial or swamp soils in that order.
- Latosols or lateritic soils: developed from crystalline metamorphic and igneous rocks under high annual rainfall (1700 - 4500 mm) and mean temperature (28-30^{0}C) and occupy about 75% of the total area of Liberia (Reed, 1951). They occur on undulating, gently rolling, rolling or steeply rolling land that varies in elevation from almost sea level to about 550 m.
- The latosols have been classified into seven types according to their location: Ganta, Gbarnga, Kakata, Salala, Suakoko, Voinjama and Zorzor.
- They are reddish brown, heavily leached, well-drained, acidic soils with good structure and deep profile. Humus, nitrogen and phosphorus contents are low, meaning that the latosols can be farmed continuously only by repeated application of fertilizers (Jallah *et al.*, 1991).
- Latosols are the most productive soils in the country on which upland rice, the largest single food crop in Liberia, is grown. Large areas of the soils also support the country's tree crops and forest as well as providing valuable materials for road construction.
- Lithosols or gravel soils: are poorly weathered soils consisting of rock fragments and poorly defined horizons. They are shallow with high gravel content, low moisture retention, as well as low humus and mineral nutrient contents.
- Lithosols make up about 17% of the soil cover of Liberia, being found mainly in hilly, rugged and mountainous regions of the country and have limited agricultural value due to their extreme topographic variation and shallowness. They are better suited for wildlife and forest reserves.
- Regosols or sandy soils: are mostly found along Liberia's coastal plains and cover about 5% of the country's land area. They are white to gray in color, acidic,

porous (60% coarse and fine sand) soils with low humus and mineral contents. There are three main groups: Claratown, Sinko and Freeport series. Although, inherently infertile, the sandy soils are suitable for pasture, oil palm and coconut production.

Swamp soils: make up about 4% of the soils in the country.

(a) They are found in swampy areas along the coast and in the interior. They include the alluvial, grey hydromorphic, 'half-bog', and mangrove swamp soils.
(b) The alluvial soils occur in narrow tracts along stream and river beds. They contain the largest amount of plant nutrients of all groups of soils in Liberia.
(c) The 'half-bog' soils occur in swampy areas where drainage is poor and water level in the upper soil layer is high. As a result, decay of plant materials is slow, resulting in the formation of a thick dark layer of a loamy-peaty organic material with high humus content. With proper drainage, the 'half-bog' soils provide good conditions for the cultivation of swamp rice and similar crops.
(d) The most frequent of the swamp soils are the water-logged, gray hydromorphic soils. They are found in the floors of the valley, which are flooded in the rainy season. They are extremely deficient in plant nutrients, and are among the least productive soils in Liberia. However, if drained and fertilized, they can be used for producing rice and other crops (SEE BELOW);

Low land paddy field suffer heavy floor at the Booker Washington Institute, Kakata, Margibi County.

Soils types in Liberia				
Soil type	**Liberian classification**	**Area (%)**	**Area (ha)**	**Properties**

Lateritic soils or latosols	Kakata, Suakoko and Voinjama Series	75%	8,352,750	Reddish brown, well-drained, deep profile, good structure, leached 10 cm top soil, low cation exchange capacity, calcium deficiency, 4-6% organic matter, acidic, aluminium toxicity, productive agricultural soils, occur in rolling hill country, used for tree crops production.
Lithosols	No information	17%	1,893,290	High gravel content, low moisture retention, shallow, low humus and mineral content, and occur in hilly and rugged terrain, medium agricultural potential.
Regosols or coastal sandy soils	Claratown, Sinko and Freeport Series	5%	2,227,400	Well-drained, 60% coarse sand, very low water-holding capacity, low humus and few mineral nutrients, found in the coastal plains, low agricultural potential
Alluvial soils or swamp soils	Gbelle, Ballam, Grayzohn and Cuttington Series	3%	22,740	Waterlogged, gray hydromorphic soils, poor drainage, thick dark layer of loamy-peaty organic material with relatively high humus and mineral contents
Source: EPA, 2007; CAAS-Lib, 2007				

Topography: The topography comprises mainly flat rolling coastal plains running into some interior plateaus, and then mountains in the north-eastern part of the country (Figure 4). There are four distinct relief zones or belts parallel to the coast - the coastal plains (up to 100 m above sea level - masl), rolling hills (100-300 masl), plateaux (300-600 masl), and northern highlands (in excess of 600 masl).

Climate Change Adaptation Agriculture Project in Liberia

What is the project about?

Women farmers planting in the fields (Photo: UNDP)

The Project which serves as a vehicle for implementation of one of the priority actions coming out of the Liberia National Adaptation Programme of Action (NAPA) aims to increase resilience of poor, agriculturally-dependent communities and decrease vulnerability of the agricultural sector to climate change in Liberia.

It also seeks to address barriers of insufficient knowledge and awareness amongst decision-makers and planners, low capacity of technical staff and extension agents and the lack of information needed by farmers on climate change by supporting the ongoing process to revitalize the agriculture sector and ensure that adaptation to climate change is integrated to achieve the following specific results:

(a) integrating concerns into relevant policies and planning processes at the state and national levels, (b) comprehensive capacity development for individuals in national agencies focusing on agriculture in pilot counties, (c) demonstration of risk reduction strategies and measures at pilot sites and (d) strengthening technical capacity to integrate climate change risk management into farmer level agricultural capacity.

Accomplishment:

Comprehensive Vulnerability and Livelihood Assessment of the impacts of climate change on agriculture conducted in Panta and Gbarzon Districts of Bong and Grand Gedeh Counties respectively; findings documented and baseline information extracted for tracking progress

Eight (8) sites identified, 200 farmers (equally disaggregated by gender) selected through a participatory process from eight towns (4 in Panta and 4 in Gbarzon) as participants of the Farmer Field Schools (FFS) which have been set up for testing

climate change adaptation innovations; the FFS curricula have been revised to fit the context of climate change adaptation in agriculture; eight FFS facilitators (2/8 are women) recruited and awaiting a 14-day training of facilitators sessions

(b) A comprehensive Climate Change Management Capacity Development Plan and Implementation Manual developed for the agriculture sector on the basis of a climate change management capacity assessment of the sector and implementation rolled out.

(c) Climate change issues and scenarios identified and documented as well as shared with relevant stakeholders through brochures, national and local community radio/TV stations and direct beneficiaries (farmers and MOA technical departments).

