

Liberia Petroleum Regulatory Authority (LPRA)



Strategic Assessment of the Potential Environmental, Economic and Social Impacts from Petroleum Operations in the Harper Basins

May 2019

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1.0 Introduction

The Harper Basin is one of the prospective offshore areas assessed as a possible location for petroleum deposits. TGS NOPEC signed a Contract with the Government of Liberia in 2013 to acquire 3D seismic data which locates structures underground that may contain petroleum deposits. No wells have been drilled in the area to ascertain the presence of petroleum or the type, but the seismic data helps to identify possible locations under the earth where petroleum may be accumulated. The data was acquired and preliminary geological report has also been submitted which looks at interpretation of areas where the oil & gas may have accumulated. However, it does not prove that oil & gas is present until a well is drilled at the locations identified. For wells to be drilled the companies will have to bid for areas and subsequently acquire offshore blocks for exploration through petroleum agreements. After that companies can bring a drilling rig and drill a well down to locations in the area identified. The Harper Basin is peach colored polygon seen in the map below.

Figure 1-1: Project Exploration Area

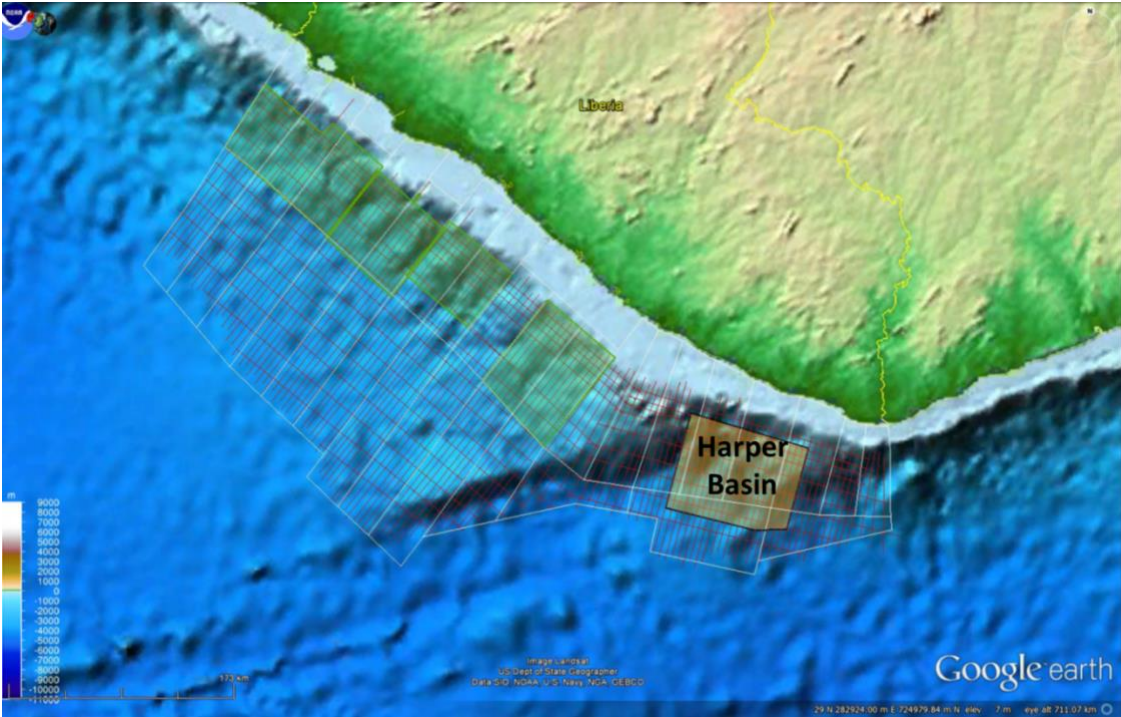


Figure 1.1: The general seafloor map of Harper Basin Area. The outlined polygon shows area generally known as the Sunfish Data Area

2.0 Reasons for Bid Rounds

By the end of the second quarter of 2018, Liberia’s economy was struggling and the country was facing significant deficit due to revenue collection shortfalls. To address these financial difficulties of the country, the Board of the Liberia Petroleum Regulatory Authority (LPR) must agree to proceed with a bid round for the re-demarcated blocks in the Liberia and Harper Basins. It is

expedient for the President of the Republic of Liberia to task the Authority with the planning and execution of the bid round. The impending bid round has three key objectives: First and foremost, achieving maximum signature bonuses to assist with the financial challenges of the country; (2) increasing Liberia's prospects for commercial discovery and development by opening vacated acreage for development and (3) making the basin attractive by engaging in an aggressive marketing program exposing leads and prospects of the basin.

This report is, thus, a Strategic Assessment of the conduct of petroleum operations in and around the Harper Basin. It is done in fulfillment of Article 13, Section 1(b), which states;

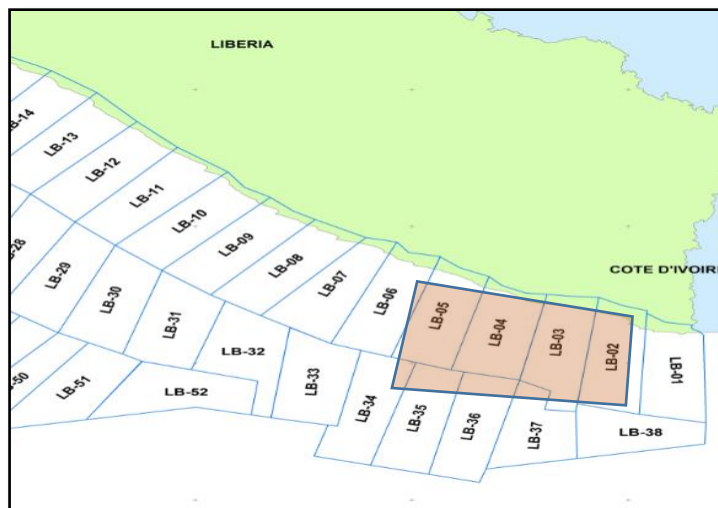
13.1 Before an area that has not previously been subject of a petroleum agreement, a production sharing agreement or a formal bid round is opened for bidding, the President shall request the Authority;

(b) Carry out a strategic assessment of the potential economic, social and environmental impact of the conduct of petroleum operations in and around the subject area;

In consideration that the Liberia Basin underwent previous petroleum operations with extant data describing the potential economic, environmental and social impacts, this assessment covers only the Harper Basin. Upon the receipt of the President's request for the opening of new areas for petroleum operations this report was prepared and submitted. This impact assessment will also be posted in the public domain, particularly the website of the Authority to allow for the public to comment for a period of sixty (60) days as per the Article 13, Section 1(c) of the New Petroleum (Exploration & Production) Reform Law of 2014. In the finalization of this report, relevant ministries will be sent copies and their comments along with that of the public will be consolidated in the final assessment report.

Location: The basin covers approximately 20,000 km² and it is clearly separated from the adjacent basins (the Liberia Basin and the Tano Basin) by two transform fault systems. Harper Basin is located in the offshore sector adjacent counties from Sinoe to Maryland. It extends from the deep water in the SW to the shallow slopes in the NE. Many drilling activities will be located several tens of kilometers seaward.

Figure 2.1: The Harper Basin Area. The outlined polygon shows primary area



3.0 Description Tentative Schedule of Petroleum Activities

No license has been issued to any International Oil Company (IOC) to conduct exploration activities within the Harper Basin. In 2013, TGS undertook 3D seismic survey of the area, but no drilling or other exploration related activities have been carried out in any of the blocks in the basin. A bid round is scheduled to occur during the second and third quarters of 2019. Companies awarded blocks in the area would not receive signed PSCs until third to fourth quarter of 2019. Thus, drilling activities are likely to begin late 2020 or early to mid-2021. The bid round will be held to allow companies to qualify for offshore leases. A total of 52 offshore blocks have been delineated as per the new law which prescribes block sizes to a maximum of 2000 sq.km.

4.0 PRELIMINARY ECONOMIC ASSESSMENT

4.1 Overview

Petroleum activities in many countries have proven to be a source of potential economic and social transformation into national wealth creation and prosperity. Under well-guided circumstances, crude oil boom can be an important catalyst for growth and development. This requires prudent management and oversight of the windfall revenue and profit associated with these activities ranging from seismic sales to negotiations and signing of contracts, from exploration to production and abandonment. Based on a commercially viable discovery, beneficiary countries receive millions of dollars on a daily basis from petroleum activities.

Oil and gas operations in some African countries have enlarged their economic basket and provided huge incentives for domestic capital investments, infrastructure development and gushing revenue inflow that cushions economic growth and development. Nigeria as a case in point is the largest oil producer and the largest economy in Africa producing up to 1.9 million barrels of oil per day. At an average traded price of US\$50 per barrel of crude oil, Nigeria is estimated to have generated up to US\$89 million per day reaching up to US\$32 billion in 2017. Crude oil exports as of 2016 earned the country US\$74B, petroleum gas earned the country US\$13B, refined petro US\$4.23B, pyrophoric Alloys US\$1.9 B among others (Africa/Facts, 2018).

Liberia started on the path of searching for oil since the late 50s long before the establishment of the National Oil Company (NOCAL) in 2000¹ which main purpose is to hold all of the rights, titles and interests of the Republic of Liberia in the deposits and reserves of liquid and gaseous hydrocarbons within the territorial limits of the Republic of Liberia. Before the 1990 civil crisis which decimated the Liberian economy, seven exploratory wells were drilled between 1970 and 1989. All of the wells drilled proved the presence of hydrocarbons, but the existing technology and the economics of deep water, the civil war, along with the low and fluctuating oil price played a crucial role in the abandonment of those well (NOCAL, 2012). Between 2010 and 2016 ten (10) additional exploratory wells were drilled but also were not commercially viable.

“Between 2000 and 2010, TGS-NOPEC Geophysical Company (Houston, TX) conducted 24, 773 km of 2D Seismic Data; 24,408 km of 2D Gravity and Magnetic Data and 18,345 km² of 3D

¹The National Oil Company of Liberia (“NOCAL”) was established by an act of Legislature in 2000 (RL, 2000).

Seismic Data. The TGS surveys established the presence of essential petroleum factors: multiple mature oil prone source beds throughout most of the study area; abundant reservoir quality sandstones; adequate seals; varied, abundant and large traps and hydrocarbon generation; and expulsion post trap formations that expand from a few hundred meters on the continental shelf to more than 2000m in the basin containing mature Cenomanian to Turonian source beds. Traps are numerous and widespread” (NOCAL, 2012).

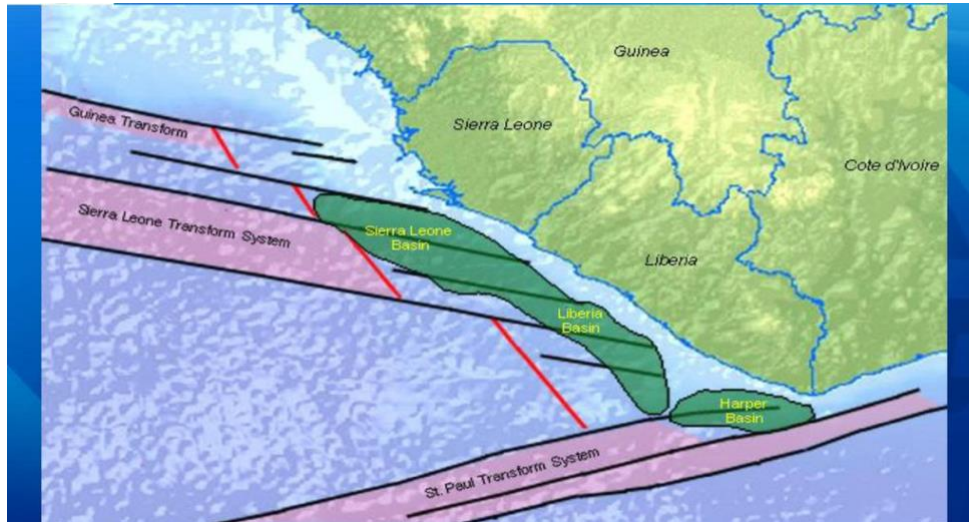
Table 4.1: Major Early Events

Major early Events	
Year	Major events
1958	Exploration License to Liberian American Exploration Corporation
1968	Chevron & Conoco acquired reconnaissance magnetic & seismic data
1969	Establishment of Liberia’s Petroleum Code
1969-1972	Liberian Government divided the continental shelf into 4 concessions blocks (A, B, C, and D)
1969	Union Carbide, Chevron, Frontier Oil were awarded blocks A, B, and C respectively. Block D was not released.
1971	Wells A1-1 and A2-1 were drilled by Union Carbide, well 11B-1 by Chevron and well Cestos-1 by Frontier.
1972	Approximately 13,000 line-km of offshore geophysical data was acquired by USGS
1976-1981	Approximately 5,900 line-km of seismic data was acquired by the Ministry of Lands, Mines and Energy in conjunction with GSI (1975) and World Bank (1981)
1982	New Liberian Petroleum Code and created 5 shelf area blocks & 4 Deepwater blocks
1983	Amoco was granted 4 off-shore blocks; 2 on the continental shelf and 2 in deepwater
1983-1984	7,800 line-km of seismic acquired
1984	Amoco obtained 2 additional blocks
1985	Amoco drilled 3 wells, S/1-1, S/3-1, and H3-1
1986	Amoco relinquished most of its acreage
1989	Amoco pulled out, program laid dormant
1997–1998	GOL divided the unlicensed offshore into 8 blocks (A – H)

Source: National Oil Company of Liberia

Liberia, in the past, had a total of 30 concessionary offshore acreage blocks labeled LB-1 through to LB-30. The present law stipulates that a maximum area of 2000 sq. km is prescribed for each block. Due to this provision, 52 blocks have been re-demarcated. The previous deep-water blocks existed close to the continental shelf ranging from water depths between 2500 - 3000 meters. The blocks considered “ultra-deep” has water depths of as much as 4500 meters.

Figure 4.2: Offshore Map of Liberia indicating both the Liberia and Harper Basins



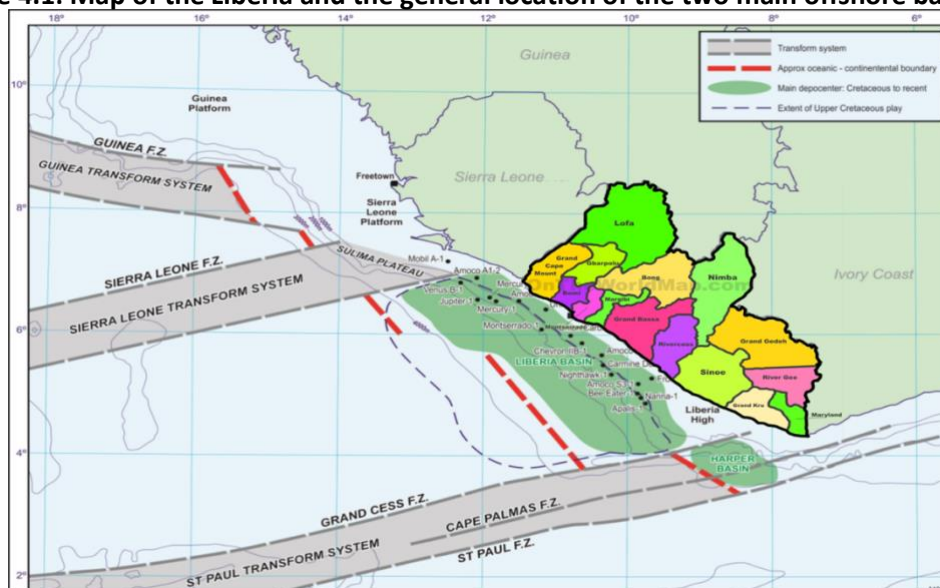
Between 2010 and 2015 some major players like Anadarko, ExxonMobil, Chevron, African Petroleum, Repsol, etc. conducted exploration activities within the Liberia Basin; but their efforts did not lead to production and

development of their exploratory wells. Since 2016, there has been no exploratory activity offshore Liberia, except for the acquisition and processing seismic data being carried out by TGS-NOPEC, a geophysical company hired by NOCAL. A new reform initiated in 2010 by the Government of Liberia resulted into the drafting and endorsement of the Petroleum Policy, the enactment of the Petroleum Law and the amendment of the NOCAL Act. The Petroleum Law of 2014 created an independent regulator (LPRA) responsible to conduct pre-qualifications, bid round, grant petroleum rights/agreement and supervise these petroleum agreements.

New Management of LPRA, working with NOCAL, has subsequently received a request from the President of Liberia to open up new blocks for bid rounds and possible negotiations for exploratory activities that might possibly lead to production and development.

This section analyzes the economic implications of oil and gas operations particularly on the fiscal regime and the road towards bid rounds within the Liberian oil and gas sector. The first part highlights the demand for oil, while the second discusses the fiscal regime. The third and final part provides assumptions on the fiscal space of conduction bid rounds.

Figure 4.1: Map of the Liberia and the general location of the two main offshore basins



4.2 Demand for Oil and Gas

The Liberian economy has been severely hit by three major shocks in recent years, namely; the Ebola crisis of 2014, global commodity price fall in 2015, and the withdrawal of the United Nations Mission in Liberia (UNMIL) in March 2018.

These shocks weighed in heavily on the performance of economic activities within the country. Though the economy is still struggling to fully recover from the abrasive hits, it is making efforts to ensure stability.

Since the hike in oil price, World oil demand averaged at 95.12m b/d in 2016 (OPEC, 2017) and is expected to grow 1.4% per year to 7.2 million metric tons in 2021.

Oil plays a major role in Liberia's energy mix, and has a growing demand mainly pushed by the transport sector. This demand will continue to rise through 2030, which is complimented by increasing population and growing levels of prosperity. Average annual population growth rate between 2000 and 2017 is 3.04%, and by 2030 population growth rate is estimated at 3.8%². As income rises, so will the demand for personal mobility, establishing the link for a higher demand for oil. The expansion of road network and the importation of cars are also factors contributing to oil demand in Liberia. Major road corridors are being rehabilitated under the Liberia Road Asset Management Project (LIBRAMP)³ (Bank, 2011) with the aim of promoting economic development in rural Liberia and to reduce the commuters' constraints on the road mainly during the rainy season. The project has significantly contributed to the reduction in transport time and monetary cost along the 246-kilometer highway from Monrovia, through Gbarnga to the Guinea border.

Petroleum products on the Liberian market are mainly imported commodities through the Liberia Petroleum Refining Company (LPRC)⁴. Though one of the functions of the LPRC is to refine crude oil, it is currently a storage facility and chief regulator of imported petroleum products in the country. As of 2015 the LPRC licensed nine petroleum importers and imported about 363,262.37 metric tons of mixed petroleum products on the Liberian market including Premium Motor Spirit (PMS), Automotive Gas Oil (AGO) or fuel and JET-A1. In 2012, approximately 305,622 metric tons of mixed products were imported, compared with 286,045 metric tons imported in 2011 (LPRC, 2015).

4.3 Fiscal Regime

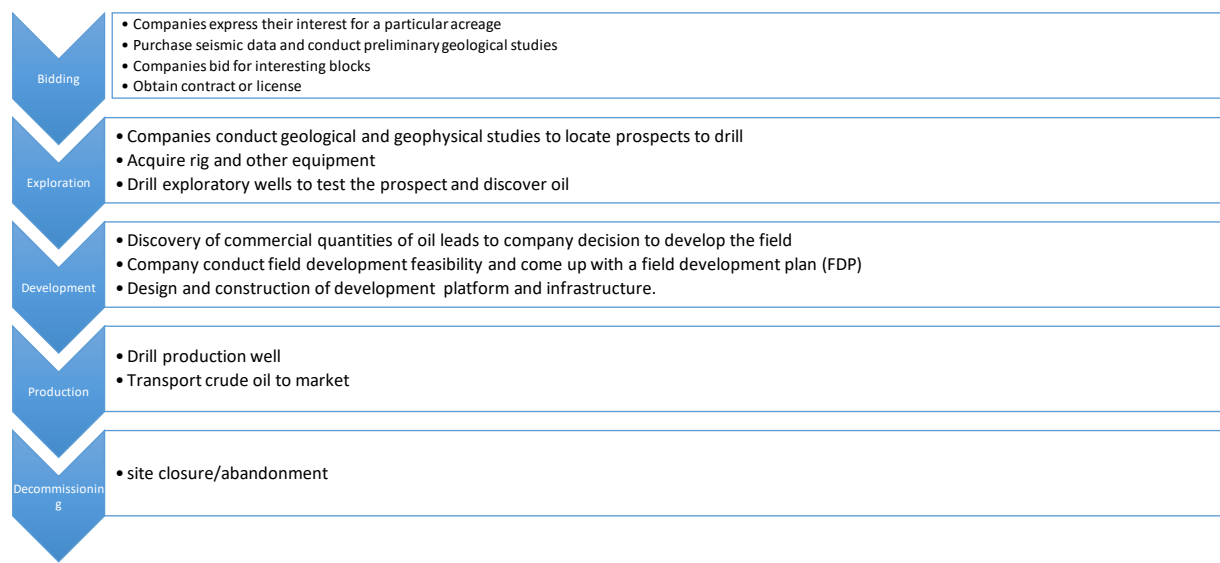
The oil and gas project cycle, for this paper, begins with the bidding process to decommissioning of the project.

² Author's estimate based on data from the World Development Indicators/ World Bank

³Total project cost includes funding from World Bank and non-bank sources in US\$ millions. The project was approved in June, 2011 and is expected to close on June 30, 2024.

⁴ The LPRC was granted exclusive rights for the importation, sale and distribution of petroleum products within the Republic of Liberia by an Act of the National Legislation on July 26, 1989.

Figure 4.2: Oil and Gas Project Cycle



From the beginning of the project cycle, fiscal terms are attributed to each of the stages. These terms account for government's share of the resources being exploited for the development of the nation. Government share comprises of total pre-tax cash flow, which includes economic rent prior to production and other taxes, fees and profit oil as well as the effect of the interactions among the different parameters constituting the fiscal regime.

Fiscal terms are agreeable between the host country and the International Oil company as per the agreement to govern their relationship and to determine how financial benefits and risks are divided. It becomes a win-win to both parties when fiscal regimes have progressive elements using such instrument as: progressive income taxes, windfall profits taxes, and variable-rate royalties. These instruments provide the incentives to increase government's revenue share as production level increases.

A fiscal regime that is over-exhaustive with mainly components of what government gets attracts the best investors. A partially designed fiscal regime could be catastrophic for the host country.

4.4 Fiscal Instruments

Petroleum operators that conducted exploration activities between 2010 – 2016 were generally subject to the following taxes in Liberia: Surface rental fee, corporate income tax, royalties and customs user fees on imported goods.

Other non-tax financial obligations imposed on petroleum operations may be as specified in applicable PSC. These typically include:

- Contribution to the Hydro Carbon Development Fund
- Contribution to the Rural Energy Fund
- Contribution to the Personnel Training Fund
- Contribution to a Social Welfare program

However, fiscal instruments are used in varying combination depending on the negotiation and agreement. Below is a list of the most frequently used fiscal instruments:

4.5 Windfall Profits Taxes

This tax is a special kind outside of the regular corporate income tax and is consistent with the progressive design of the fiscal regime. It is usually set up during the production period to give the government a greater share of project surpluses, through additional tax payments, when prices or profits exceed the levels necessary to attract investment. Windfall profit taxes may also be applied to farm-outs above the price paid for blocks.

4.6 Bonuses

Bonus is a one-time payment payable by contractor at a particular stage of the project. It could be made upon the finalization of a contract, the launch of activities on a project, or the achievement of certain goals laid out in the law or contracts. Examples are Signature Bonus; as the name depicts, is usually payable around the time when the Production Sharing Contracts are passed into law. A commerciality bonus is a bonus paid when the producer decides, with the state's approval, to develop a project on the grounds that doing so will be economically profitable, or "commercial, and there are even bonuses payable based on the commercial rate of production for a particular period, among other as may deem necessary between the parties. These bonuses may vary in amount and range from tens of thousands to even hundreds of millions of dollars depending on the prospectivity of the petroleum projects.

4.7 Royalties

Royalties are normally a portion of revenue or production made to government. Most royalties are based on a percentage of 5% of the value of output produced. In a progressive fiscal regime, host countries may impose royalties based on incremental commodity prices or on the length of production. In Liberia, the revenue code puts royalty for gross petroleum production at 10% payable by all company holding petroleum rights including NOCAL.

Income Tax and Other Taxes and Fees. Additional sources of fiscal revenues for the state include withholding tax on dividends and payments made overseas, excise taxes, and customs duties.

4.8 Surface Rental or land/acreage rental fees

Surface rental fees - a form of rent, where government charges the contractor a fee per square unit of area of the offshore block lease. Surface rental fees are generally higher on land and lower with increased water depth. This is because of the increase in cost with the increase in water depth. It requires more advance technology to drill deep-water and ultra-deep areas and lower surface rental fees encourages companies drill in higher water depths where there are potentially huge reserves to be unlocked.

Production Sharing

Many oil and gas contracts entitle the state to a share of the physical quantities of petroleum produced. These systems typically allocate such resources as reimbursements on production costs, then split control over the remaining “profit” oil or gas between the operating group of companies and the government. The government either sells its portion on its own, or takes cash payment from the operating companies in lieu of physical delivery of the commodity (NRGI, 2015).

4.10 Ring-Fencing

Ring-Fencing is simply putting borders around a project to avoid complex financial calculations and disagreements between host country and partners. Companies with multiple projects within one country sometimes use losses incurred in one of their projects to offset profits earned in another project, thereby reducing overall tax payments. Ring-fencing resolves this by affording government collect taxes and revenue on a project-by-project basis.

4.11 Loss Carry-forwards

Some governments allow for loss carry-forward but place a limit on them to restrict either the period of time that a loss can be kept on the books or the amount of income in any given year that can be offset by past losses.

5.0 Bid Round

In preparation for the upcoming bid round⁵, it is necessary to make few assumptions to give an indication of what the financial outcome may look like.

During the bid round process, the state is expected to generate revenue from potential partners. This section gives the assumption of two scenario analysis based on the value bonus. Holding all existing fees structures unchanged, scenario one assumed a signature bonus of US\$15million while scenario two assumed a signature bonus of US\$25million based on the re-demarcation of the existing blocks and offering a minimum of ten blocks (7 in Harper Basin & 3 in Liberia Basin) to successful bidders.

The analysis below showed that potential revenue can be generated from two core sources: Pre-award processes (announcement of bid round) and post award processes (awarding of blocks). Once the sector’s players conclude all the modalities pertaining to the announcing a bid round, potential bidders would commence the processes of pre-qualification, qualification and submission of bids. Based on past experiences, these bidders would immediately obtain license of seismic data for their respective areas of interest. Additionally, LPRA can mandate each bidder to acquire minimum amount of data as the basis for the qualification. This would ensure that all interested bidders pay some money upfront. Therefore, a total of US\$10.05million is projected to be raised provided the appropriate pricing mechanism is established and re-package the seismic data to present a new story compared to the previous basin narratives.

⁵ The New Management Team anticipates conducting bid rounds in 2019

The second source is the post award of the ten blocks. The signature bonuses would be paid upfront and transferred from LPRA directly to the Government of Liberia. Production Sharing Obligations and Surface Rentals are due on each anniversary date of the signing of the agreements for the period of the exploration, and would continue if commercial discoveries are made and exploited.

These amounts are not immediate. Given the two scenarios, the sector could potentially generate either US\$159million or US\$259million.

Table 5.1: Bid Round Summary

Scenario	1	2
At Announcement of Bid Round		
Data Licensing Fee	\$9,400,000.00	\$9,400,000.00
Bid Round Fees	\$650,000.00	\$650,000.00
Sub-Total	\$10,050,000.00	\$10,050,000.00
Post Awards of Bid		
Signature Bonus	\$150,000,000.00	\$250,000,000.00
PSC Obligations*	\$8,250,000.00	\$8,250,000.00
Surface Rentals*	\$1,175,000.00	\$1,175,000.00
Sub-Total	\$159,425,000.00	\$259,425,000.00
Total Inflows	\$169,475,000.00	\$269,475,000.00
Distributions		
GoL Direct Transfers	\$151,175,000.00	\$251,175,000.00
Sector's Players Operations**	\$18,300,000.00	\$18,300,000.00

* Payments due on Annual Date(s)

** LPRA & NOCAL

5.1 Historical Perspectives on Bid Rounds

NOCAL has conducted three bid rounds since 2006. During the first bid round, eight offshore blocks were awarded to five companies (Regal Liberia Limited, Oranto Petroleum Pty. Ltd, Broadway Consolidated Plc, Woodside West Africa Ptl. Ltd and Reposol Exploration S.A.). At the second bid round three additional blocks were awarded to Anadarko Liberia Company, Mittal Investments and Hong Kong Tong-Tai Petroleum International. Lastly, in the third bid round, four blocks were offered and awarded to Kosmos Energy, Liberty Petroleum and A-Z Petroleum.

However, over the years, several of the companies either farmed out of the blocks or their contracts were not consummated for various reasons. Currently, the offshore areas are completely vacant

and there is a need to attract companies to increase exploratory activities and the chances of making a commercial discovery.

5.2 Joint Venture

Normally, in the Oil and Gas industry, many players form a special purpose vehicle or company called a Joint Venture to acquire exploratory, appraisal, development and production of oil and gas. The nature of the petroleum industry is such that involves very huge costs and project risks, which requires substantially frontloading of investments and sharing of risks.

According to Ernst & Young, 71% of upstream investment is spent through strategic alliance or JV relationships. The participants in these relationships contribute assets, capital, unique expertise or labor to access diverse advantages such as scale, risks sharing, market entry, optionality, tax benefits and access to other unique capacities.

6.0 Economic Evaluation

In order to access the economic viability of entering into a JV relationship, several assumptions must be made. We must assume that the venture acquires a block and makes an oil discovery and then determine the financial benefits to the partners based on the existing upstream fiscal terms

6.1 Assumptions

Reserve Estimates 1billion barrels, Recovery rate 70%
 Exploration cost US\$560million, Development Cost US\$839million
 Operating Cost US\$10 per barrel, Oil Price US\$70 per barrel
 Assuming project life of 20 years, JV ratio 50%
 Existing Fiscal Terms (Royalty-5%, cost recoverable limit 70%, depreciation 20% annually, Income tax 30%, Production sharing mechanism)

6.2 Results

Table 6.1: Ratio Analysis

Ratio Analysis		
Net Present Value (NPV)	\$ 3,369,387	\$ '000
Internal Rate of Return (IRR)	43.64%	%
Time to Payback	6	Years
Discounted Payback Time	7	Years
Return on Equity	68.77%	%
Return on Investment	47.62%	%

Given a 10% discount rate, a project with such magnitude would generate a net present value of US\$3.3billion with an internal rate of return of 44% to the state. However, it must be noted that

the analyses assumed that the state would be carried by the venture partner(s) for all costs until production begins. In terms of other project dynamics, capital recovery would be as long as 6 years (un-discounted cash flow) and 7 years (discounted cash flows). Return on equity is 69% while return on investment is 48%.

6.3 Sensitivity Analysis

Three sensitivity analyses were performed to determine the effects of changes in key project assumptions. Under the first sensitivity, government share of the JV was varied from 25% up to 70% given different ranges of oil prices. The sensitivity showed as government share of the JV decreases, its net present value would be higher. The underlying reason is due to the assumption that the government would be paying less for capital expenditure, which commences at production.

Table 6.2: Government Share Sensitivity

Government Share Sensitivity							
\$ 3,331,938	25.00%	30.00%	35.00%	40.0%	50.00%	60.00%	70.00%
55	3,749,606	3,483,339	3,217,073	2,950,806	2,418,273	1,885,740	1,353,207
60	4,204,348	3,908,044	3,611,740	3,315,436	2,722,828	2,130,220	1,537,612
65	4,659,090	4,332,749	4,006,408	3,680,066	3,027,383	2,374,700	1,722,017
70	5,113,833	4,757,454	4,401,075	4,044,696	3,331,938	2,619,180	1,906,423
75	5,567,927	5,181,381	4,794,835	4,408,289	3,635,197	2,862,106	2,089,014
80	6,021,625	5,604,832	5,188,040	4,771,247	3,937,662	3,104,077	2,270,493
85	6,475,322	6,028,283	5,581,244	5,134,205	4,240,127	3,346,049	2,451,971

The second sensitivity is capital expenditure. The analysis showed that if the state can ensure that each project is executed in a cost effective manner, then lower the cost, the higher the return to the state.

Table 6.3: Capex

Capex							
\$ 3,331,938	70.00%	80.00%	90.00%	100.00%	110.00%	120.00%	130.00%
55	2,613,047	2,548,689	2,483,481	2,418,273	2,353,065	2,287,858	2,222,650
60	2,915,511	2,852,942	2,788,036	2,722,828	2,657,620	2,592,413	2,527,205
65	3,217,976	3,155,407	3,092,591	3,027,383	2,962,175	2,896,968	2,831,760
70	3,520,441	3,457,872	3,395,302	3,331,938	3,266,730	3,201,523	3,136,315
75	3,822,906	3,760,337	3,697,767	3,635,197	3,571,285	3,506,078	3,440,870
80	4,125,371	4,062,801	4,000,232	3,937,662	3,875,093	3,810,633	3,745,425
85	4,427,836	4,365,266	4,302,697	4,240,127	4,177,558	4,114,988	4,049,980

The third sensitivity analysis is based on the size of the recoverable reserves. The analysis showed that as the recoverable rate declines the net present value from the project accrued to the state would be lower.

Table 6.4: Sensitivity Analysis

16 Page Sensitivity Analysis								
		recovery rate						
	\$ 3,331,938	20%	40%	50%	60%	70%	80%	90%
Oil Price	55	178,636	1,089,889	1,536,013	1,977,167	2,418,273	2,859,380	3,300,486
	60	272,052	1,266,092	1,753,600	2,238,214	2,722,828	3,207,442	3,690,915

Figure 6.1: Model in US Dollars

Model is in *000 USD Dollars

Exploration Cost		
	Quantity	Cost
Seismic Surveys	1	\$ 5,000
Exploration Well	3	\$ 125,000
Appraisal Well	2	\$ 90,000
Capex Multiplier	1.00x	
Signature Bonus	\$ 15,000	
Discovery Bonus	\$ 5,000	

Development Cost		
	Quantity	Investment
Conversion Wells	3	\$ 3,000
Development Wells	5	\$ 80,000
Surface Facilities	1	\$ 400,000
Pipeline and Port	1	\$ 30,000

NPV \$ 3,369,387
IRR 43.6%

Production

Gas to Oil Ratio 1.25x Mscf/bbl
Gas Price (\$/MSCF) \$ 5.00

Production Year	bbls/y	Oil Price
P1	35,000,000	\$ 70.00
P2	35,000,000	\$ 70.00
P3	35,000,000	\$ 70.00
P4	35,000,000	\$ 70.00
P5	35,000,000	\$ 70.00
P6	35,000,000	\$ 70.00
P7	35,000,000	\$ 70.00
P8	35,000,000	\$ 70.00
P9	35,000,000	\$ 70.00
P10	35,000,000	\$ 70.00
P11	35,000,000	\$ 70.00
P12	35,000,000	\$ 70.00
P13	35,000,000	\$ 70.00
P14	35,000,000	\$ 70.00
P15	35,000,000	\$ 70.00
P16	32,900,000	\$ 70.00
P17	30,926,000	\$ 70.00
P18	29,070,440	\$ 70.00

US Inflation	LIBOR
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%
0.80%	1.50%

	E1	E2	E3	D1	D2	Total
Exploration Capex	\$ 5,000	\$ 375,000	\$ 180,000			
Development Capex				\$ 419,500	\$ 419,500	
Field Capex	\$ 5,000	\$ 375,000	\$ 180,000	\$ 419,500	\$ 419,500	\$ 1,399,000
Total Capex	\$ 20,000	\$ 375,000	\$ 185,000	\$ 419,500	\$ 419,500	\$ 1,419,000

Capex Depreciation (in %) 20%
Capex Depreciation (in Years) 5

Operating Cost

Variable Cost (\$/bbl) \$ 10.00
Fix Cost (% of Capex) 5%

Government

Cost of Oil (% of Revenues) 70%
Royalties 5%

Government Share 50%

Tax Rate 30%

Financing

Debt % 50%
Maturity (in years) 10
Spread over LIBOR 5.50%
Financing Fee 1.00%
Contractor Equity Ra 10.00%

WACC (for reference) 7.5%

Reserves

Oil in Place 1,000 MM bbls
Recovery Rate 70%
Reserves 700 MM bbls
Prod per Year 35,000,000 bbls/y

Select Analysis Type

Initial Analysis Monte Carlo Simulation

Decision Tree

Final Decision

6.4 Selling of Share (Privatization)

The Finance team determined the expected monetary value of the exploratory rights based on a single block or discovery. It must be emphasized that in the absence of certified evaluation report of the total undiscovered resources within our basin, this is just an estimation of the value of 1billion reserve given several probabilities of discoveries.