(d) modules developed for short courses on climate change and adaptation in agriculture for the College of Agriculture and Forestry at the University of Liberia and the College of Agriculture & Sustainable Development at the Cuttington University; a collaboration built with the UL, CU, CARI and University of Pretoria, South Africa through which a climate change research is now ongoing in the two pilot counties.

Use of Organic fertilizers:

To increase water productivity on rain fed farms. They stimulate crop growth and production of roots (organic matter in the soil). This increases soil water-holding capacity, reduces temporary moisture stress in plants, improves soil structure and prevents the erosion of rich topsoil.

Such fertilizers are made of animal or vegetable matter such as compost, leaves, decomposing crop residue, nitrogen-rich green manure (legumes), animal manure and worm compost. Organic fertilizers also include liquid fertilizers made and fermented on the farm.

- ✓ Helps sandy soils to retain water and nutrients.
- ✓ Makes the soil more fertile for plants.
- ✓ Helps the soil to capture, absorb and store more water, so less is lost to runoff.
- ✓ Increases the pores or holes in the soil for aeration, root growth and drainage to groundwater.
- ✓ Helps clay soils to drain.
- ✓ **Organic matter acts as a sponge to retain water and make it more available to plants.**

COMPOST PRODUCTS PREPARED AT BWI, MEETING THE CHALLENGES FARMERS FACED DURING THE LOST OF SOIL FERTILITY.

Drip irrigation system introduced at the Booker Washington Institute - BWI

RUMINANT LIVESTOCK PRODUCTION SYSTEMS

Live stock population: Cattle, sheep and goats are the main ruminants (FAO, 2005; LISGIS, 2009b; SFNS, 2010) most of which are owned by traditional farmers who use local, less productive animal breeds and basic techniques. They have access to few inputs, and receive few or no government support services. Households in counties bordering Cote d'Ivoire (Grand Gedeh, Maryland, River Gee and Nimba counties), in which grasslands are vast, remain most likely to own goat, sheep and cattle, although the numbers of cattle are low. Table 5 shows population trends of ruminants (cattle, sheep and goats) and non-ruminants (pigs and poultry) from 1985-2010. The Total Livestock Units declined from 1985-1995, and increased by about 7% from 2005-2010.

Livestock and poultry population trends (1000 head) in Liberia, 1985-2010*

	Year				Annual growth rate (%)
Species	1985	1995	2005	2010	2005-2010
Cattle	42	36	36	40	1.9
Sheep	238	210	210	264	4.3
Goats	235	220	220	338	8.9

Pigs	127	120	130	265	17.3
Chickens	3,500	3,500	5,300	6,800	4.7
Total LU	129	120	140	201	7.3

LU: Livestock Unit; conversion factors: cattle (0.50), sheep and goats (0.10), pigs (0.20) and poultry (0.01).
*It should be noted that the recent report by Koikoi (2011) suggests that numbers of livestock are much lower than the FAO data in this Table. Further studies, including an agriculture census, are needed to clarify the situation.
Source: FAO, 2012; FAOSTAT accessed on 6th July 2012.

A recent survey showed that more than 74% of the cattle population are found in Grand Gedeh, Maryland, Lofa, Bong, and Nimba counties; while Nimba, Grand Gedeh, Bong, Lofa, River Gee and Grand Cape Mount counties harbour 77% of the sheep and goat populations (Koikoi, 2011). Households in all counties own sheep and goats, but cattle ownership is restricted to households in 9 out of the 15 counties (Table 6). The percentage of households owning cattle is highest in Grand Gedeh and Maryland; while Grand Gedeh, Maryland, Nimba, River Gee, Grand Kru and Bong have the highest percent of household ownership of sheep and goats.

Ownership and proportion of total heads of cattle, sheep and goats per county in Liberia

	Ownership (% households)[1]			Percent of total heads[2]		
County	Cattle	Sheep	Goats	Cattle	Sheep	Goats
Bomi	0.0	1.4	1.0	1.3	0.6	0.1
Bong	0.2	3.5	13.7	33.6	14.1	16.8
Gbarpolu	0.2	7.6	13.6	0.2	2.8	1.4
Grand Brass	0.0	1.8	7.4	0.0	0.7	1.9
Cape Mount	0.0	2.8	1.8	0.5	0.3	0.4
Grand Gedeh	1.4	4.0	27.2	8.1	5.5	10.8
Grand Kru	0.6	3.3	16.0	11.5	4.3	9.6
Lofa	0.2	3.4	8.2	3.8	9.7	7.8
Margibi	0.0	1.8	7.4	1.4	2.1	1.2
Maryland	1.4	8.4	23.8	1.4	4.8	4.0
Nimba	0.0	7.8	22.3	0.8	4.3	4.0
River Gee	0.6	8.6	23.6	32.3	43.5	36.7

River Cess	0.0	1.0	7.8	0.4	0.3	0.4
Montserrado	0.4	1.6	5.0	2.4	3.7	4.7
Sinoe	0.2	4.6	19.4	2.3	3.3	3.0
Liberia	**0.3**	**2.6**	**8.9**	**-**	**-**	**-**
Sources: [1]SFNS, 2010; [2]Estimates from LISGIS, 2009b						

Cattle

Cattle production is not popular in Liberia because the humid forest environment is not suited for cattle rearing. The cattle population consists mainly of the trypanotolerant N'Dama (46.3%) and Muturu (53.7%) breeds (Koikoi, 2011). They are found mostly in Bong, Nimba, Grand Kru, and Grand Gedeh. A few farmers have recently introduced the Zebu from Mali for experimental purposes. The cattle population declined during the war, and it is yet to reach the pre-war level as of 2010 (Table 5).

N'Dama. The N'Dama originated from Fouta Djallon in Guinea and was introduced into Liberia centuries ago and later became a Liberian breed (Koikoi, 2011). Until now, few cattle breeders in Liberia continue to purchase N'Dama breeding stock directly from Guinea or Cote d'Ivoire (Koikoi, 2011). N'dama cattle are mostly found in the north (Nimba), centre (Bong), north-west (Lofa) and west (Grand Cape Mount) counties, which are adjacent to the breeding areas in Sierra Leone and Guinea. There is more variation among N'Dama in village herds because breeding is not selective and there is more crossing with the Muturu (Photo 1).

Multiplication herds of N'Dama were maintained by the Liberian Agricultural Company in Bong county, David More Farm, Foya Unity Cooperative, Todee State Farm, Buto Oil Cooperation, the United Methodist Church and Panama Agricultural Training Centre and private farms such as the Liberian Government Farm, Firestone Plantation, President Tubman Farm, and Minister Philip before the war (FAO, 2011b). Animals kept on the Firestone Plantation recorded age at first calving of 25 to 30 months (Weijer and Tappan, 1965). Calving rate was 83%, and mortality rate of 27% for calves up to one year. Average weight for adult cow and bull were 215 kg and 242 kg respectively. Average carcass weight was about 140 kg.

Muturu or Lagoon. This breed is commonly kept in the south-east (Grand Gedeh, River Gee, Grand Kru Maryland and Sinoe counties) of the country for slaughter on special occasions (Koikoi, 2011).They are a dwarf type measuring less than one metre at the withers with heavy bodies, plain black or black-and-white

coats, and short horns (Photo 2). Quantitative data on performance traits of the Muturu is limited. However, they are known to be early-maturing, fertile and survive with minimum care (Koikoi, 2011). Consequently, the Government of Liberia intends to establish a Muturu Research Centre to conserve and promote its use. The Muturu has an average carcass weight of about 110 kg.

N'Dama crossbreds. In an attempt to upgrade the milk and meat production of N'Dama, crossbreeding was started on the Firestone Plantation in 1961 (FAO, 2005). N'Dama cows were inseminated with Jersey, Brown Swiss and Santa Gertrudis semen imported from the United States of America. Birth weight of the N'Dama x Jersey (18 kg), and N'Dama x Brown Swiss and N'Dama x Santa Gertrudis (21-26 kg) were higher than the pure N'Dama (Anlicker, 1964).

The most prevalent diseases in cattle are Contagious Bovine Pleuro-pneumonia (CBPP) causing up to 20-50% mortality (Koikoi, 2011). Others are flukes, ticks and mite mange.

Sheep and Goats

Sheep can be found in all counties, but the numbers are higher in Nimba , Bong , Grand Gedeh, Grand Cape Mount and Lofa counties (Table 6). The indigenous, trypanotolerant West African Dwarf (WAD) or Djallonké is the common sheep breed in all the counties (FAO, 2011b; Kamara, 2011; Koikoi, 2011). It is hardy, prolific and breeds all year round. The large and long-legged Fulani or the Sahelian sheep has recently been introduced under the national re-stocking program. There are small numbers of the Fulani as well as crosses between the WAD and Fulani sheep in Bong, Lofa and Nimba counties. The sheep population recently reached and now exceeds the pre-war levels.
Data on WAD sheep at the Central Agricultural Experimental Station at Suakoko gave adult female and male weights of 17.1 kg and 25.3 kg respectively. Single lambs weighed 1.5 kg at birth, and twin lambs weighed 1.1 kg. Kamara (2011) reported average age at first lambing of 15 months, 142% lambing, 20% twining, litter size of 1.2, and lamb viability of 75% for WAD sheep under semi-intensive management. Lambs weighed 1.4 kg at birth and 10.4 kg at weaning.

Goats. Most goats in Liberia are of the trypanotolerant WAD breed (FAO, 2011b). There are considerable numbers of the Red Soot breed and crosses between the WAD and the Red Sokoto goat breeds. Nimba , Bong , Grand Gedeh , Grand Kru and Lofa counties have the highest goat population (Table 6). The long-term goat population trend shows that numbers declined in the civil war,

started to increase from 2005 and by 2010 exceeded the pre-war level.

Liveweights of 20.7 kg and 22.3 kg respectively for adult female and male WAD goats were reported at the Central Agricultural Experimental Station at Suakoko. Kamara (2011) reported average age at first kidding of 16 months, 200% kidding, 80% twining, litter size of 1.6, and kid viability of 65%. Birth weight for single lambs averaged 1.5 kg, and 1.3 kg for twin lambs. Kids weighed 1.2 kg at birth and 9.6 kg at weaning for WAD goats under a semi-intensive production system.

Sheep and goats suffer from PPR (pest des petits ruminants), mite mange, flukes, CPP (contagious caprine pleura-pneumonia), foot-rot, contagious agalactia, sheep pox and goat pox (Sumberg and Cassaday, 1984; Kamara, 2011; Koikoi, 2011). These diseases are not treated because of a lack of veterinary services in rural areas. As a result, mortality rates of 70-80% in PPR, and 50-60% in CPP have been reported (Koikoi, 2011).

Ruminant husbandry systems: About 80-90% of the ruminants are kept under the extensive/traditional/village husbandry system (Sumberg and Cassaday, 1984; Hoste *et al.*, 1992; FAO, 2011b; Kamara, 2011). Other husbandry systems, such as the pastoral, agro-pastoral, integrated cattle-tree plantation, ranching and peri-urban exist to a limited extent.

Dairy production systems. There is no dairy production in Liberia at the moment (Koikoi, 2011). The trade of imported milk is done from importers to stores and small traders.

Traditional, village or extensive system. Most cattle, sheep and goats are kept in free-roaming flocks or herds in villages and their environs, scavenging for feed. Owners of the free-roaming animals provide little or no supplementary feed, housing, health care and breeding management (FAO, 2011b; Hoste *et al.*, 1992; Kamara, 2011; Koikoi, 2011; Sumberg and Cassaday, 1984). The free roaming animals may or may not be tethered during the cropping season. Tethering is common in communities where the extensive or free-roaming system is becoming disruptive to crop production, and where farmers have small number of animals, and limited access to land. Animals may be tethered in the compound or in areas where forages are available for *in situ* grazing. Forage may also be cut-and-carried to tethered animals in some instances. For example, Muturu cattle are sometimes tethered to avoid damage to crops in Maryland and Sinoe counties.

Pastoral and agro-pastoral systems. N'Dama herds under Fulani management are common in the northern Guinea savannah zone. During the cropping season, cattle are grazed on fallow lands and areas of natural vegetation. In the dry season,

they are brought back to cultivated areas where they graze in swamps, rice fields and various areas which they cannot graze during the wet season. Herding is continuous during the rains but much more casual in the dry season. The herds are gathered in the evening and are either penned or tethered. Cows are rarely milked, although some Fulanis in Boni county are reported to occasionally milk N'Dama cows to provide fresh milk for home consumption.

Mixed crop-livestock farming or agro-pastoral systems. Integrated crop-livestock production is practiced in almost all agro-ecological zones and provinces in Liberia. Under this system, the crop and livestock enterprises are integrated components of a single farming system. The level of integration is, however, closer in the savanna than the forest zone. In the Guinea savannah zone for example, settled pastoral families are combining growing crops with rearing small herds of cattle or flock of small ruminants in the Guinea savannah zone.