Given the analysis above, the expected monetary value of a 1billion reserve is estimated below:

Table 6.5: Expected Monetary Value

Expected Monetary Value		
Probability	NPV	EMV
		3,369,387.00
10%		336,938.70 Millions
20%		673,877.40 Millions
30%		1,010,816.10 Millions
40%		1,347,754.80 Millions
50%		1,684,693.50 Millions

In view of the foregoing analysis, selling shares in NOCAL assuming this minimum reserve could be priced at any of these levels.

The three scenarios presented above gauge these different options from which NOCAL could generate potential benefits in re-energizing the sector.

7.0 PRELIMINARY ENVIRONMENTAL ASSESSMENT

7.1 Affected Environment

The proposed bid round activity will be conducted for offshore blocks located in the Harper and Liberia Basins, all deep-water marine environments. Several blocks are expected to be up for active petroleum activities to commence. After companies have signed contracts with the Liberian government, these companies will be required to identify environmentally and socially sensitive areas via the ESIA process prescribed by the Environmental Management Law of Liberia 2003. However, it is known generally that whales and dolphins migrate through waters offshore Liberia

and sea turtles nest on beaches adjacent to the proposed sites. Fishing and shipping vessels pass through the waters of the Blocks, although sensitive fishing grounds or shipping routes have not been identified to be in this area.

7.2 Potential Impacts and Alternatives

Many of the potential impacts identified for the exploration activities are associated with routine events for which there are procedures and mitigation measures in place as part of standard operating practices. The biggest risk comes from the unfortunate event of an oil spill or blowout which may result into damage to biodiversity, increase environmental degradation, disruption in ecosystem services, and impact to human lives and health. Potential impacts associated with accidental events will require exigency planning and additional resources. Most of these impacts may consist of potential short term effects on marine water quality, marine fauna, sensitive shoreline features and fishing activities from spills of oil, fuel, wastes, hazardous materials or cuttings containing hydrocarbons.

Oil companies in the past that were fortunate to get into our basin previously utilize port facilities in Takoradi, Ghana or Abidjan as their main supply base and processing hazardous waste as there are none in Liberia. A slight increase in marine traffic from supply vessels traveling to/from Takoradi/Abidjan to the drill sites has been likely. In addition, during the drilling phase of exploration activities, a one kilometer safety zone has been established around drilling locations that will be off-limits to fishing and boat traffic. However, due to the nature of the deepwater, it is unlikely that fishing boats venture out this far. Pirate Trawlers have been known to venture into deepwater areas but said activity is unlikely as many such endeavors have been discouraged vigilantly by West African government. However, all legal seagoing vessels are alerted via the normal maritime system of the rig presence and shall act as per the International Maritime Laws.

An increase in cost for drilling operations and turnaround for drilling logistics and supplies is experienced during the drilling campaign is due to the fact that many companies in the basin have to rely on supply basis in Ivory Coast or Takoradi/Ghana. LPRA in collaboration with the government of Liberia intends to convert this cost into a benefit for Liberia, by revamping the Port of Greenville and/or Harper, Sinoe County. These ports are very close to many of the blocks to be given out and when completed will also have an economic impact on the Southeastern area. The area has access issues especially during the rainy season, and the social impact is that a functional port in the area could help reduce the turnaround times also for goods and services to the southeast. Many plantations are also located in the area including rubber and palm concessions. A port facility in the area will greatly assist these businesses in transporting their produce to other major ports in the area. Oil companies will also improve their turnaround times and reduce the safety risk of moving supplies and waste over many thousands of kilometers.

As usual, crew changes will be done through Monrovia. The flight path, via helicopter, will be a direct line between the Robertsfield International Airport or Spriggs Payne Airport and the offshore drilling location. The flight path will be primarily away from shore, so helicopters involved in exploration operations will not pass along potentially sensitive receptors.

While there may be a short-term positive benefit for the economy due to the purchase of goods and services, exploration activities may not generate many jobs for local residents as they lack the basic skills for such operations. However, to prepare for a discovery and subsequent exploitation of oil, Liberians will be trained in various fields related to the industry so as to take advantage of the opportunities during production.

Prior to initiating the drilling, companies will be required to analyse the seafloor conditions based on detailed geophysical and seafloor imagery to determine if there are any anomalies (e.g., steep seafloor slopes, boulders or gas vents) that could represent either higher biological diversity habitat than surrounding seafloor areas or potential hazards to safe and successful drilling. If any such features are perceived, the specific location of the drill site can be adjusted to avoid them. For exploratory drilling programs, alternatives result in little variation in terms of potential environmental and social impacts and are often limited because of technical requirements.

7.3 Methodology

The ESIA will be prepared in accordance with the Terms of Reference (TOR) approved by the Environment Protection and Management Law of 2003 and the ESIA regulation issued in 2016. To meet these requirements in the law, an ESIA Consultant will utilize an established method for impact screening, evaluation and mitigation that have been applied on EIAs worldwide. Details concerning this methodology will be included in the next edition.

The next descriptions contained here are aligned with Section 14 of the Environment Protection and Management Law of Liberia (EPML) which states that the ESIA shall incorporate “a detailed description of the proposed project or activity and of activities it is likely to generate.” Companies who will be issued licenses in the basin will be responsible to follow through with the EPML 2003 and submit to fulfill all its requirements, before, during and after petroleum operations. These petroleum operations may include the reconnaissance, exploration, development and production, as well as decommissioning. Operations may also include those related to petroleum operations as well as those involving the laying and operation of petroleum transportation systems.

7.4 The ESIA Process

7.4.1 Introduction to the Process

In compliance with the EPML, companies winning the bid round must complete the following activities before commencement of operations:

1. Submit a letter to EPA - Liberia announcing their intention of implementing a deep-water exploration project
2. Submitted a Project Brief to EPA - Liberia
3. Published a Notice of Intent (NOI) in a number of local newspapers

The EPA reviews the Project Brief and determined that an EIA is required. In accordance with Section 11 of the EPML, a Scoping process will be initiated to:

1. Identify, inform, and receive input from potentially affected stakeholders
2. Further define the scope of issues to be addressed in the EIA
3. Identify and define potentially significant impacts and alternatives with the Project
4. Encourage public participation early in the EIA process
5. Address relevant issues and alternatives in the EIA
6. Provide Chevron with information necessary to formulate the EIA TOR
7. Provide guidance for the EIA Team to meet objectives

At EPA's request, the IOC will facilitate a workshop to present information regarding the Project and to discuss exploratory drilling practices and impacts. This will be followed by a Scoping Stakeholder Consultation Meetings where project details will be discussed and information to address potential stakeholder concerns will be given.

Suggested stakeholders to meet with IOCs:

1. Ministry of Lands Mines and Energy
2. Bureau of Maritime Affairs
3. Ministry of Agriculture (Bureau of National Fisheries)
4. Ministry of Internal Affairs
5. Superintendent of Grand Bassa County
6. Superintendent of Montserrado County
7. National Oil Company of Liberia (NOCAL)
8. EPA (Executive Director)

Additionally, where there are travel concerns (as in the case of leeward counties), letters discussing the Project and requesting feedback will be issued to stakeholders.

7.5 Mitigation and Monitoring Required

An Environmental Mitigation and Environmental and Social Management Plan (ESMP) will be developed (per block) to manage potential impacts of the proposed drilling activities such that they remain at acceptable levels throughout the respective exploration programs. Proposed mitigation measures will be targeted, achievable, and evaluated.

7.6 Regulatory Review

The legislative framework and institutional framework governing oil and gas exploration activities in Liberia is summarized in the below table. The Environmental Protection Agency of Liberia (EPA) is the environmental regulatory authority in charge of reviewing the Environmental and Social Impact Assessment (EIA) process.

7.6.1 Legislative Framework

The table below describes relevant Liberian environmental legislation. **Table 7.1** describes the main categories of legislation in Liberia and **Table 7.2** provides a summary of relevant Liberian environmental legislation.

Table 7.1: Categories of Legislation in Liberia

Legislation Type	Description
Law	Laws are passed by the National Legislature of Liberia comprised of the Senate and the House of Representatives. Any citizen or group of citizens, Cabinet Ministers, Managing Directors of public corporations or agencies can propose a bill to the National Legislature for enactment. The draft bill is first passed over to the appropriate Steering Committee of the Legislature. In the case of an environmental bill, this committee is generally the Committee on Natural Resources and the Environment. The Committee reviews, assesses and presents the bill to the Legislative Plenary with appropriate amendments for debate, public hearing and subsequent enactment by the Legislature.
Executive Order	The Executive Branch of government headed by the President can issue Executive Orders without the approval of the National Legislature. Executive Orders have the power of law provided that they do not contravene existing law. The power of such orders has a limited time of existence.
Regulation	The national Legislature has empowered Cabinet Ministers and Managing Directors of public corporations and agencies to issue regulations for their respective functionaries without legislative approval or supervision, provided that such regulations are not inconsistent with the statutory Laws and the Constitution of Liberia.

Table 7.2 provides a summary of relevant Liberian environmental legislation

Title	Year	Description
Conservation of the Forests of the Republic of Liberia	1953	This law provides the framework for the use of forest and wildlife resources and allows for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.
Supplementary Act for the Conservation of Forests	1957	This Supplementary Law also provides the framework for the use of forest and wildlife resources and allows for the creation of government reserves, native authority reserves, commercial forests, national parks and wildlife refuges.
The Act that created the Forestry Development Authority (FDA)	1976	This Act established and defined the responsibilities of the FDA, outlined forest offences and penalties, made provisions for an Advisory Conservation Committee and specified powers of forest officers with regard to trees in reserve areas.
Public Health Act	1976	Contains provisions for the protection of drinking water resources and the inspection of potential sources of pollution.
The Natural Resources Law of Liberia	1979	This Law includes chapters on forests, fish, and wildlife, soil, water, and minerals.
Wildlife and National Parks Act	1988	The Act identifies a number of protected areas and specifies policies and objectives regarding wildlife and conservation in the country.

The Environment Protection Agency (EPA) Act	2002	The Act provides the Agency with the authority of government for the protection and management of the environment in Liberia. It provides for an Environmental Administrative Court to hear from aggrieved parties and requires that an ESIA be carried out for all activities and projects likely to have an adverse impact on the environment.
The Environment Protection and Management Law	2002	The Act enables the Environment Protection Agency to protect the environment through the implementation of the Law. It arranges the rules, regulations, and procedures for the conduct of ESIA's and establishes regulations for environmental quality standards, pollution control and licensing, among others.
The National Environmental Policy Act	2002	It defines policies, goals, objectives, and principles of sustainable development and improvement of the physical environment, quality of life of the people and ensures coordination between economic development and growth with sustainable management of natural resources.
National New Forestry Reform Law	2006	The administration of this Act provides for the Forestry Development Authority to exercise power under the law to ensure sustainable management of the Republic's forestland, conservation of the forest resources, and protection of the environment. It also has provisions for sustainable economic development with the participation of and for the benefit of all Liberians to contribute to poverty alleviation in the country.

7.6.2 Constitution of the Republic of Liberia

Article 7 of the 1986 Constitution of the Republic of Liberia sets the fundamental basis for the constitutional, legislative, and institutional frameworks for the protection and management of the environment. It also encourages public participation in the protection and management of the environment and the natural resources in Liberia.

7.6.3 Environment Protection and Management Law of the Republic of Liberia

Section 1 of the Environmental Protection and Management Law (EPML), April 30, 2003, delegate's responsibility for sustainable development, protection and environmental management to the EPA in partnership with the Ministries and regulated organizations and in a close relationship with the people of Liberia. The EPA is responsible for providing high quality information and advice on the state of the environment and for matters connected therewith. The EPML indicates that environmental protection by the EPA should take into consideration Liberia's public health and welfare.

Section 6 of EPML requires an Environmental Impact Assessment License for the commencement of projects listed in Annex 1 of the EPML, including oil and gas exploration and development projects. Section 3.3, below, defines the Environmental Impact Assessment License application and approval process, including required public consultation. Section 12 of the EPML requires environmental review for projects or activities that may have significant impact on the environment. The project proponent shall submit to the EPA their plans for robust environmental performance including:

- Identification of the major environmental effects; and
- A comprehensive mitigation plan in accordance with section 15 of this Law

Section 15 of the EMPL states that business investors should present an environmental mitigation plan to the EPA, which should include the following sections:

- Objectives
- Description of activities to be carried out by the project to mitigate any adverse effects on the environment
- Period within which the mitigation measures shall be implemented
- Proven efficacy of the mitigation measures or indication of their experimental nature

7.6.4 Effluent Discharge License

Section 56 of the EPML prohibits discharge of hazardous waste or "mixture containing oil" (defined as mixtures containing more than 100 PPM of oil) without a license. This license applies to offshore oil and gas discharges into the marine environment.

7.6.5 Solid and Hazardous Waste Disposal License

Section 55 of the EPML prohibits, "...export from Liberia to any county hazardous waste or substances unless he has a license issued by the Agency." The EPML then states, "The exporter of hazardous waste or substance shall, before a license is issued, produce to the Agency written confirmation from an appropriate Agency of the receiving country that the Agency subject to such conditions as the Agency may impose." This license applies to the project proponent and not the waste contractor.

7.6.6 Pollution Emission License

Section 71 of the EPML requires project proponents to acquire a Pollution Emission License for, "any project or activity which is likely to pollute the environment in excess of any standards or guidelines issued under this Law [the EPML]..." The license is provided by the EPA for a period of not more than one year.

7.6.7 National Environmental Policy

The National Environmental Policy of Liberia provides a systematic and logical framework by which to address environmental issues. Section 4.7 of the policy calls for an EIA on all major developmental, socio economic and land use activities in any form which may have adverse effect/impact on the environment to one degree or another.

7.6.8 The Act Creating the Environmental Protection Agency

The Act Creating the EPA provides for:

- An autonomous entity empowered to ensure that environmental policies and laws are implemented
- A Policy Council to propose and update environmental policies as required/needed

- An institutional arrangement that supports the agency in carrying out its mandate/functions

7.6.9 National Energy Policy

In February 2007, the Government of Liberia (GOL), through the Ministry of Lands, Mines and Energy (MLME), with the support of the United States Agency for International Development (USAID) published the National Energy Policy (NEP). The NEP's principal objective is to ensure universal access to modern energy services in an affordable, sustainable and environmentally friendly manner to foster economic, political, and social development of Liberia.

The NEP recognizes the fact that energy is essential towards the GOL Development Agenda including the recently adopted Pro-Poor Agenda for Prosperity and Development. The NEP assumes the implementation of proposed energy sector reforms founded on three essential features:

- (1) Demonstrating the government's resolve for good governance and ensuring financial transparency in all sector transactions;
- (2) Overcoming the significant obstacles to private sector investment in energy supply; and
- (3) Creating the requisite institutional and legal framework and an independent regulatory regime.

7.6.10 Statements of Policy

Below are key statements of the NEP:

- Given the government's limited human, financial, and material resources and infrastructure, upstream and downstream petroleum operations (exploration, production, refining, wholesale, and retail operations) shall be undertaken by a single state-owned corporation operating in partnership with domestic and international private enterprise.
- It is the policy of the government to ensure transparent and independent regulatory oversight by vesting policy setting functions in the MLME, policy monitoring functions in the Energy Regulatory Board, and limiting the role of public and private companies to policy implementation.
- It is the policy of the GOL that environmental protection is exercised to the maximum extent possible throughout all aspects of petroleum exploration and development. Petroleum exploration and development should be conducted within sound principles of resource conservation together with due regard for the health and safety of workers, marine and other waterborne wildlife, and surrounding communities. Where laws need modification to ensure such environmental protection, it is the policy of the government that this be made a critical priority of both the legislative and executive agencies.
- It is the policy of the government that throughout the entire process of petroleum exploration and extraction there should be transparency of procedure and accountability to the Liberian people.

7.6.11 New Petroleum Law of Liberia

Section 55 deals exclusively with the general provisions and requirements for environmental and social impact assessment, pollution control, environmental and social management plan (ESMP)

and other best practices to mitigate and avert any potential or known environmental and social impacts from petroleum operations. It states, specifically, in section 55.1 that “the contractor shall submit to the EPA for approval (with a copy to the Authority) each Environmental and Social Impact Assessment (ESIA) and Environmental and Social Management Plan (ESMP) relating to planned petroleum operations as and when required under the Environment Protection Law, the EPA Environmental Guidelines, good international petroleum industry environmental practice or the contractor's petroleum agreement, as and when required by applicable law or regulation or by the terms of the relevant petroleum agreement or license under this Act.”

Environmental and social issues are addressed in other parts of the petroleum law. For example, section 2.5.2 provides that “all holders of petroleum contracts or reconnaissance licenses shall abide by the environmental protection laws of Liberia. Such holders shall declare their sites and installations to the agent(s) of the Environmental Protection Agency of the Republic of Liberia.”

Section 2.5.3 obligates the holder to, “carry out all operations and work using the techniques commonly used in the international petroleum industry, and undertake, particularly, all measures necessary to preserve and protect the environment, ecosystems and natural settings, as well as the security of person and goods.” Section 12.8 A holder of a reconnaissance license shall not commence a reconnaissance operation unless that person has complied with:

- (a) the relevant statutory requirements on environmental protection prescribed in the Environmental Protection Agency Act; and

Table 7.3: International Environmental Conventions Signed/Ratified by the Government of Liberia

Convention	Status	Year	Objective
African Convention on Conservation of Nature and Natural Resources	Ratified	NA	1. To encourage individual and joint action for the conservation
Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Ratified	1981	1. To prevent trade of endangered or threatened species
Convention Concerning the Protection of the World Cultural and Natural Heritage	Signed	2002	1. To recognize and protect cultural and natural heritage for future generations
Framework Convention on Climate Change and the Kyoto Protocol	Signed	2002	1. To achieve stabilization of green house gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climatic system 2. To strengthen the commitment of developed country parties with a view to reduce their overall emissions
Stockholm Convention on Persistent Organic Pollutants (POP)	Signed	2003	1. To strengthen National Capacity and to enhance knowledge and understanding amongst decision makers, managers, industry and the public at large on POPs 2. To develop a National implementation Plan (NIP) to manage the elimination of POPs.

Ramsar Convention on Wetlands of International Importance	Signed	2003	<ol style="list-style-type: none"> 1. To manage wetland systems so that the human uses of these areas are undertaken in such a way as to retain their natural capital for future generations. 2. To encourage and support countries to develop and implement national policy and legislative frameworks, education and awareness raising programs, as well as inventory, research and training projects.
Convention on Biodiversity	Ratified	2000	<ol style="list-style-type: none"> 1. To promote conservation of biological diversity 2. To promote sustainable use of ecological components 3. To promote fair and equitable sharing arising out of the utilization of genetic resources

7.7 Institutional Framework

At a regional cooperation level, Liberia is a member of a number of organizations that play an important role in the protection and management of the environment. These organizations include the Economic Community of West Africa, The Mano River Union, The West African Rice Development Association, and the African Union. Liberia signed the three Rio conventions on climate change (UNFCCC), biodiversity (CBD) and combating desertification (UNCCD).

At the national level, the institutions described below are relevant to the proposed drilling program

7.7.1 Environmental Protection Agency

Part II, Section 5 of the EPML designates the EPA as the principal Liberian authority for environmental management which coordinates, monitors, supervises, and consults with relevant stakeholders on all activities for environmental protection and the sustainable use of natural resources.

The main functions of the EPA are to:

1. Coordinate, integrate, harmonize and monitor the implementation of environmental policy and decisions of the Policy Council by the Line Ministries,
2. Propose environmental policies and strategies to the Policy Council and ensure the integration of environmental concerns in overall national planning;
3. Collect, analyze and prepare basic scientific data and other information pertaining to pollution, degradation and environmental quality, resource use and other environmental protection and conservation matters; undertake research; and prepare and disseminate every two years a report on the state of the environment in Liberia;
4. Encourage the use of appropriate environmentally sound technologies and renewable sources of energy and natural resources;
5. Establish environmental criteria, guidelines, specifications and standards for production processes and the sustainable use of natural resources for the health and welfare of the present generation and to prevent environmental degradation for the welfare of the future generations.
6. Provide guidelines for the preparation of Environment Assessments and Audits, and the evaluation of environmental permits.

Other organizations that play a vital role in environmental protection and management include the Forestry Development Authority, MLME, Ministry of Planning and Economic Affairs (MPEA), Ministry of Justice, Ministry of Public Works (MPW), Ministry of Health and Social Welfare (MHSW), MOA, Ministry of Commerce, Monrovia City Corporation and the Liberia Water and Sewer Corporation.

7.7.2 Liberian Coast Guard

Since its civil war, Liberia's 360 mile coast line and 1,900 square mile EEZ has been defenseless against the abuses of illegal fishing, drug trafficking, human smuggling and other illegal activities. National losses have been estimated at \$12 million USD annually.

The Liberian military has been completely rebuilt with help from the United States State Department's Security Sector Reform program. The Liberian Coast Guard is the newest addition to the Armed Forces of Liberia. At the request of the Government of Liberia, the United States Coast Guard made an assessment in 2008 and provided recommendations for reestablishing the Liberian Coast Guard. As part of the Security Sector Reform program, U.S. Africa Command is coordinating and funding this reestablishment project.

The GOL and its Ministry of Defense are leading this initiative with U.S. Africa Command providing support from its component commands, the United States Coast Guard and the U. S. State Department.

U.S. Africa Command is helping Liberia rebuild its maritime interdiction capability in order to control illegal activities, including poaching, drug trafficking and human smuggling, provide for search and rescue and disaster response, and acquire maritime domain awareness.

7.7.3 Ministry of Mines and Energy

Among other responsibilities, the MLME supervises the development and management of energy resources and conducts scientific and technical investigations required for environmental assessments. The implementation of water and sanitation activities is done through the Ministry's Department of Mineral and Environmental Research, which houses both, the Liberian Geological Survey and the Liberian Hydrological Service. The Liberian Hydrological Service is responsible for collecting data on the quality, sources, and quantity of water resources in Liberia and monitoring rainfall and stream flow in river basin as well as ground and surface water quality. Training of technicians from the Ministry of Rural Development in emergency disinfection (chlorination) of open wells has also been undertaken by MLME. The Liberian Hydrological Service is involved in special projects evaluating urban sanitation and provides guidance for geotechnical investigation of solid wastes landfill disposal sites.

7.7.4 Ministry of Public Works

The MPW is responsible for the design, construction and maintenance of roads and highways, bridges, storm sewers, public buildings and other civil works in the country. Additionally, it has responsibility for the administration of urban and town planning, as well as provision of architectural and engineering services for all government ministries and agencies. In principle, it

is responsible for the installation of the entire infrastructure required for waste management delivery services including the construction of sanitary landfill facilities.

7.7.5 Ministry of Health

The MHSW coordinates and administers all general health services in Liberia, including preventive services; collects health statistics; ensures drug availability; and monitors events and conditions affecting public health. It also maintains statistics from birth and death registrations. Through its Division of Environmental and Occupational Health, the Ministry assesses the environmental health of the population and regulates and monitors environmental impacts resulting from pollution of air, water, food/feed and soil, and sewage, as well as occupational health and chemical safety. The Division had a water quality laboratory prior to the civil war, but it does not exist anymore.

7.7.6 Ministry of Internal Affairs

The Ministry of Internal Affairs administers the affairs of all government functionaries in Liberia, oversees the activities of all local bodies, such as chiefdoms and clans, and supervises all county superintendents.

7.7.7 Ministry of Agriculture

Established in 1910, the MOA plans, administers, and supervises agricultural programs and provides extension services. It also trains local farmers in improved agricultural practices and provides farm inputs to increase food security. The Ministry conducts inspections and enforces rules and regulations governing the agriculture sector. The Ministry also implements agricultural programs, protects farmer's interests, encourages investment in the agricultural sector, and monitors overall activities including the movement of agricultural commodities into and out of the country. It focuses on trans-boundary commodity movements that are intended for the consuming public, or use on farms, large plantations and the agribusiness sector in Liberia in collaboration with neighboring countries such as Sierra Leone, Guinea, Cote d'Ivoire and other countries in the region. The Ministry also regulates the harvesting of botanical species by herbalists and other farmers as a part of shifting cultivation practices.

7.7.9 National Fishery and Aquaculture Authority

The NAFAA is charged with conserving all fish resources and aquatic environments in Liberia. The NAFAA is highly involved with the planning and implementation of the Draft Fisheries Policy.

7.8 Environmental and Social Impact Assessment Process

The following sources were used in defining the regulatory steps for the EIA:

- *An Act Creating the Environmental Protection Agency of the Republic of Liberia*, Ministry of Foreign Affairs, April 30, 2003
- *An Act Adopting the Environment Protection and Management Law of the Republic of Liberia*, Ministry of Foreign Affairs, April 30, 2003
- *The National Environmental Policy of the Republic of Liberia*, Ministry of Foreign Affairs, April 30, 2003
- *Republic of Liberia Environmental Protection Agency, Environmental Impact*

Assessment Procedural Guidelines

- Communications with EPA officials, and local experts (i.e. Earthtime, Inc.)

It is important to note that while the EPML, 2002 provides for EIA, the new regulation issued in 2016 provides for an Environmental and Social Impact Assessment including a resettlement action plan where applicable. Thus the change from EIA to ESIA.

An ESIA Process Flow Chart has been included as **Figure 3-1**. The main steps in the process are:

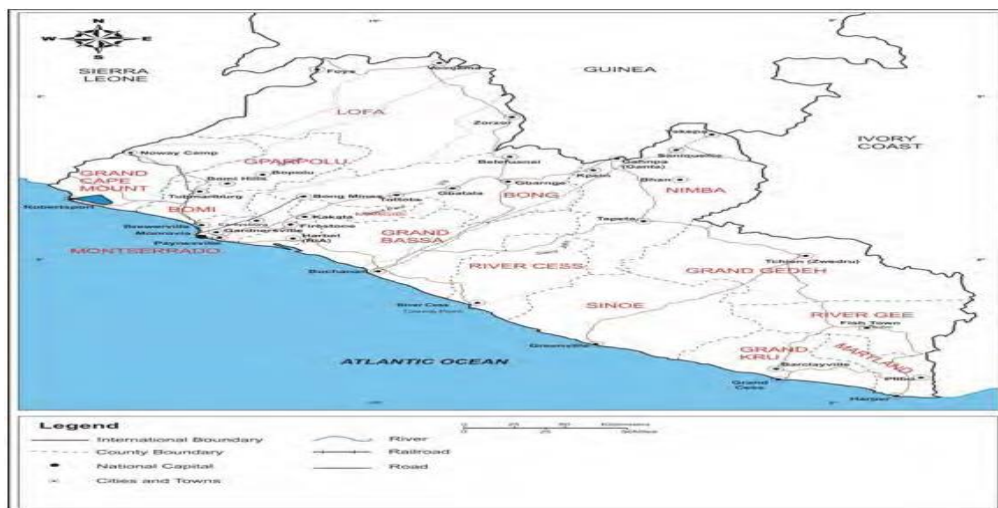
- Prepare Application for Environmental and Social Impact Assessment License
- Prepare Notice of Intent (NOI)
- Submit Project Brief (allow 14 working days for EIA review and feedback)
- Conduct Scoping Process

7.9 General Background of Liberia

Liberia is located on the southwest corner of West Africa. It is positioned on the Atlantic coastline of Africa, and has a total surface area of 111,370 km². It lies between the longitudes of 7°30' and 11°30' west and latitudes 4°18' and 8°30' north. It is bordered by Guinea on the north (border length: 563 km), Sierra Leone on the west (border length: 306 km) and Côte d'Ivoire on the east (border length: 716 km) Liberia lies within the upper Guinean Forest region and prior to the impact of man was almost entirely covered by tropical rain forests. The capital, Monrovia, is the country's largest city. The next largest cities are Buchanan (port city for rubber and iron exports), Harper, situated on the coast, and the inland trade centre of Yekepa, near the border with Guinea. There are 15 administrative counties in Liberia.¹

Liberia has a coastline 579 km long and claims an economic zone of 13 nautical miles and territorial zone of 200 nautical miles.² The coast is characterized by unbroken beaches, and consists of swamp-related vegetation, including mangroves forests that extend up to 25 miles inland.

Figure 7.2: Liberia Country Map

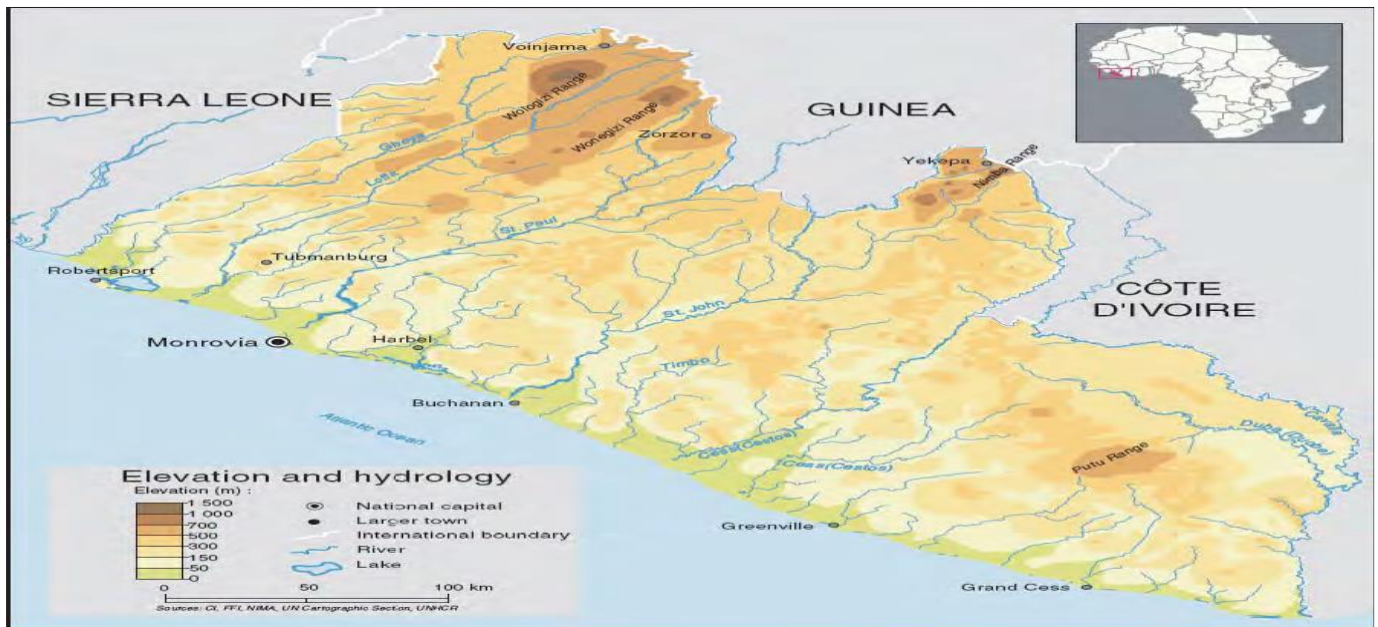


Source: United Nations Environment Program. 2004. Desk Study on the Environment in Liberia.

Liberia can be roughly divided into four geographical zones (**Figure 7.2**):

1. Coastal plain
2. Rolling hills
3. Plateau and tablelands
4. Northern highlands

Figure 7.3: Elevation and Hydrology of Liberia



Source: United Nations Environment Program (UNEP), 2004

7.9.1 Coastal Plains

The coastal plains extend up to 65 km inland. They are low and sandy, with miles of beaches interspersed with bar-enclosed lagoons, mangrove swamps, and a few rocky promontories. The highest promontory is Cape Mount (about 1,000 feet or 300 meters in elevation) in the northwest, with Cape Mesurado in Monrovia, and Cape Palmas in the southeast. Its deepest extensions lie along the watercourses. Except for those promontories and capes and an occasional small hill, the elevation of the coastal region usually rises no higher than 30 to 60 feet. The mouths of the rivers are easily obstructed by shifting sandbars and submerged rocks so there are no natural harbors.⁴

7.9.2 Rolling Hills

The rolling hills are situated behind the coastal zone. This zone is characterized by hills, valleys and watercourses. Most of the agricultural land is situated in this zone due to the favorable climate and topography. The rolling hills have an elevation of approximately 90 m above sea level on average and contain large tracts of tropical rainforests to the southwest and southeast.

7.9.3 Plateau and Tablelands

Plateau and tablelands extend up to 300 m in elevation and mountain ranges reach an altitude of 610 m. Important ranges within this zone are the Mano River Mountains and the Bea, Bong, Gibi, Kpo, Putu and Tienpo ranges. The greatest width of this zone is approximately 130 km between the Lofa and Saint Paul rivers.

7.9.4 Northern Highlands

The northern highlands are located in the upper Nimba and Lofa counties. The highest points of Liberia are Mount Wuteve at 1,380 m and the Liberian part of Mount Nimba, both located in the Nimba Range. The Wologizi Range in Lofa County has a maximum altitude of 1,356 m.

7.9.5 Meteorological Setting

The climate of Liberia is highly determined by its equatorial position in the Inter-tropical Convergence Zone, an area encircling the equator where winds originating in the northern and southern hemispheres come together. In Liberia, the Inter-tropical Convergence Zone is primarily influenced by the interaction of low and high-pressure belts along the African continent and the Atlantic Ocean. Liberia typically has a fairly warm temperature throughout the year with high humidity.

7.9.6 Precipitation

Liberia has two seasons. The dry season usually lasts from November to April and the rainy season usually is from May to October.