Integrated cattle-tree crop plantation. There is a long history of integrated cattle-tree plantation production systems in Liberia, the main one being the rearing of N'Dama cattle under rubber plantations. For example the Liberian Agricultural Company kept a herd of N'Dama cattle on their rubber plantation at Buchanan in Grand Bassa county before the war (FAO, 2011a). Integration of livestock into tree plantations has many advantages, including reduction in the cost of weeding and re-cycling of nutrients through urine and manure. In such systems, planted or volunteer vegetation under the plantations provides the main source of feed (Asiedu *et al.*, 1978). They include species of grasses (e.g., *Panicum maximum*, *P. laxum, P. repens, Paspalum conjugatum*), legumes (e.g., *Calopogonium mucunoides*, *Centrosema pubescens*, *Desmodium adscendens*, *Pueraria phaseoloides*) and forbs (e.g., *Aspilia africana*, *Asystasia gangetica*, *Commelina nudiflora*, *Euphorbia hirta*). However, the available biomass and regeneration of the vegetation after grazing generally diminishes with increasing age of the plantation due to closing of the canopy. [For further details of grazing livestock under tree crops, especially coconuts, refer to Reynolds, 1995].

Ranching. Commercial cattle production was started by the government, some parastatal institutions and private farmers in the Guinea savannah zone to multiply trypanotolerant cattle and sheep before the war. The cattle ranches include: Foyah, Todee, Panama, Kpain, Panta and Shanghai Farm. Additionally, the College of Agriculture and Forestry and the Central Agricultural Experimental Station established cattle ranches for their research and training purposes, while the Liberian Agricultural Company and Firestone had ranches in their rubber plantations. Cattle on the ranches grazed natural and/or sown pastures of mostly *Panicum* and *Hyparrhenia* grasses. They grazed day and night or were herded by day and kept in pens at night. The animals had access to mineral salt licks and were

dipped or sprayed 2 to 4 times a month. The ranches were deserted during the war. Some ranches still exist, but they have been neglected (CAAS-Lib, 2007). Recent reports indicate that ranching is gradually emerging, and private establishments are stocking existing ranches with N'Dama and Zebu cattle (Koikoi, 2011).

Peri-urban and urban. Rearing of cattle, sheep and goats in and around cities is common in Liberia (Rhissa, 2007; Koikoi, 2011). For example in urban areas in Lofa and Gbarpolu counties, livestock farmers practice more or less semi-intensive rearing of cattle, sheep and goats for meat (Koikoi, 2011). The animals are kept on family and/or private land. Feeding is based on cut-and-carry forages, household waste, crop residues and agro-industrial by-products. The animals may also graze freely or are tethered to graze by road side where possible. The peri-urban and urban systems supply fattened rams and bucks for the expanding urban markets, especially during religious festivities.

Challenges and opportunities

Development of the ruminant sub-sector is constrained by several technical and socio-economic factors (FAPS, 2008). An FAO survey (Smith, 2002) revealed some limitations to livestock development, as follows:

- Lack of improved breeding stock.
- Lack of feed.
- Diseases and unavailability of veterinary services.
- Lack of adequate training of available livestock officers.
- Lack of processing facilities.
- Inadequate transportation and roads, and
- Inadequate policy.

The Liberian Agriculture Sector Investment Program report (LASIP, 2010) identified the following as obstacles to the development of the animal/livestock industries:

- Out-dated legislation (regulations and operational rules) and the absence of modern technical and sanitary standards to ensure safety and quality control.
- Weak institutional capacities for planning, policy formulation, and extension due to lack of appropriate information and insufficient trained officers in the livestock service of the Ministry of Agriculture.
- Lack of inadequate infrastructures (abattoirs, slaughtering, storage and distribution of livestock products), and,
- Weak land access, security and utilization arrangements.

A recent review (Koikoi, 2011) of the livestock sector with respect to

smallholder dairy and livestock and meat sub-sector development in Liberia identified major limitations and constraints in livestock/meat development as:

- Institutional: lack of veterinarians; limited number of trained livestock technicians; no well-defined policy on livestock; lack of farmers' cooperatives or associations; imports of animals and livestock products which is a disincentive to smallholder farmers, and inadequate budgetary support to the livestock division of the Ministry of Agriculture.
- Insufficient infrastructure and equipment: poor state of and/or lack of slaughter houses and livestock infrastructures.
- Animal diseases: lack of disease surveillance in the field resulting in high mortality rates; lack of trained veterinary doctors; limited number of livestock husbandry officers; lack of adequate animal health service delivery system and facilities; lack of research on prevalent diseases in the country, and inadequate quarantine of live animals being brought into the country.
- Breeding stock: insufficient improved breeding stock.
- Feed: traditional methods of pasture management with inefficient and inadequate efforts to make improvement; concentrate feeds are very limited and expensive for livestock farmers.

Recommendations to improve the livestock sub-sector include (Smith, 2002; Rhissa, 2007; Koikoi, 2011):

- Micro-finance credit opportunities - improve livestock farmer access to credit and loan through banking institutions with government serving as collateral.
- Capacity development - training of veterinary doctors, livestock technicians, and farmers to adopt a business approach to livestock production.
- Breeding stock – improved breeding stock of cattle, sheep and goats should be secured by government and made available to farmers.
- Feed – promoting local production to improve availability and accessibility.
- Diseases – improving disease surveillance to reduce mortalities.
- Infrastructure – existing livestock facilities should be rehabilitated and new facilities constructed, where possible.
- Livestock policy - A clearly defined policy on livestock production is needed.
- Innovation platforms - smallholder livestock farmers and other actors should be assisted to form associations and interest groups, and to operate in consonance with the Cooperative Development Agency.

Livestock production is one of the areas of focus under Liberia's Food and Agriculture Policy and Strategy (FAPS, 2008). According to Ellen Johnson Sirleaf, President of the Republic of Liberia "we shall strive to make the transition from "Subsistence to Sufficiency" in the food and agriculture value chains by 2015 and make substantial progress in meeting our millennium development goal of halving the proportion of our people who suffer from hunger".

THE PASTURE RESOURCE

Liberia has about 2 million hectares of pasture land which provide the bulk (90-95%) of feed for the ruminant population. It comprises mainly the coastal, derived and Guinea savannahs (CAAS-Lib, 2007). Only 2,025 hectares were improved and utilized by government and private farms before the war in 1990.