Average annual rainfall along the coastal belt is over 4,000 mm and declines to 1,300 mm at the forest-savannah boundary in the north.⁶ Monrovia, the capital, receives almost 4,600 mm of rain per year. The corridor of the eastward flowing Cavalla River is one of the driest areas of the country, but even there the land receives over 1,775 mm of rain a year. The months of heaviest rainfall vary from one part of the country to another, but are normally June, July and September. Observations concerning the diurnal distribution of rainfall prove that two thirds of the rain received along the coast falls during the night between 18:00 and 07:00 hours. Most of the rest of the rain usually falls during the morning while only a minimum of rain is recorded between mid-day and early afternoon.

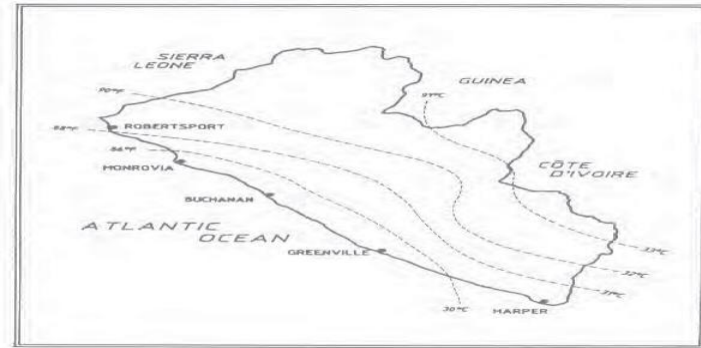
7.9.7 Temperature and Sunshine

The Atlantic Ocean has an additional ameliorating effect on the temperature along the coast with maximum annual and daily variations. Generally, temperature remains warm throughout the county and there is little change between seasons. The temperature over the country ranges from 27-32°C during the day and from 21-24°C at night (**Figure 7.4** and **Figure 7.5**). The average annual temperature along the coast ranges from 24-30°C. In the interior it is between 27-32°C. The highest temperature occurs between January and March and the lowest is between August and September.

The sun is overhead at noon throughout the year, giving rise to intense solar radiation in all parts of the country, thus resulting in high temperatures with little monthly variations.⁸ Temperature would be much higher without cloud cover, winds, humidity and rainfall, which are influenced

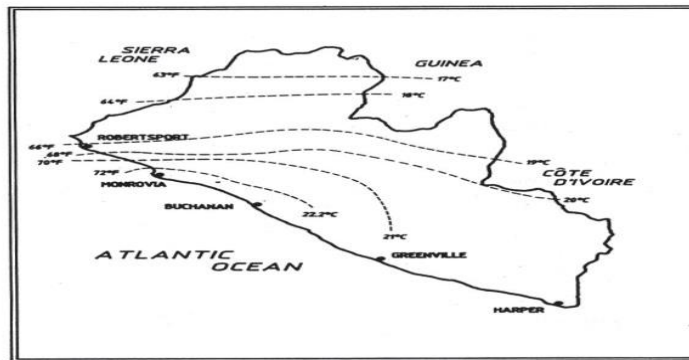
by the vegetation cover of the country. The days with longest hours of sunshine fall between December and March. Daily sunshine hours are at a minimum during July, August and September.

Figure 7.4: Isotherms of Yearly Average Maximum Temperatures in Liberia



Source: Ssentongo, 1988. Marine Fishery Resources of Liberia: a Review of Exploited Fish Stocks.

Figure 7.5: Isotherms of Yearly Average Minimum Temperature in Liberia



Source: Ssentongo, 1988. Marine Fishery Resources of Liberia: a Review of Exploited Fish Stocks

7.9.8 Wind

The seasons in Liberia mainly result from the movement of two air masses:

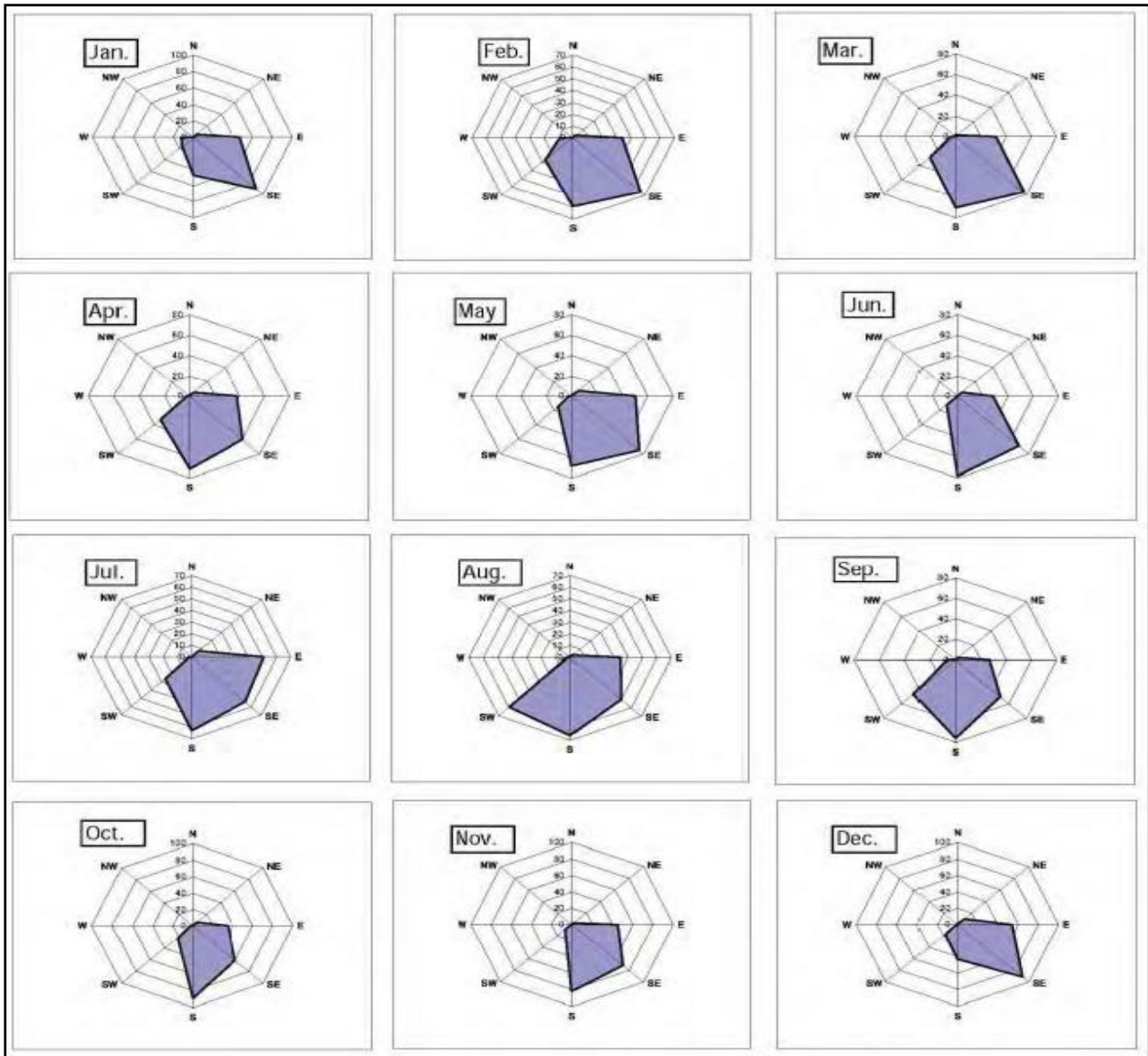
1. The Inter-Tropical Convergence Zone from the northern hemisphere, and
2. Cool air masses over the South Atlantic Ocean from the southern hemisphere.

Pressure shifts between the air masses force the dry continental air mass and the moist southequatorial maritime air mass to replace each other every six months.⁹

7.9.8.1 Wind Direction (Robertsfield, 2000-2006)

Monthly mean wind direction shows southeast as the dominant direction and south as the second dominant direction (**Figure 7.6**).

Figure 7.6: Monthly Frequency of Wind Direction at Harper in 2000-2006



Source: JICA, 2009, The Master Plan Study on Urban Facilities Restoration and Improvement in Monrovia. The Republic of Liberia.

7.9.8.2 Wind Speed (Robertsfield, 2000-2006)

Monthly mean wind speed shows maximum 10.3 km/hrs in August, minimum 7.1 km/hrs in January and average 9.3 km/hrs.¹¹ Total wind speed is greatest in the rainy season and lowest in the dry season, being lower in the interior, where high vegetation cover serves as a windbreak. Along the coast, the average annual wind speed is 30 km/h.¹²

7.9.8.3 Offshore Winds

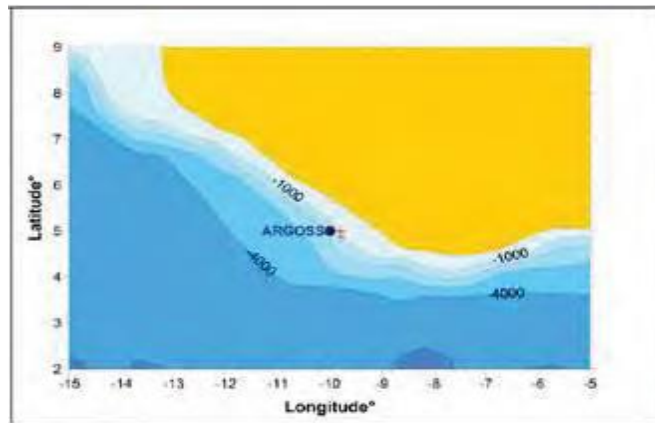
The ARGOSS Hindcast Wave model provides long term (18 year) wind data frequency distributions of wind speed by month and direction for specific points worldwide. **Figure 7.7** identifies the model grid point used to investigate winds offshore Liberia. **Figure 7.8** provides summary statistics of winds at the site of interest.

7.9.9 Relative Humidity

Relative humidity is generally high throughout the year. A relative humidity of 90 percent to 100 percent is common during the rainy season. During the dry season it decreases to as low as 65 percent. Along the coast it does not drop below 80 percent and on the average is above 90 percent. There is a wider variation in the interior and may fall below 20 percent during the Harmattan period, a dry and dusty West African trade wind that blows south from the Sahara into the Gulf of Guinea between the end of November and the middle of March.

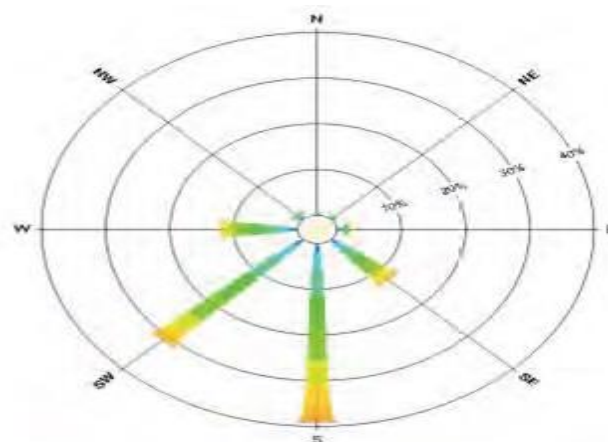
In Monrovia, the relative humidity shows a relationship with the existing air temperature and its variation depends on the prevailing season and the hour of the day. During the dry season I decreases to 80-85 percent. In January and February, the driest period of the year, relative air humidity may be as low as 65 percent. Regardless of the season, the relative humidity at night and in the early morning is usually in the range of 90-100 percent. Data from other weather stations such as Bomi Hills, Harbel and Greenville show similar results. Only the zone north of the Inter-Tropical Convergence Zone, where the continental air masses prevail from mid- December to the end of January, exhibits arid conditions. At times, due to the extreme dryness of the Harmattan, the humidity may drop to below 50 percent.¹⁵

Figure 7.7: Location of ARGOSS Model Grid Point Used



Source: PhysE, 2010

Figure 7.8: Rose Plot– Wind Speed vs. Direction at the Site of Interest



7.10 Geological Setting

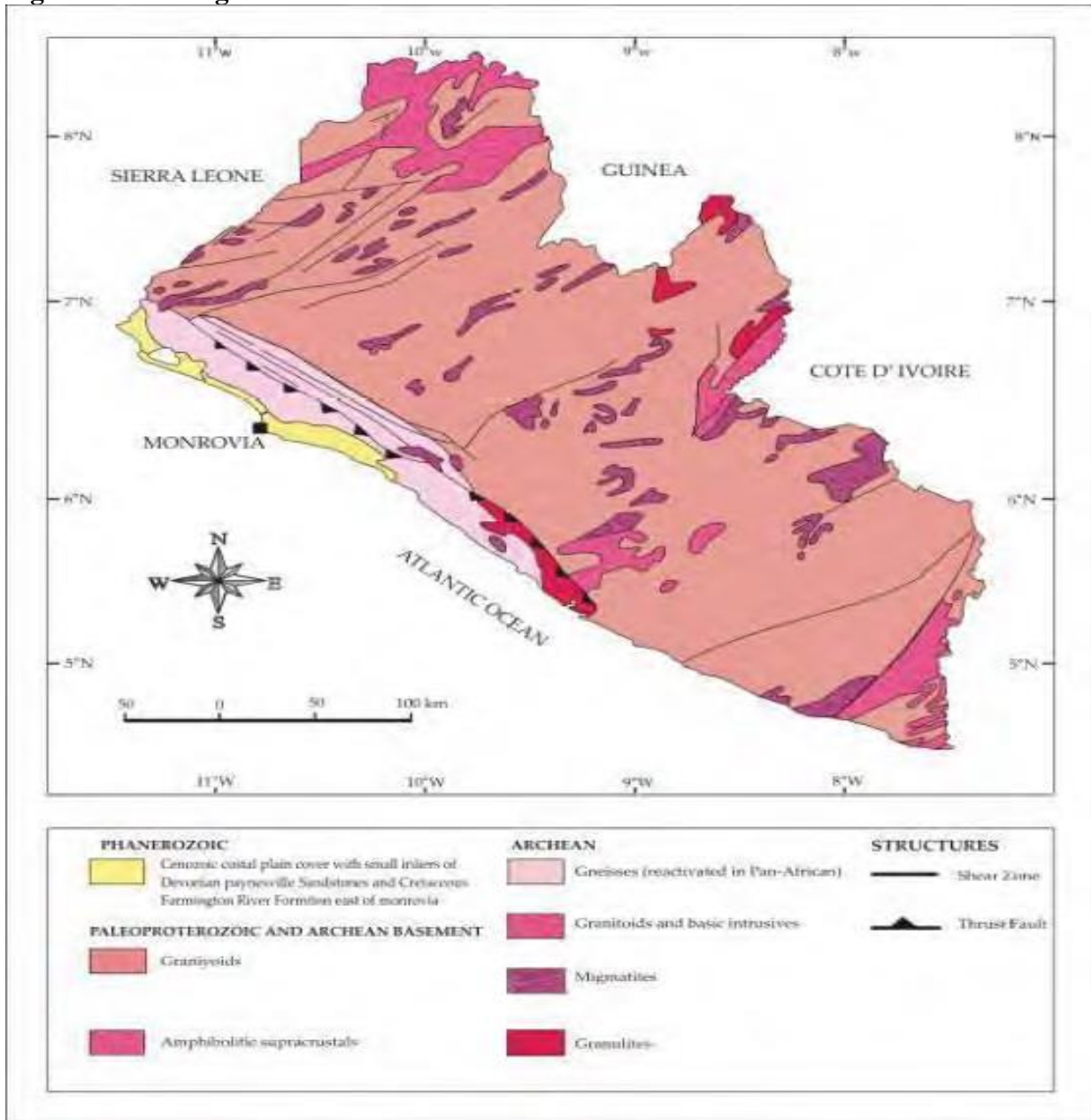
7.10.1 Stratigraphy

Liberia is underlain by the Guinean Shield of West Africa and is composed mainly of Precambrian igneous and metamorphic rocks. Other rocks occur locally and are mainly Paleozoic sandstone, Jurassic diabase dikes, Cretaceous sandstones and Quaternary unconsolidated deposits. Rocky outcrops are sparse in Liberia owing to tropical weathering that has produced a thick laterite and saprolite cover, which supports a dense rainforest. The rocks forming this crystalline shield consist of an older series of granulitic and migmatitic gneisses and amphibolites with subordinate granitoids. Remnants of slightly younger supercrustal rocks of sedimentary and volcanic origin are aligned predominantly in a SW-NE direction. Phanerozoic sediments are only exposed along a narrow coastal strip.

Approximately 90 percent of Liberia is underlain by Archean and Paleoproterozoic granitic rocks (**Figure 7.9**). Two small outliers of classic sedimentary rocks, the Precambrian Gibi Mountain Formation, form heavily forested hills 32 km northeast of the Todi Shear Zone. They lie on Archean gneisses and are overlain by klippen of Precambrian itabirite-bearing quartzite.

Isolated diabase or gabbro dikes (400-180 million years ago) are intrusive to the Precambrian rocks. Unmetamorphosed laminated sandstones, arkoses, siltstones and conglomerates of possible Cretaceous age occur in a narrow section (<5 km) along the coast.

Figure 7.9: Geological Overview of Liberia



Source: Thorman and Tysdal, 1983 (modified).

7.10.2 Structure

The structure of the crystalline basement that underlies most of Liberia is complex, and involves faults, folds, intrusive dikes and mylonite zones.^{16 17 18 19 20 21 22 23}

Two onshore sedimentary depocenters are defined by negative gravity anomalies in the Cretaceous Farmington River Formation, which overlies a tabular body of Devonian Paynesville Sandstone. The Roberts Basin depocenter occurs about 50 km east of Monrovia and that of the Bassa Basin is about 25 km northwest of Buchanan. Both basins are bordered landward by high-

angle faults. A gravity model profile across the Roberts Basin shows the Cretaceous strata to be as much as 1.5 km thick and the underlying Devonian strata to be about 1 km thick.^{25 26}

Holocene uplift of a few meters has permitted preservation of unconsolidated quartz sand both in beach ridges along the coast and beneath savannahs, which are as much as 15 km wide, behind the ridges. Anomalies on the radiometric maps of the coastal area mark the positions of zircon and monazite in heavy-mineral concentrations in lenses of the beach ridges.²⁷

7.11 Surface Hydrology

7.11.1 Rivers

Liberia has six major rivers that generally flow in a northeast-southwest direction. They include: Mano, Lofa, St. John, Cestos, Cavalla and St. Paul (**Table 7.4** and **Figure 7.10**).

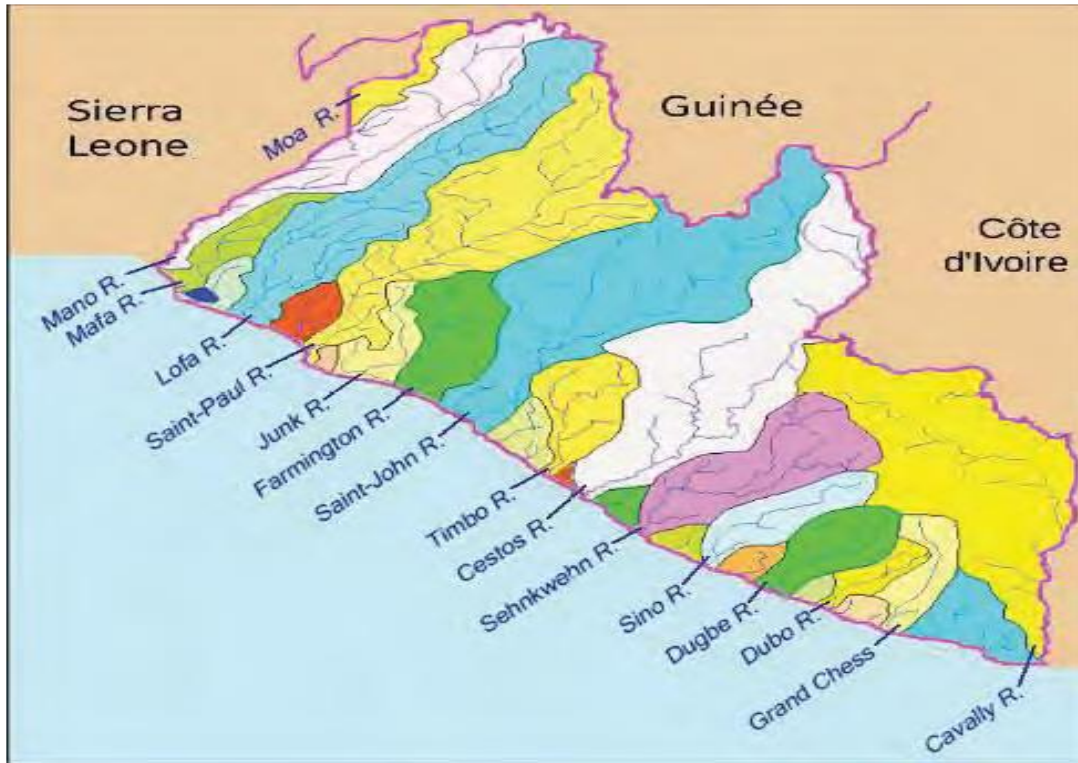
The hydrological system is influenced by the geological structure and relief slope. The system generally follows the direction of the mountain ranges from northeast to southwest perpendicular to the coast, with the exception of the Cavalla and its tributary, the Duobe which flow for some distance due east before they ultimately turn to the sea. The other rivers are roughly parallel to each other and spaced at fairly regular intervals across the county. The six rivers are not navigable, and therefore do not support water transport or industrial fishing. Many rocks, waterfalls, rapids and sandbanks reduce navigation of these rivers; bedrock frequently outcrops in the riverbeds. Valleys and flood plains are not well developed, the gradients are fairly steep and irregular, and the basins are mostly narrow.

Figure 7.4: Rose Plot– Wind Speed vs. Direction at the Site of Interest

Basin	Area (Km ²)	Annual Flow (m ³ /sec)	Sediment Load (metric ton/annual)	Highest Elevation (m above seal level)
Mano	6,604	251	580	750
St. Paul	12,820	512.3	1,920	N/A
St. John	14,726	N/A	15,108	1,000
Cavalla	13,726	380	988	1,500
Cestos	10,000	60.3	850	1,500
Lofa	9,194	N/A	11,200	1,200

Source: Liberian Hydrogeological Service. 1988. Rainfall Data Book of Liberia from Inception to 1981.

Figure 7.10: Liberian Watersheds



Source: Food and Agriculture Organization of the United Nations Environment Program. 2011.28

Closer to the coast, river grades diminish and tidal currents prevent river outflow from removing sand bars and accumulations. However, most streams overflow their banks regularly, and during the rainy seasons there is often severe flooding along the coastal plains. The six major rivers in Liberia drain approximately 80 percent of the country, with headwaters of the major river basins originating in Guinea. Small coastal water courses drain about 20 percent of the country and include, but are not limited to, the Po, Du, Timbo, Mesurado, Farmington, Seinken and Sinoe Rivers.

Seasonal precipitation causes considerable fluctuations of the river levels. All main rivers have significant flow year round. However, the upper courses are usually shallow because of the fast run-off, especially during the dry season.

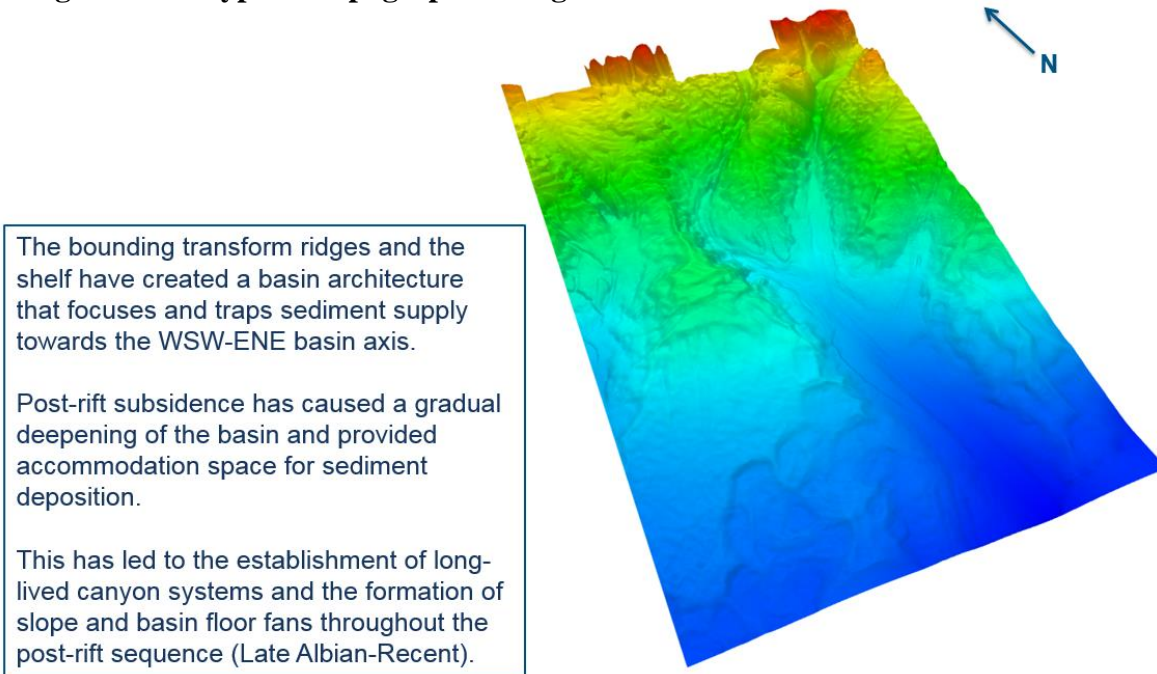
7.11.2 Lakes

There are only two major lakes in Liberia: Lake Piso in Grand Cape Mount County in the north and Lake Shepherd in Harper, Maryland County in the south. Both are proposed protected areas.²⁹ Lake Piso is the larger of the two, and both are located along the coast. Lake Piso is characterized by a vast expanse of wetlands and lowland forest vegetation. It is located in Robertsport (Grand Cape Mount County) approximately 60 km from Monrovia.

7.12 Coastal Topography

The coastline of Liberia is approximately 579 km long. The continental shelf of approximately 18,400 km² is relatively wider between Grand Kru and Maryland compared to the western (Monrovia to Grand Cape Mount). In the northwest the continental slope starts at 300 m depth, whereas it starts at 100–120 m in the southeast. Beyond this depth the sea floor has canyons and rocky outbreaks. Topographic images of the Blocks are shown in **Figure 7.11**.

Figure 7.11: Typical Topographic Image of the Sea Floor



Source: Harper Basin Prospectively: from regional 2D to 3D seismic

7.12.1 Oceanography

The oceanography of Liberia is influenced by the surface wind system of the equatorial zone. Three zone systems can be recognized in the inter-tropical region: a central doldrum zone with some clouds, precipitation, light wind and low atmospheric pressure corresponding to the heat equator; a zone of the northeast trade winds free of cloud and rain, also known as the Harmattan; and a zone of the southeast trade winds (with more clouds and rain) which gives rise to the southwest onshore monsoon north of the equator.

7.12.2 Temperature and Salinity Factors

The coast of Liberia, like that of Guinea and Sierra Leone, is characterized by high temperatures, high humidity, and heavy rains. Liberian waters are characterized by a hydrographic system that

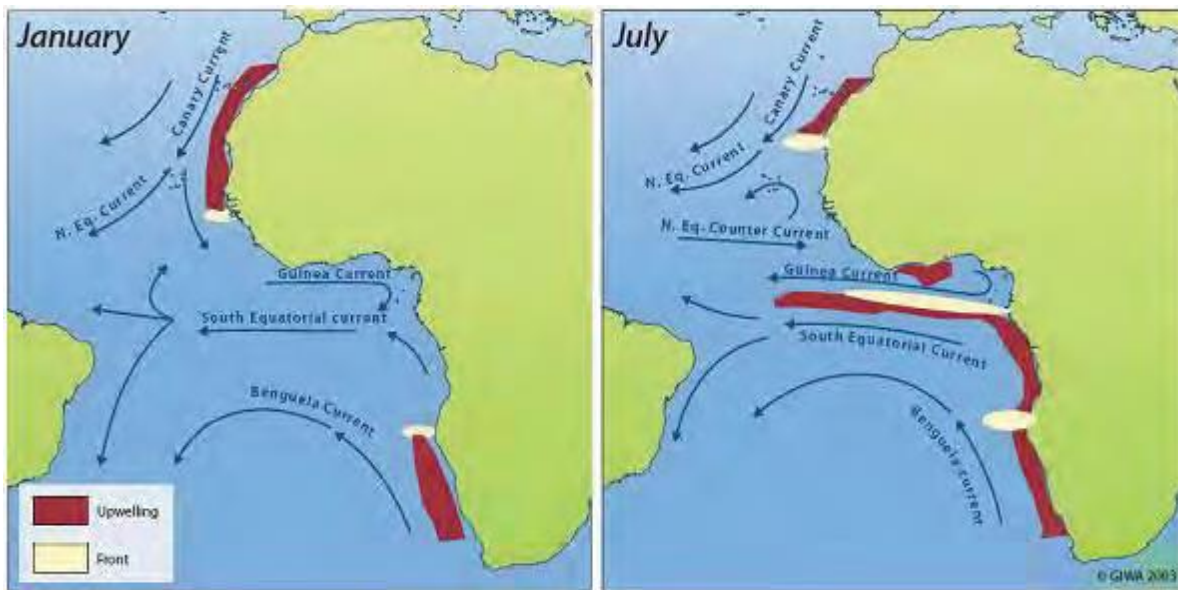
accounts for a relatively stable, shallow thermocline lying at mid-shelf. The average depth of the thermocline is between 20 and 35 m depth in most areas of West Africa.³⁴ As a consequence, there is lack of renewal of water, low productivity and dominance of river influence as opposed to upwelling. The Liberian surface waters are uniformly warm (26-28°C) and of low salinity.³⁵

The relatively low salinity, mostly less than 32 parts per thousand³⁶, is due to heavy rainfall and high river discharge. In Liberia, the highest river discharge occurs during the period June-November which is also the rainy season. There is seasonal oscillation of the thermocline and nutrients according to the oscillation of the equatorial undercurrent.

These temperature salinity profiles support the existence of a separate surface current (the eastern moving Guinea Current) signified by a pronounced step in salinity and temperature at approximately 50m below the sea surface.

7.12.3 Currents and Waves

Figure 7.12: Waters offshore Liberia are primarily influenced by the Guinea current.³⁸



Source: Abe, J., Wellens-Mensah, J., Diallo, O. S. and C. Mbuyil Wa Mpoyi. 2003. Global International Waters Assessment Guinea Current, GIWA Regional Assessment 42. University of Kalmar on behalf of United Nations Environment Programme

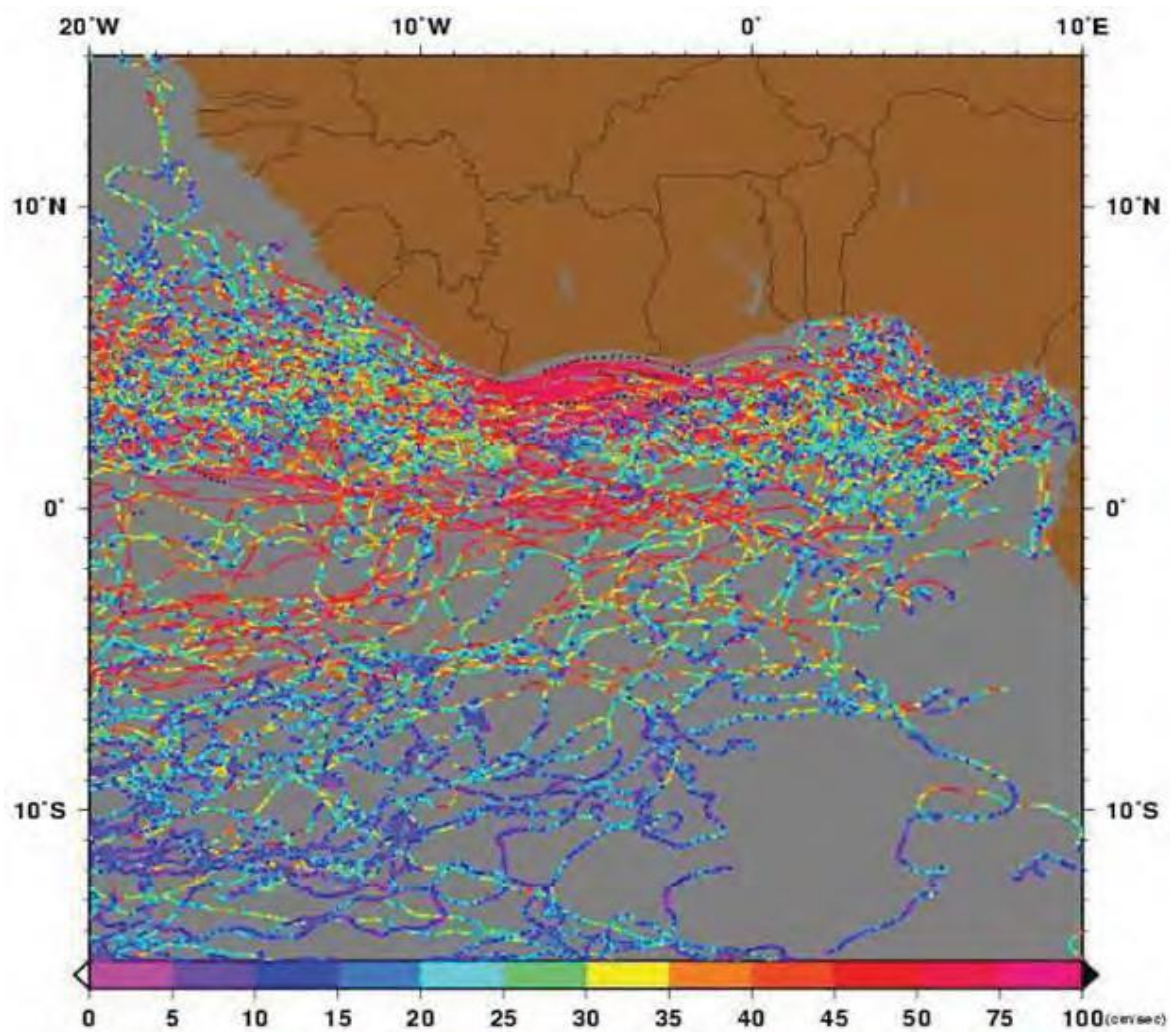
7.12.4 The Guinea Current

The Guinea Current flows along the western coast of Africa at approximately 3°N.³⁹ At peak speed, it can obtain velocities close to 100 cm s⁻¹.⁴⁰ It has at least two sources: the North Equatorial Countercurrent (NECC) and the Canary Current (CC). The seasonal instability of these

two currents can affect the seasonal variability of the Guinea Current.^{41 42} The Guinea Current experiences a minimum during the winter (November through February) and a maximum during the summer (May through September).

Current speeds shown in **Figure 7.13** are color-coded from low speeds in purples and dark blues to measure buoy speeds of over 100 cm/s in black. Major currents are visible in these plots with concentrated "ribbons" of red, pink, and black. Also note that in the ocean interior, the predominant speed is 5-15 cm/s, and that in the more energetic eddy regions near the major currents, the predominant speed is from 20-40 cm/s.