Ranches in Liberia before the civil war in 1990		
Cattle Ranch	Area (ha)	Cattle (heads)
Panama	25	25
Kpaine	50	50
Sanghai	50	50
Todee	100	100
Central Agricultural research Institute (CARI)	300	100
Parta	500	500
Foya	1000	500
Total	2025	1325
Source: CAAS-Lib, 2007.		

Natural pasture

Coastal savannah: includes patches of grasslands found in the mangrove swamp and grass/thicket in the coastal plains, especially in Bomi, Grand Bass, River Cess, Maryland and Sinoe counties. The vegetation and composition of plant communities are dictated by several factors, including hydrological conditions, such as the frequency and duration of flooding, depth of the water level, soil type, and physiography. Plant communities in the mangrove swamps contain grasses such as *Axonopus flexuosus*, *Cenchrus biflorus*, *Dactyloctenium aegyptium*, *Hyparrhenia mutica*, *Leptothrium senegalense*, *Sporobolus virginicus*, *Panicum congoense*, *P. repens*, *Paspalum vaginatum*, *Pennisetum polystachion*, and *Setaria anceps*. Grasses found in the grass-thicket plant communities include: *Andropogon canaliculatus*, *A. gayanus*, *Brachiaria*

fulvibarbis, *Hyparrhenia smithiana*, *Schizachyrium sanguineum*, and *Vetiveria fulvibarbis*. Areas with loose soil and moisture derived from run-off and drainage have tall grasses such as *A. gayanus*, *Cymbopogon giganteus*, *Hyperthelia dissoluta*, *Panicum maximum*, *Pennisetum purpureum*, and *Rottoboellia exalta*.

Derived savannah: is an expanding zone along the forest fringes where grassland or savannah is gradually replacing forest as a result of human interference (Rose-Innes, 1977). The vegetation is a mixture of trees with closed or partially closed canopy and a thick ground cover of tall shade-tolerant grasses and forbs. It contains relic patches of forest trees such as, *Antiaris*, *Borassus*, *Burkea*, *Elaeis*, *Daniellia*, *Lonchocarpus*, *Lophira*, *Parkia*, *Phyllanthus* and *Pterocarpus*. The grass species include Andropogon gayanus, A. tectorum, Beckeropis uniseta, Chasmopodium caudatum, Hyperthelia and Hyparrhenia spp., Panicum maximum, Pennisetum purpureum, Rottboellia exaltata, Schizachyrium sanguineum, Paspalum and Melinis species. Forage legumes, such as Centrosema pubescens and Pueraria phaseoloides may be seen along the forest-savanna fringes.

Guinea savannah: a typical fire-controlled tree savannah community of broad-leaved deciduous trees, densely distributed in a continuous ground cover of perennial bunch grasses and forbs. The crowns of the trees reach a height of 12-15m but seldom form a closed canopy except over small areas. The height and density of trees may vary from place to place in response to soil conditions as well as the type and degree of disturbance such as the season and frequency of burning, and intensity of grazing.

The main woody genera include: Afzelia, Briedelia, Daniellia, Entada, Gardenia, Isoberlinia, Lannea, Lophira, Monotes, Parkia, Butyrospermum, Mangifera, Pterocarpus and Terminalia. Most of the tall grasses found in the derived savannah are also found in the Guinea savannah. Significant grass species are Andropogon gayanus, Beckeropsis uniseta, Brachiaria jubata, Chasomopodium, Ctenium newtonii, Cymbopogon giganteus, Digitaria diagonalis, Hyparrhenia, Panicum maximum, Pennisetum purpureum, Seteria and Tristachya superba.

Grasses in the savannah woodlands generally grow fast during the wet season, resulting in the accumulation of biomass deficient in nitrogen and of low digestibility by the end of the growing season. Also, legume composition of the natural pastures is generally low, although some herbaceous (e.g., *Centrosema pubescens* and *Pueraria phaseoloides*) and shrubby legumes may occasionally be seen growing in the derived and guinea savannahs.

Sown pasture

Artificially re-vegetated pasture resources (sown pastures) are limited (Rhissa, 2007; Koikoi, 2011). As stated earlier, only 2,025 hectares out of the estimated two

million hectares of natural pastures were established and utilized on ranches owned by government and private farmers before the war in 1990 (Table 7). Several technical and socio-economic factors could be responsible for the limited area of sown pastures. They include: vast communally grazed natural pasture resources; the relatively small ruminant population mostly owned by smallholder farmers who do not approach livestock rearing as a business, and problems with land acquisition.

Information on artificial pastures in Liberia is limited. Signal grass (*Brachiaria brizantha*) introduced from Colombia in the 1970s was the most common pasture species for ruminant production in Liberia before the war, but its dry matter yield and quality declined during the dry season (Smith, 1995). Others (FAO, 2011b; Kamara, 2011) mention the use of improved pastures for cattle grazing at the Firestone and the Liberian Agricultural Company rubber plantations before the war. Names of grasses and legumes species were, however, not given. Eleven legume accessions (*Centrosema brazilianum* CIAT 5234, *C. pubescens* CIAT 5189, *C. macrocarpum* CIAT 5062, *C. macrocarpum* CIAT 5065, *Centrosema* sp. CIAT 5112, *Desmodium incanum* CIAT 13032, *D. ovalifolium* CIAT 3784, *Macroptilium atropurpureum*, *Stylosanthes guianensis* CIAT 136 and *S. macrocephala* CIAT 1582) introduced from Columbia were evaluated at the Central Agricultural Experimental Research Station at Suakoko, Bony County from 1985-1988 to identify adapted legumes for integration into the smallholder crop and livestock production systems (Smith, 1995).

Desmodium ovalifolium CIAT 3784, *D. incanum* CIAT 13032, *M. atropurpureum*, and *S. macrocephala* CIAT 1582 perished after the first year. *Stylosanthes guianensis* CIAT 136 was the best biomass producer and weed suppressor in the first year; but it gave the lowest dry matter in the third year (Table 8). The high dry matter yield and weed suppression potentials of *S. guianensis* CIAT 13032 during the first year suggested that it could be used in short-fallow to produce feed for livestock and to improve soil fertility. *Centrosema pubescens* CIAT 5189, *Centrosema* sp. CIAT 5112 and *C. macrocarpum* CIAT 5062 and 5065 consistently increased in dry matter yield and suppressed weeds best over the 3-year study period, suggesting that *Centrosema* species can be used in pastures under tree crop plantations for feed and for weed management.