Figure 7.13: Trajectories (cm/s) of NOAA Drifting Buoys (1978-2003)



Source: Joanna Gyory, Barbie Bischof, Arthur J. Mariano, Edward H. Ryan. 2005. "The Guinea Current" Ocean Surface Currents. Retrieved from the University of Miami Website November 5, 2010
<http://oceancurrents.rsmas.miami.edu/atlantic/guinea.html>

The Guinea Current is characterized by areas of upwelling⁴⁴ and increased biological productivity.⁴⁵ The Guinea Undercurrent (also referred to as the Ivorian Undercurrent) flows to the west.

7.12.5 Guinea Undercurrent

Most available models and analysis focus on current speeds in the surface layer, however NODC records for two mooring locations offshore Liberia indicate the presences of a westerly undercurrent at the site of interest. Extrapolating the measured current meter series the 1 year current speed is approximately 25 cm/s and flow is predominantly westerly, aligning north westerly along the coast.⁴⁶

7.12.6 Waves

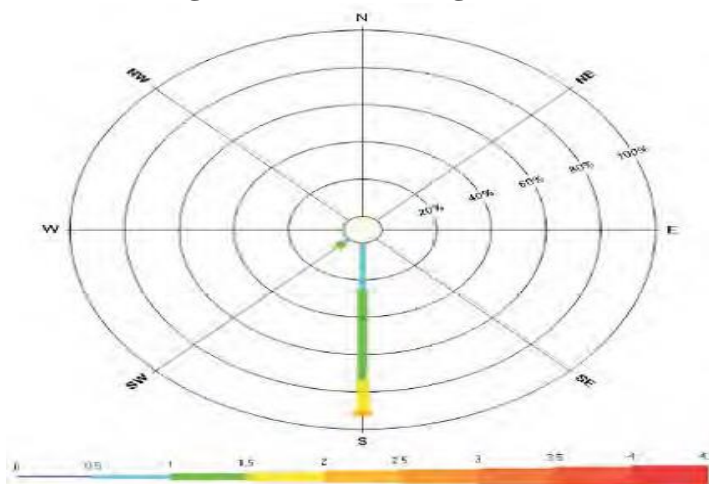
Wave height ranges generally between 0.5 and 2 m often coming from the south, sometimes from the south west. Seasonal distribution of the mean wave height shows that waves are higher in summer times. Swell waves most frequently occur from the south and are more pronounced during the summer. Swell heights reach 3.5 to 6m in the winter and the same in the summer.⁴⁷ **Table 7.4 and Figure 7.14** provide summary statistics of wave frequency and direction based on ARGOS Wave modeling data for a location close to the Blocks (*See Figure 7.7*).⁴⁸

Table 7.4: 2D Frequency Distribution – Significant Wave Height (Whole Sea) vs Month

		Month													
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	
Significant Wave Height (m) Total Sea	lower	upper	0	0	0	0	0	0	0	0	0	0	0	0	0
	4	4.5	0	0	0	0	0	0	9	10	0	0	0	19	
	3.5	4	0	0	0	0	0	0	9	10	0	0	0	19	
	3	3.5	0	0	0	10	0	18	27	17	3	0	0	75	
	2.5	3	0	5	12	14	24	88	208	186	83	21	3	644	
	2	2.5	26	38	104	108	236	515	698	1139	591	166	91	12	3724
	1.5	2	203	246	494	818	1689	2118	2425	2001	1853	1262	536	169	13614
	1	1.5	2307	2260	2922	2982	2350	1527	1087	1054	1734	2781	2918	2650	26572
	0.5	1	1915	1523	932	388	165	54	10	57	56	234	769	1620	7723
0	0.5	13	0	0	0	0	0	0	0	0	0	3	13	29	
Total		4464	4072	4464	4320	4464	4320	4464	4464	4320	4464	4320	4464	52600	

Source: Physe, 201049

Figure 7.14: 2D Rose Plot – Significant Wave Height (Whole Sea) vs. Direction (FROM)



7.12.7 Coastal and Marine Ecosystems

The coastal zone of Liberia has enormous resources that are both biologically and socioeconomically significant. The forest resources of Liberia's tropical coast provide an important source of fuel woods, medicinal plants, food, and construction materials for coastal inhabitants. The coastal area consists of swamp-related vegetation, which includes mangrove forests and savannah that extends 40 km inland. The mangrove species prevalent along the coast provide the nutritional inputs to adjacent shallow lagoons and lakes that constitute the primary habitat, spawning and breeding grounds for many aquatic species of commercial importance.

The continental shelf and territorial sea produced between 10,300 and 11,700 tonnes per year from 2000 to 2004.⁵⁰ The marine ecosystem plays a significant ecological role, exerting influence over local processes such as the absorption of atmospheric carbon dioxide.

The coastal ecosystem in Liberia also provides many economic benefits to society by supporting industries ranging from fisheries to sustainable tourism. The coastal area and marine environments are subjected to a variety of pressures, including erosion due to sand mining, anthropogenic pollution, oil pollution, human settlement and lack of an integrated coastal zone management program. Intensive fishing, shipping, land-based pollution and development, the increasing human population and the introduction of aquatic alien species all have had an impact on the coastal and marine ecosystems in Liberia.⁵¹

The overall marine and coastal database is limited in Liberia. The coastal ecosystem consists of swamp related vegetation (wetlands) which includes mangrove forest and savannah along with sandy beaches. There is little published information about the presence of coral reefs or seagrass beds in West Africa. While no major coral reefs or sea grass beds are known, it is likely that these do occur sporadically along the coast.

7.13 Wetlands

Liberia is endowed with wetlands that provide both subsistence and economic benefits to its many inhabitants. Like wetlands all over the world, they have become over burdened by human induced activities.

Eight (8) wetlands have been identified in Liberia of which:

- 3 are coastal wetlands;
- 2 are coastal lacustrine; and
- 3 are inland riverine wetlands

The coastal wetlands (Marshall, Mesurado and Lake Piso) are relatively flat with transition between coastal sandy soil extending 12-16 km (8-10 miles) inland and sandy loam or lateritic soil inland beyond this point.⁵² These wetlands are characterized by the presence of lakes, ponds, lagoons, rivers and creeks, together comprising the scenic beauty of the locales. Generally, the altitude of these areas varies between 0-320m above sea level⁵³

Key characteristics of the ecosystem and vegetation of the coastal wetlands (Mesurado, Marshall and Lake Piso) include:54

- Humid forest containing representatives of many flora and fauna species of Liberia
- Mangrove forests
- Sea coast
- Savannah woodland (in the Lake Piso and Marshall Wetland regions)

All three of these coastal wetlands are dominated by mangrove vegetation and a well-developed hydrological system generally consisting of rivers, creeks and ponds.

The national environmental policy of Liberia explains that the importance of wetlands is not fully understood, and that wetlands are threatened with degradation due to factors such as: pressure from fire wood gatherers and charcoal producers, uncontrolled solid and liquid wastes, unregulated settlements near wetlands, agriculture production and industrial expansion and other constructions. Some strategic actions recommended by the National Environmental Policy (2003) include:

- Establishment of full protection status for wetlands of biodiversity significance
- Development of wetlands policy and management plans
- Inventory of wetlands

Part VI, sections 74 and 75 of the Environment Protection and Management Law of Liberia deal with management and protection of wetlands. The Law provides for a penalty of US\$5,000.00 (five thousand United State Dollars) or imprisonment for a period not exceeding two years for violators.

7.13.1 Mangroves

The coastal wetlands of Liberia are dominated by mangroves that cover a large area along the coast from Cape Mount to Cape Palmus.

Mangroves are one of the world's richest ecosystems. They form vital coastal ecosystems by providing habitat for fish, invertebrates and epiphytic plants, and are considered more efficient photo synthesizers than most plants. Mangrove forests also provide:

- Spawning grounds for fish species, crabs, shrimps, mollusks and other forms of sea life;
- Habitats for many endangered species of manatees, crocodiles, turtles, migratory birds;
- Flood regulation and protection from violent storms;
- Protection of shore line from erosion; and
- Water recharge and water quality improvement

7.13.2 Coastal Wetlands with no Conservational Approaches

As described earlier, the majority of the wetland areas in Liberia have conservation status as proposed natural reserves or are classified as wetlands of international importance under the

RAMSAR Convention. Only two of the eight wetlands of Liberia have no conservation status. These are the coastal wetlands of Bafu Bay and the Lake Shepherd wetlands.⁵⁶

7.13.3 Bafu Bay Wetlands

Bafu Bay is located in the southeast and is situated along the Bafu River in Sinoe County. Beach sediment deposits are mainly of unconsolidated deposits of white quartz. Lagoon sediment deposits include silt sand and clay. These deposits are derived from the sea via tides and become trapped in the mangrove swamps. The Bafu bay wetland is one of the few places along the coast adjacent to evergreen forest in Liberia. It has great potential for tourism. The major human activity in this area is fishing.

7.13.4 Lake Shepherd Wetlands

Lake Shepherd is located in Maryland County in the southeast. It is approximately 7 km long and less than 1 km wide. It is often described as a long and narrow lagoon parallel to the coast. The coastal area is characterized by narrow sandy beaches separated by rocky promontories backed by broad rolling savannahs. Beach sand deposits obscure much of the underlying rocks in the area.

7.13.5 Coastal Savannah

The coastal savannah consists of low grasses with scattered low trees. It also contains palm and coconut trees along with mangrove and *Raphia* palms.⁵⁷ Coastal savannah is mostly found in southeastern Liberia, from Rivercess to Maryland counties, and more pronounced in Grand Kru County.⁵⁸

7.13.6 Beaches

About 90 percent of the Liberian coastline consists of a narrow sand beach 20-25 meters wide, reaching 60-80 meters in some parts of southeastern Liberia. During the dry season (early November to the end of April) beaches from Robertsport to Cape Palmas are widely used by beach goers, live bands and other local tourism activities. International tourism is minimal, yet growing.⁵⁹

Sea turtles are reported to nest along the beaches in Liberia, but no mass nesting sites were identified. The sandy beaches are often fringed by coconut plantations and in some areas by thorny thick shrubs. They face major threats due to erosion, sand mining and waste dumping.

7.13.7 Seagrass Beds

There is almost no information on the occurrence, location, densities and species composition of seagrass in West Africa in general, and in Liberia in particular. It is likely that seagrass beds are found sporadically in Liberia in the intertidal and near shore waters. No large seagrass

concentrations were identified⁶¹. In West Africa, only one species, *Halodule Wrightii* has been recorded.⁶²

7.13.8 Coral Reefs

Coral reefs constitute one of the world's most valuable ecosystems due to their high productivity, rich fishery, habitat value and support of biodiversity (comparable to tropical rainforests).⁶⁴ Such communities develop best in clear, tropical waters, particularly around islands and shallow areas located far from shoreline discharges, at depths of less than 50m. This is due primarily to upwelling and strong cold coastal currents that reduce water temperatures in these areas and a predominance of sand, silt and shells in the bottom deposits.⁶⁵

Coral reefs are rare along Africa's west coast and there is little literature available on the abundance and composition of coral reef communities present in Liberia. However, two oculind corals, *Schizoculina africana* and *S. fissipara*, are endemic to the region and are adapted to Guinean waters and very low salinities.⁶⁶ Colonial shallow water dendrophyllids are among the most abundant corals in West Africa, covering vertical rocky surfaces. Their taxonomy is still confused and it not clear how many species are restricted to the area. The genus *Astrangia* is well represented. *Millepora* and hermatypic corals are found mainly around the islands where some of them are endemic, and the more tolerant species also occur in low salinity mainland littoral waters. *Madracis pharensis* seems to be abundant everywhere in the tropical and subtropical Atlantic. The taxonomy of *Siderastrea* still needs clarification. *S. Sidera*, a form similar to *S. Stellato*, and *S. Radians* are found in the islands of the Gulf of Guinea. There are three species of *Porites*: *P. Astreoides*, *P. Porites* and *P. Bernardi*. *P. Bernardi* is endemic to West Africa and is found from Liberia to Gabon.

7.14 Coastal and Marine Protected Areas

7.14.1 Ramsar Wetlands of International Importance

As mentioned earlier, there are five designated Ramsar Wetlands of International Importance in Liberia. Three of these are located on or adjacent to the coastline.

7.14.2 Lake Piso Wetlands

The largest inlet on the Liberian coast, situated in Robertsport, Grand Cape Mount County, Lake Piso is characterized by a vast expanse of wetlands and lowland forest vegetation. The area is surrounded by forested hillsides (including one of the rarest tropical rainforests in the region) and fed by a number of creeks and rivers that drain a series of swamps above the lagoon, the lower ones of which are tidal and support mangroves. Additional mangrove swamps occur behind the dune ridge on the west side of the lake mouth and at creek mouths. A series of small lakes with swampy margins occurs on the sandy forested spit that separates the lake from the sea. Some 38

communities, totaling about 7,000 people, depend on Piso for transportation, commercial and non-commercial fishing, and sand for construction. Farm-to-market infrastructure was well-developed prior to the civil war. The site is important both as a nursery and spawning ground for fish and sea turtles and as feeding and roosting places for large numbers of shore and sea birds. Mammals such as antelopes, duikers, monkeys, and bushbucks, along with crocodiles are found in the area.

7.14.3 Mesurado Wetlands

Located in the capital city Monrovia, Montserrado County, the Mesurado Wetlands (6,760 ha) is important for the protection of three mangrove species (*Rhizophora harrisonii*, *R. mangle* and *Avicennia africana*), which are threatened by intense charcoal burning and fuel wood collection. It provides a favorable habitat and feeding ground for several species of birds including the African spoonbill (*Platalea alba*), common pratincole (*Glareola pratincola*) and Eurasian curlew (*Numenius arquata*). It also hosts the vulnerable African dwarf crocodile (*Osteolaemus tetraspis*), the Nile crocodile (*Crocodylus niloticus*) and the African sharp-nosed crocodile (*Crocodylus cataphractus*) and plays an important role in shoreline stabilization and sediment trapping. The wetlands are currently threatened by: deforestation for fuel wood and charcoal collection, solid waste disposal, unregulated fishing, industrial pollution including from an oil refinery and paint factories. No management plan currently exists, but there are plans to put it under a protected area management.

7.14.4 Marshall Wetlands

Located in Margibi County, the Marshall Wetlands (12,168 ha) comprise three small rivers and their surrounding mangroves and forests. The area has sandy and rocky shores along the coast and the inflowing streams are surrounded by mangrove forests. Vegetation found further inland is characterized by secondary forests and savannah woodland. The wetland is chiefly a mangrove type with mature trees reaching up to 30m. In addition to the Red Colobus monkey, a number of bird species listed by the Convention on Migratory Species appear in the area, such as the glossy ibis (*Plegadis falcinellus*), lesser kestrel (*Falco naumanni*) and common pratincole (*Glareola pratincola*). The wetlands provide control against flooding, provides ground water recharge and is a sediment trap. The very large stands of mangroves, fish population and wildlife are valuable resources for inhabitants in the area. The three rivers are navigable and are used for transport from one village to another. Research on chimpanzees for human vaccines against hepatitis A, B and C is also being carried out at the wetlands, with the animals released on islets in the mangroves afterwards.

7.14.5 Nationally Protected Areas

Nationally protected areas of Liberia are shown in **Figure 7.15**. There are currently no coastal or marine protected areas; however, two coastal sites have been proposed as national parks: Cestos-Senkwehn and Cape Mount Nature Reserve.



7.14.6 Cestos-Senkwehn

This coastal site lies on the coast between the towns of Buchanan to the north-west and Greenville to the south-east (along the coasts of Sinoe and Rivercess counties) and stretches inland northwards from the coast approximately 70 km. It includes part of the lower reaches of the scenic Cestos and Senkwen rivers, as well as the estuary of the latter. Part of the coastal site overlaps the Krahn Bassa National Forest.

The site comprises evergreen lowland rainforest, 1,200 ha of mangroves and undisturbed coastal vegetation including some of the last examples of littoral forest in West Africa. It is believed to be home to substantial numbers of the endangered pygmy hippopotamus (*Choeropsis liberiensis*).⁶⁸ The objectives of designating this site a national park include:⁶⁹

- Protection of a primary forest area with a representative fauna;
- Protection of the sensitive Cestos River;
- Protection of the biological transitions between inland and littoral forests and the coast.

Deforestation, a large influx of people and associated development of settlements, and agriculture threaten the conservation value of the coast.⁷⁰ Due to intense logging and subsistence agricultural activities in this area, its conservation value has been seriously undermined and the possible boundaries of a biosphere reserve are being reconsidered.⁷¹

7.14.7 Cape Mount Nature Reserve

The proposed Cape Mount Nature Reserve (48,593 ha) lies northwest of Monrovia. It includes a spit of land which separates Lake Piso from the Atlantic. The town of Robertsport lies at the tip of this spit. The site includes part of the lagoon, mangroves, rocky and sandy shorelines together with a small area of lowland forest.⁷² Biodiversity richness includes migratory bird species, sea turtles, hippos, manatees, primates, fish species and medicinal plants, plus a wide variety of habitats and ecosystems such as coastal, marine, forest, mangrove, brackish water, island, and freshwater habitats. Opportunities for conservation are based on the very unique marine biodiversity, the presence of mangroves as a breeding ground for marine species, the existence of baseline data for establishing a protected area, and a potential for funding from tourism, research and fishery sectors.⁷³ Lake Piso has also been designated as a Ramsar site.

The main threats are mangrove deforestation, unregulated fishing, hunting, farming, settlements on hills, port development, and sand mining.⁷⁴

7.14.8 Key Biodiversity Conservation Areas

In addition to national protection, Liberia remains an international priority area for conservation. For example, in December 1999 the Global Environmental facility (GEF) funded the West African Conservation priority-setting exercise for the Upper Guinea Ecosystem. The project identified Liberia as a top priority country in West Africa for conservation purposes since 41 percent of its area is designated as being of exceptionally high biological importance. In September 2002, the West African chimpanzee conservation identified the southeastern Liberia forest block as one of the highest or top priority rainforest sites for chimpanzees.