Yield and weed composition of legumes at 9 weeks of growth, Suakoko, Liberia

Species	CIAT no.	Dry matter tield (tonnes/ha)			Weeds (%)		
		1985	1986	1987	1985	1986	1987
S. guianensis	136	5.41	1.86	1.17	3.9	12.9	42.2
C. pubescens	5189	2.73	2.92	3.36	11.4	9.6	23.7

C. macrocarpum	5065	2.64	2345	4.29	19.4	9.9	18.6
C. macrocarpum	5062	2.40	2.56	4.33	13.7	15.1	16.2
Centrosema sp.	5112	2.39	2.35	3.98	16.2	12.1	16.1
C. brasilianum	5264	1.24	1.64	2.04	38.7	31.6	45.3
Source: Smith, 1995.							

Fodder shrubs and trees

Native (e.g. Pterocarpus erinaceous, Bauhinia rufescens, Afzelia africana, Ficus gnaphalocarpa, Opilia celtidifolia and Khaya senegalensis) and exotic (Leuceana leucocephala) shrubs and trees are occasionally used as feed for small ruminants. For example, L. leucocephala is fed to sheep and goats in Gbarkpolu, in the farming system.

Pastoral development:

A pastoral area development plan, aimed at reducing degradation of pastoral resources by ensuring their rational management to increase animal production and to satisfy the needs of the people, was proposed for implementation during 2007-2009 (CAAS-Lib, 2007; Rhissa, 2007). Priority activities of the plan included: taking inventory of rangeland and pastoral resources; rehabilitating existing ranches (Table 7); developing pastoral areas; and building human capacity in pastoral management.

Other activities envisaged under the plan were to: 1) design and establish schemes for resource development at the communal, local, county and national levels; 2) construct animal passage channels or grazing routes; 3) map pastures and watering sites; 4) rehabilitate and/or construct stock watering facilities (ponds, wells, dams, micro-dams, etc.); 5) control tsetse fly and/or establishment of tsetse free zones; 6) design and implement pasture and grazing management strategies; and 7) monitor pastoral ecosystems.

Challenges

Liberia has pasture resources with high potential for cattle, sheep and goat production. However, many are yet to be rehabilitated. With the exception of the cattle ranch of the Central Agricultural Research Institute which is currently utilized by M. D. Sow and Associates (a cattle breeding incorporated group), other ranches lie in ruins or are overgrown by bushes (Koikoi, 2011). Several technical and socio-economic factors constrain improvement of the pasture resources in Liberia (FAPS, 2008; Koikoi, 2011; SFNS, 2010). Among these are:

- Commercial outlook – rearing of cattle, sheep and goats is not considered as a business by most farmers. There is need to assist farmers to adopt market-oriented ruminant production.
- Abandonment of existing grazing areas – ranches established before the war for multiplication of trypanotolerant livestock has been neglected.
- Lack of enabling policies – e.g., there is no comprehensive policy on grassland, and pasture and fodder crops.
- Land ownership or land tenure – most cattle farmers do not have title to land. Hence, there is no incentive for development of the pasture resources.
- Limited rural financing – farmers have difficulties accessing loans and credits.
- Bush fire – indiscriminate annual burning reduces the amount of biomass available for grazing during the dry season. This poses a big threat to ranching.
- Limited and outdated data – scanty information on yield and quality of pasture resources, defoliation management, and carrying capacity.
- Use of legumes - limited integration of forages, especially forage legumes into the production systems.
- Poor access to inputs – quality forage seed and planting materials of improved species are not available.
- Inadequate extension services and personnel – very low extension to farmer ratio, most extension staff have limited knowledge on livestock and pasture management.

OPPORTUNITIES FOR IMPROVEMENT OF FODDER RESOURCES

In spite of the numerous constraints, opportunities exist to increase the contribution of pasture and fodder resources to livestock production and natural resource management. A few are outlined below:

Enabling environment. The Government of Liberia and some donors are interested in investing in the livestock sub-sector to reduce poverty, food insecurity and unemployment as part of the 'Livestock Development and Promotion' program (LASIP, 2010). A priority activity under the program is to 'preserve, improve, and exploit common pastoral property resources of the country'.

Research and development partners are available. The Central Agricultural Research Institute (CARI) is a semi-autonomous institute that undertakes applied and adaptive research in crop and animal sciences, including pasture and fodder resources. CARI is well connected to the network of international agricultural research and development partners such as the International

Livestock Research Institute (ILRI), International Institute of Tropical Agriculture (IITA), and FAO. Others are international and national non-governmental organizations (NGO) and farmers' groups that are interested in dissemination of improved pasture and ruminant production, at the grass-root level.

There are universities (e.g., University of Liberia, Cuttington University), institutes (e.g., Agricultural Institute and Training Bureau, Gardnersville, Monrovia) and training centres (e.g., Youth Agriculture Training Centre, Johnsonville) which can be strengthened to train research and extension staff on various aspects of ruminant and pasture production. In addition, the agricultural extension system is being re-oriented to be operational at the national, provincial, district, and farm levels to facilitate knowledge dissemination. Also, Farmer Training Centres are being developed in all counties to train farmers on various aspects of farming including livestock and pasture and production.

Also, there are proven technologies on pasture resources in the West African sub-region (e.g., Ghana and Cote d'Ivoire) that can be adapted to the Liberian conditions. In addition, the Forage Genebank of ILRI has large collections of grass and legume species which can be used by CARI to initiate research on pasture and fodder crops.

Grassland policy. The absence of a grassland policy negatively affects the development and management of the country's pastoral resources and the ruminant livestock industry. A comprehensive grassland policy is needed. It should take into consideration the peculiarities of the different vegetation zones, the entire value chain, interest of consumers and producers and preservation of the natural resource base. The focus should be on the Derived and Guinea savannah zones, indigenous grass and legume species, counties bordering Cote d'Ivoire (Grand Gedeh, Maryland, River Gee and Nimba counties) with vast grasslands, and bush fire management.

Establishment of County Grassland Management Committee. For efficient and sustainable management of the communally grazed grassland, a multi-disciplinary and multi-institutional County Grassland Management Committee (CGMC) will be needed. The committee should be comprised of herders, farmers, research and extension staff, and decision makers at the local, district, county and national levels. The CGMC should be mandated to develop and implement a pasture resources improvement plan for each county.

Land tenure. The land tenure system needs to be revised to make it easier for those who really need land for ruminant production to obtain it. Communal

grazing, which is common in the counties, is free, and therefore unattractive for commercial livestock enterprises.

Strengthening institutional capacity. The Ministry of Agriculture, CARI, universities and agricultural institutes have limited staff with specialization in pasture resources management. There will be a need to establish strategic partnerships with international research (e.g., ILRI, IITA) and development (e.g., FAO, Heifer International) partners to train more research and extension staff.

Rural finance. The ruminant industry is dominated by resource-poor smallholder livestock keepers. Therefore, enabling policies and institutions should be put in place to assist farmers who are interested in the ruminant industry (fattening or dairy production) to access loans and credits to purchase inputs.

Mapping pastures resources. The pasture resources of the country must be mapped at the national, county, district and local levels. The extent of the savannah woodlands and their status should be noted. Indigenous knowledge on pasture resources management should be documented. This information will be needed to develop a comprehensive grassland policy.

Rehabilitation of abandoned and degraded pasture resources. The County Grassland Management Committee should give priority to rehabilitation and equipment of the existing ranches to bring them back to production. Based on the inventory of pasture resources proposed above, degraded grasslands in each county should be identified and rehabilitated in partnership with the local communities. Several rangeland improvement methods could be employed, including: selective felling of unwanted trees and shrubs to encourage vigorous growth of grass; control of weeds such as *Imperata cylindrica*, *Sporobolus spp*. and *Eleusine spp*., *Sida spp*. and *Acanthospermum spp*.; planting of native browse species such as *Pterocarpus erinaceous*, *Bauhinia rufescens*, *Afzelia africana*, *Ficus gnaphalocarpa*, *Opilia celtidifolia* and *Khaya senegalensis*; introduction of an acceptable nutritious legume (*S. humilis*) and/or grass (*A. gayanus*); repairing existing stock watering points (ponds, wells, dams); and grazing management (deferred grazing, rotational grazing).

Database on pasture resources. There is scanty quantitative data on pasture and forage resources in Liberia. On-station and on-farm research will be needed to collect biological and socio-economic data in the different agro-ecological zones. Research is needed to increase knowledge on the role of the adapted grass (e.g., *P. maximum*, *A. gayanus*) and legumes (*S. guainensis*) species. Information is also required as to their distribution, variability, reaction to grazing intensity, tolerance to fire, seed production potential and nutritive

value in relation to stage of growth. The reaction of natural grasslands to burning and the use of fire to maintain grass species and production in the dry season also need careful study.

Development of grazing reserves. Areas in the northern savannah region can be designated for cattle production and group ranching. Grazing reserves should be established in the context of total land use systems. Regulatory control of herd size and distribution to achieve ecological balance and avoid overgrazing will need policy attention.

Bush fire management. Indiscriminate annual bush fires which drastically reduce the available biomass for grazing during the dry season are a big threat to ranching in the country. Enabling policies and appropriate institutions will be needed to control annual fires.

Integration of legumes. Nitrogen deficiency constrains crop and livestock production in the smallholder, low-input, shifting cultivation system. Forage legumes such as *Stylosanthes guianensis*, *Centrosema pubscens*, *Pueraria phaseoloides*, *Chamaecrista rotundifolia*, and *Aschynomene histrix* can be integrated to improve soil nitrogen through biological nitrogen fixation. The legumes can also provide protein-rich fodder as supplements to ruminants fed low quality straw diets. Possible entry points for the legumes include: improved fallows, cereal-legume rotations, pasture under tree crop plantations and fodder banks.

Intensive fodder production. Farmers involved in market-oriented peri-urban fattening and (in due course) dairy production systems should be encouraged to establish fodder banks or intensive feed gardens. Fodder banks of forage legumes species such as *S. guianensis*, *C. pubescens*, *C. rotundifolia* and *A. histrix* can be used to supplement rangeland grazing in the pastoral and ranching systems. Intensive feed gardens of either pure stands of grass species (e.g., *P. maximum*, *Cenchrus ciliaris*, *Pennisetum purpureum*) or grasses in association with legumes (e.g., *C. pubescens*, *S. guianensis*, *P. phaseoloides*) can be used for cut-and-carry feeding.

Forage seed production. Rehabilitation of degraded pasture resources and sustainable integration of forages into the production system as fodder banks and feed gardens require a steady source of forage seeds and planting materials. However, there are no established domestic forage seed industries. Private sector investment in forage seed production should be promoted. Village-based seed systems should be encouraged to make quality forage seeds available at affordable prices.

Tsetse control. An outstanding negative feature of the Derived savannah and some part of the Guinea savannah is the presence of tsetse flies (*Glossina spp.*)

and the constant threat of trypanosomiasis. Selective bush clearing and tsetse control should be undertaken to create tsetse-free zones and allow safer and increased production of N'Dama cattle.

Conclusion

Climate change is real and the actions of mankind greatly contribute to the origin of the mess. Technological and economic changes have negatively affected the natural systems functioning through pollution/contamination, over exploitation and degradation of natural resources. The growing population, urbanization, deforestation, continuous use of artificial fertilizers, industrialization with its continuous pollution, encroachment on wetlands and swamps all trigger climate change and put the entire ecosystem at risk. Never the less, mankind has to devise means through which agriculture can remain productive under the changing weather/climatic patterns. It only requires sustainable agricultural and environmental protection practices like environmental conservation, soil and water management, use of organic fertilisers, reduced use of dangerous chemicals and anything that otherwise would contribute to emission of green house gases in the atmosphere.

REFERENCE:

(RESEARCH AND DEVELOPMENT ORGANIZATIONS AND PERSONNEL)

Central Agricultural Research Institute (CARI) ,Suakoko, Bong County
Liberia
Telephone: +231 649 4261

Samuel Tucker
Head, Pasture and Fodder Unit
Pasture and Fodder Production Expert involved in extension of forage technologies
Ministry of Agriculture
P. O. Box 9010
1000 Monrovia 10
Liberia
Telephone: +231 647 8077
Website: www.moa.gov.lr

Seklau Elizabeth Wiles National Livestock Program Coordinator,
National Livestock Bureau, Ministry of Agriculture Liberia
Telephone: +231 612 6704

Smith E. G.
Assistant Professor, Forage Agronomist involved in forage production and utilization research, Department of Agronomy, University of Liberia School of Agriculture and Forestry Capitol Hill, Monrovia, Liberia
Telephone: +231 658 7654

Anlicker, W. L. 1964. The cattle breeding programme of the Firestone Plantations Company. Research Division Report No. 75. Monrovia, Firestone Plantations Co. 21p.

Asiedu, F. H. K, Oppong, E. N. W & Opoku, A. A. 1978. Utilization by sheep of herbage under tree crops in Ghana. Tropical Animal Health and Production, 10:1-10.

CAAS-Lib (Comprehensive Assessment of the Agricultural Sector in Liberia). 2007. Comprehensive Assessment of the Agricultural Sector in Liberia, Monrovia, Liberia.

CBL (Central Bank of Liberia). 2009. Central Bank of Liberia, Annual Report 2008.

CFSNS (Comprehensive Food Security and Nutrition Survey). 2008. Government of Liberia, UN and Development Partners. Comprehensive Food Security and Nutrition Survey Report, Monrovia, Liberia.

CIA (Central Intelligence Agency). 2010. CIA World Factbook (Accessed, 27 October 2011).

EPA (Environmental Protection Agency of Liberia). 2007. National Report on Marine and Costal Environments in Liberia. May 2007.

FAO (Food and Agriculture Organization). 2005. FAO/AGAL Liberia Livestock Sector Brief.

FAO (Food and Agriculture Organization). 2011a. FAOSTAT data (Accessed, 27, October 2011).

FAO (Food and Agriculture Organization). 2011b. Chapter 6: Livestock in Liberia. [reproduced from the ILCA publication: Trypanotolerant livestock in West &

Central Africa - Volume 2. Country studies. Monograph No. 2] "http://agtr.ilri.cgiar.org/agtrweb/Documents/Library/docs/x5537e/x5537e07.htm. (Accessed, 27 October 2011).

FAO (Food and Agriculture Organization). 2012. FAOSTAT data (Accessed, 6 July, 2012).

FAPS (Food and Agriculture Policy Strategy). 2008. Food and Agriculture Policy Strategy Report, Ministry of Agriculture, Monrovia, Liberia.

Hoste, C. H., Chalon, E., & d'Ieteren, G. 1992. Trypanotolerant livestock in West and Central Africa: A decade's result. Chapter 6. Liberia. ILCA Monograph 2.

Jallah, J. K., Mulbah, C. K., Kiazolu, J. S., Frank, K. & Morris, M. Z. 1991. Efficient fertilizer use for increased crop production: The Liberia experience. Fertilizer Research, 29:55-64.

Kamara, A. 2011. Position paper on sheep and goat production in Liberia. http://www.fao.org/docrep/004/s8374b/S8374b18.htm (Accessed, 27 October 2011).

Koikoi, K. K. 2011. Review of the livestock sector with respect to smallholder dairy livestock and meat sub-sectors development in Liberia. Consultancy report submitted to the Food and Agriculture Organization of the United Nations, May, 2011. 20 pp. Monrovia, Liberia.

LASIP (Liberia Agriculture Sector Investment Program). 2010. Report for the Comprehensive African Agriculture Development Programme (CAADP) Compact, Monrovia, Liberia, September 2010.

LISGIS (Liberia Institute of Statistics and Geo-Information Services). 2009a. 2008 Population and Housing Census, Final Results, Monrovia, Liberia, May 2009. Supported by FAO and EU Food Facility, Africa Rice Centre, and Central Agricultural Research Institute.

LISGIS (Liberia Institute of Statistics and Geo-Information Services). 2009b. Production Estimates of Major Crops and Animals. Ministry of Agriculture, FAO, EU Food Facility, Africa Rice Center, Central Agricultural Research Institute.

Reed, W. E. 1951. Reconnaissance soil survey of Liberia. United States Department of Agriculture Bulletin Number 66.

Reynolds, S.G. 1995. Pasture-Cattle-Coconut Systems. FAO RAP Publication 1995/7, 683 p. < http://www.fao.org/docrep/005/af298e/af298E00.htm#TOC

>.

Rhissa, Z. 2007. Comprehensive Assessment of the Agricultural Sector in Liberia (CAAS-Lib), Sub-Sector Reports, III. Livestock Sub-sector. FAO Mission Report.

Rose-Innes, I. 1977. A manual of grasses in Ghana. Land Resources Division, Ministry of Overseas Development, Surrey, England.

SFNS (State of Food and Nutrition Security). 2010. The State of Food and Nutrition Security in Liberia. Ministry of Agriculture and World Food Programme, VAM Food Security Analysis, Report, October 2010.

Smith, E. G. 1995. Preliminary evaluation of tropical forage legumes in Suakoko, Liberia. Pasturas Tropicales, 17:34-37.

Smith, E. G. 2002. Assessment of the small-scale livestock sub-sector in Liberia. A consultancy report submitted to the Food and Agriculture Organization of the United Nations.

Sumberg, J. E. & Cassaday, K. 1984. Sheep and goats in humid West Africa. In: Sumberg J. E. and Cassaday, K. (eds.) Sheep and goats in humid West Africa. Proceedings of the workshop on Small Ruminant Production Systems in the Humid Zone of West Africa, held in Ibadan, Nigeria, 23-26 January 1984. ILCA, Addis Ababa. 74pp.

Weijer, J. & Tappan W. C. 1965. 'A genetic and commercial analysis of the Firestone plantation cattle herd'. Research Department Report No. 46. Monrovia, Firestone Plantations Company.

Brent M. Simpson and C. Gaye. Burpee (2014). Adaptation under the "new normal" of climate change: the future of agricultural extension and advisory services. In MEAS Discussion paper 3.CRS-MEAS Filed guide; Climate change

CRS-MEAS Smart Skills, Understanding Natural Resources.

Gaye. Burpee, Brendan S. Janet, & Axel Schmidt. Preparing smallholder farm families to adapt to climate change. In Pocket guide 3, Managing water resources.

Gliessman, S. (1990). Agroecology: Researching the ecological basis for sustainable agriculture. New York, NY: Springer-Verlag.

For additional information, please contact the author as below: Dr Asamoah Larbi

P. O. Box AN 8345 Accra North, Ghana
Mobile: +233 207 055 952
E-mail: a_larbi@hotmail.com

[The profile was edited by S.G. Reynolds and J. M. Suttie in December 2011 and further revised in July 2012].

This profile was prepared in the period November 2011 to July 2012 by Asamoah Larbi, a consultant Systems Agronomist at the International Institute of Tropical Agriculture (IITA), Tamale, Ghana since February 2012.

CONTACTS

Prepared by William C. Todd Jr., Head of Department of Agriculture, Booker Washington Agricultural & Industrial Institute, Kakata, Margibi County, Liberia. Also, an Instructor teaching the following courses: Annual Crop production and Introduction to farm mechanic. Contact number:+231(0)886-470-967/+231-(0)77-21-40-21/toddwilliamc@gmail.com