7.14.9 Coastal and Marine Protected Areas of Cote d'Ivoire

As described in Chapter 2, operating companies may have to use the Port of Takoradi, Ghana as its supply base. This will involve transportation of supply vessels between Liberia and western Ghana. While the focus of this baseline remains the Liberian coast adjacent to the Blocks, it is important to note that the Cote d'Ivoire and Ghana coasts could be affected in the event of an emergency (i.e. supply boat collision or large oil spill). Protected areas on the Cote d'Ivoire coast include (from east to west):

- Monogaga Forest
- Complex Sassandra – Dagbego (RAMSAR Wetland)
- Dassieko Forest
- Fresco (RAMSAR Wetland)
- Port Gautier Forest
- Azagny National Park (RAMSAR Wetland)
- Grand Bassam (RAMSAR Wetland)
- N’Ganda (RAMSAR Wetland)
- Illes Ehotile National Park (RAMSAR Wetland)

There are no coastal protected areas in Ghana between Cote d'Ivoire and Takoradi, Ghana.

7.15 Coastal and Marine Biodiversity

7.15.1 Overview

Information about coastal and marine biodiversity in Liberia is very scarce. Minimal coastal and/or marine biodiversity studies have been conducted recently, and few are publically available. FishBase (www.fishbase.org) and SeaLifeBase (www.sealifebase.org) globaldatabases exhibit lists of fish species and other marine organisms of Liberia, however these need field validation. Fishbase describes 464 species of marine fish for Liberia. SeaLifeBase lists some 42 crustaceans and 33 mollusks (mostly cephalopods).

7.15.2 Coastal and Marine Flora

Description of the marine phytoplankton communities is absent for Liberia. In addition, seagrass existence is not verified.

Along the southeastern coast of Liberia, chlorophyll concentration, indicator of phytoplankton abundance, reaches a maximum on the inshore side of the continental shelf. Primary production ranges from approximately 0.98mg/m³ to 1.3mg/m³ depending on the season.⁷⁶

As mentioned previously, mangrove forests dominate the length of the coast of Liberia. Also common in the coastal zones are palm trees, raffia palm, mango and other fruit trees and ornamental plants.⁷⁷

7.15.3 Mangrove Species

The most common mangrove species in Liberia is *Rhizophora racemosa*, but six (6) other species occur in the country. Mangrove species such as *Rhizophora harrisonii*, *Rhizophora mangle* and *Avicennia africana* occur together with impressive tracts of Pandanus. Lagoon mangroves around Cape Palmas in south-eastern Liberia are dominated by *Conocarpus erectus* with only rare specimens of *Avicennia germinans* and *Rhizophora racemosa*.⁷⁸ Near Buchanan on the central Liberian coast, estuarine mangroves occur consisting of stunted *Rhizophora harrisonii*, *Avicennia germinans* and *Conocarpus*.⁷⁹ *Rhizophora harrisonii*, *R. mangle* and *Avicennia africana* characterize the Mesurado, Marshall and Lake Piso Wetlands.

7.15.4 Fish

In 1988, the FAO published a report about the exploited fish stock in Liberia⁸⁰ in which the author described the Liberian fish communities based on reports of surveys conducted previously by Russian (R/V Belogorsk) and Norwegian (R/V DR. F. Nansen) vessels and in another FAO report published in 1983⁸¹. The report segregated the Liberian fish communities into eight groups based on their distribution patterns.

In 1990, a Spanish vessel conducted a trawling survey on the demersal fish of Liberia within the

Guinea 90 survey of the Eastern Central Atlantic.⁸⁴ The survey took place between 20–700 meters (m) depth using fishing gear with 45 mm mesh. Five depth strata were considered in reporting the results (20-50 m, 50-100 m, 100-200 m, 200-400 m and 400-700 m depth). Catch rate were the highest in the 50–100 m depth stratum. The most abundant catch in the first depth stratum (20-50 m) corresponded to non-commercial species, *Saurida brasiliensis* and *Serranus accraensis*. Sparids dominated between 20 m and 400 m. The dominant species at 100–200 m depth was *Dentex angolensis*. In the 50–100 m depth stratum they were important catch of “groupers”, *Epinephelus*, species of considerable commercial value to artisanal fisheries in the region. Sparids were also abundant between 200 and 400 m depth with dominance of *Antigonia capros*. In addition to Sparids, catch of Sciaenids were high in the shallow waters, the dominant species being *Brachydeuterus auritus*. Between 100 and 200 m depth, there were abundant catch of species belonging to the deep shelf community, mainly *Antigonia capros*. Beyond 200 m, the slope community dominated, with a majority of *Hypoclydonia bella* and *Centrophorus granulosus* at 400–700 m, where catches were nevertheless very small.

In 2007, a Norwegian vessel conducted another survey on the pelagic and demersal fish of Liberia.⁸⁵ The main pelagic fish species found within 300-500 m bottom depth during that survey were: *Sardinella maderensis*, *Sardinella aurita*, *Ilisha africana*, *Engraulis encrasicolus* *Chloroscombrus chrysurus*, *Decapterus punctuatus*, *Trachurus trachurus*, *Trachurus trecae* and *Selene Dorsalis*. On the other hand, the demersal fish communities found within 300 m bottom depth were dominated by species such as *Dentex congolensis*, *Dentex angolensis* (Sparids), *Umbrina canariensis* (Scianids) and families of Serranids (groupers), Haemulids (Grunts) and species of sharks and rays.

Koranteng summarizes the species assemblages as follows⁸⁷:

- The structure of species assemblages on the continental shelf in the Gulf of Guinea is mainly determined by depth and sediment type, but their dynamics are influenced by the physicochemical parameters of the water masses;
- Demersal fauna are quite similar across the entire Gulf of Guinea, but the presence of isolated patches of rocky bottoms, estuaries and lagoons produces differences in distribution and abundance of demersal fish species; and,
- Changes in structure and composition of species assemblages can occur as a result of differential reaction to seasonal environmental changes -- for example, upwelling can affect demersal species assemblages and species diversity.

7.15.5 Reptiles

Five of the seven species of turtles worldwide are found in Liberia. They are reported to either migrate through Liberian waters and/or nest on its shores. These include: leatherback (*Demochelys Coriacea*), olive ridley (*Lepitochelys olivacea*), green (*Chelonia mydas*), loggerhead (*Caretta Caretta*) and hawksbill (*Eretmochelys imbricate*) turtles.⁸⁸ IUCN lists the leatherback and hawksbill as critically endangered, the green and loggerhead turtles as endangered, and olive ridley as vulnerable.⁸⁹

Sea turtles nest on the entire coast from Sinoe to Maryland County, except in the few areas broken by rocky sections. Their abundance is higher in Picniness and Welabo Beach, Karblaken and Cavalla, and Bafu Bay (Sinoe County). The peak of the nesting period appears to be climatically influenced. The nesting season falls between late September and March with a peak in nesting occurring during November and December. This time falls within the dry season in Liberia. 90

Population sizes of turtles in Liberia are largely unknown, though the most common sea turtle nesting on the coast is the leatherback followed in abundance by the olive ridley. Green turtles and hawksbill turtles only nest sporadically⁹¹. The critically endangered hawksbill turtle has recently been observed nesting near Bafu Bay in Sinoe County and Borgor Point in Rivercess County.⁹²

Despite international initiatives to protect these endangered species, sea turtles are still secretly hunted for food throughout Liberia. Their eggs are also collected by humans, destroyed by dogs and pigs on the beaches, and are occasionally caught by artisanal fishermen in nets.

Based on surveys conducted by the Save My Future Foundation, four areas are recommended for immediate protection for the conservation of sea turtles nesting areas. They are, in the following order of priority⁹³:

- Borgor Point (Rivercess County, around the town of Rivercess)
- Grandcess (central Grand Kru County)
- Bafu Bay (Sinoe County, 20 km northwest of Greenville)
- Karblakeihn (near Harper)

7.15.6 Marine Mammals

The study area is located in the Guinea Current Large Marine Ecosystem (LME) 94. Marine mammals that inhabit the waters of the Gulf of Guinea are mainly cetaceans (whales and dolphins) and sirenians (manatees). At the end of summer, toothed whales (those belonging to the suborder Odontoceti), fin (*Balaenoptera physalus*) and humpback (*Megaptera novaeangliae*) whales migrate to the waters of the Gulf of Guinea from Antarctica.⁹⁵ ⁹⁶ Specific information on the presence and habits of marine mammals in the study area is very limited. Researched literature suggests that Marine mammals in Liberia are likely to include approximately 30 species of cetaceans and one species of sirenian (manatee). Most of these species are listed as “data deficient” or “least concern” by IUCN.

7.15.7 Birds

Terns and most importantly black terns (*Chlidonias niger*) pass through the offshore waters of Liberia mainly in the spring when food stocks are high. In addition, the tiny rocky islands of southeastern Liberia shelter many sea-birds and some colonies of land birds during the summer season. The red-eyed dove (*Streptopelia semitorquata*), the rock pratincole (*Glareola nuchalis*) and the orange weaver (*Ploceus aurantius*) are examples of these inland birds.⁹⁸ Terns prefer to rest on the sandy coastal strip. Other species of birds found are herons and waders. Nine Important Bird Areas have been identified by Birdlife International in Liberia: Cape Mount, Cestos-Senkwehn, Grebo, Lofa-Gola-Mano Complex, Nimba Mountains, Sapo National Park,

Wologizi Mountains, Wonegizi Mountains, and Zwendru. Two of these, Cape Mount and Cestos-Senkwehn, are located on the coastline. These areas provide breeding and feeding habitat for numerous waders and other sea birds listed in the Convention on Migratory Species, such as the glossy ibis (*Plegadis falcinellus*), lesser kestrel (*Falco naumanni*) and common pratincole (*Glareola pratincola*).

7.15.8 Invasive Alien Species

Invasive species are alien species that are introduced into a country either intentionally or accidentally. Once established they can spread gradually and become a threat to native biodiversity by imposing economic costs on agriculture, forestry, fisheries and other human enterprises, as well as on human health. As they spread, they can become noxious weeds killing off marine species and providing shelter and breeding environment for harmful insects and vectors of diseases. The invasive alien species found in Liberia are summarized in **Table 7.5**.

Table 7.5: Invasive Alien Species of Liberia

Species	Description
<i>Bidens pilosa</i>	Major crop weed, threat to native fauna, and a physical nuisance
<i>Chromolaena odorata</i>	A fast-growing perennial shrub that is a nuisance agricultural weed
<i>Eichhornia crassipes</i>	Water hyacinth; may choke slow moving to still water bodies and prevent beneficial use for fishing or navigation
<i>Hypnea musciformis</i>	Marine algae that forms thick, unpleasant-smelling mats
<i>Imperata cylindrica</i>	Invasive grass in tropical savannas and extremely problematic agricultural weed that establishes vast, monotypic stands that alter ecosystems and community structure
<i>Lantana camara</i>	Herb and serious agricultural weed
<i>Leucaena leucocephala</i>	Agro-forestry tree that can invade semi-natural or natural habitats which are of conservation interest
<i>Solenopsis geminata</i>	Fire ant that destroys native ant communities, harms agriculture, and is a painful pest to humans
<i>Vibrio cholerae</i>	Bacteria that causes cholera

Of these alien species, only two occur in the coastal or marine environment; the water hyacinth (*Eichhornia crassipes*) which occurs in the coastal wetlands, marshes and lagoons and marine algae (*Hypnea musciformis*).

The water hyacinth is very invasive and fast growing, with populations known to double in as little as 12 days. Infestations of this weed block waterways, limiting boat traffic, swimming and fishing. Water hyacinth also prevents sunlight and oxygen from reaching the water column and submerged plants. Its shading and crowding of native aquatic plants dramatically reduces biological diversity in aquatic ecosystems.100

8.0 SOCIAL IMPACT ASSESSMENT

8.1 Socioeconomic Conditions

As described in **Chapter 1**, the Zone of Influence includes the entire coastline of Liberia due to potential impacts from oil spill. The EIA team focused our baseline investigations on the communities in the Direct Zone of Influence directly adjacent to the Blocks. These include: Montserrado, Margibi and Grand Bassa.

8.2 Demographics

The population of Liberia as reported by Liberia Institute of Statistics and Geo-Information Services is 4,243,475 in 2016.⁶ Liberia's population was estimated at 4,243,475 in 2016.⁷ The national average household size is 4.3 persons; and ranges from 3.7 to 4.9 persons per household in Gbarpolu county (Northwest region) to 4.9 in Maryland (Southeastern region) respectively. At the current growth rate, the total population is likely to be between 4.8 and 4.9 million by the end of the planning period in 2023. Figure 1.1 shows the population pyramid in 2016. Figure 1.2 shows the population forecast to 2028 offering three fertility scenarios—low, medium, and high.⁸

Figure 1.1: Population Pyramid by Age by Gender

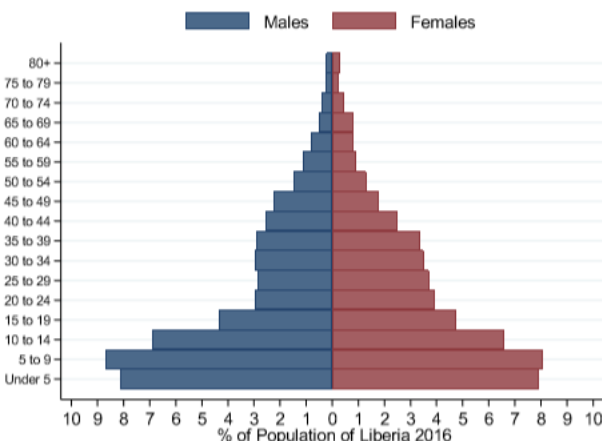
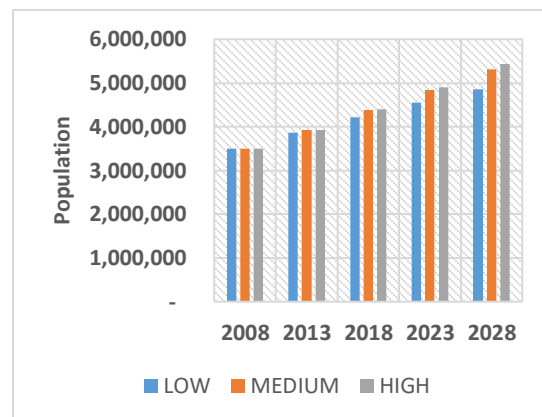


Figure 1.2: Population Forecast to 2028



8.3. Gender and Age Distribution

Females make up 51.1 percent of the population and male 48.9 percent. The sex ratio of the population is 1.011 (1.011 male per 1 females) which is lower than the global sex ratio (1.016 male per 1 female). By age categories, the skew leans heavily towards children, youth, and young adults at productive stages of the life cycle. About 70 percent of the population were below the age of 35 and nearly half (44.5%) of the population were below the age of 15 years in 2016.

⁶ LISGIS, *Op cit*, 2016

⁷ LISGIS, *Op cit*, 2016

⁸ LISGIS, *2008 Population and Housing Census: Analytical Report on Population Projections*, Sept 2011

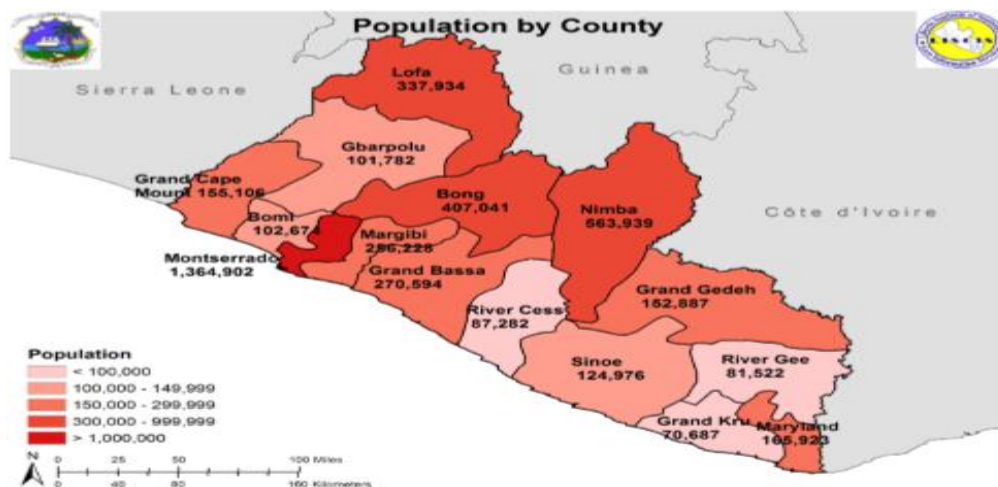
Table 1.1 shows that nearly two-thirds of the population live in Montserrado and the North Central statistical regions comprised of four counties. Figure 1.3 shows the overall spatial distribution of the population by county.

Table 1.1: Distribution of the Population by Statistical Regions

Region	Total		Male		Female		Sex Ratio
	Number	%	Number	%	Number	%	
Montserrado	1,364,902	32.2	647,803	47.5	717,099	52.2	90.3
North Central	1,308,913	30.8	645,292	49.3	663,621	50.7	97.2
South Central	526,822	12.4	259,662	49.3	267,160	50.7	97.2
South Eastern A	365,145	8.6	183,423	50.2	181,722	49.8	100.9
North Western	359,562	8.5	181,397	50.4	178,165	49.6	101.8
South Eastern B	318,132	7.5	156,351	49.1	161,781	50.9	96.6

The total national population is unevenly distributed among the counties. The population distribution favors Montserrado, Nimba, Bong, Lofa, Margibi, and Grand Bassa Counties in descending order of magnitude. Montserrado, Nimba and Bong Counties hold 56 percent of the population. On the other hand, Grand Kru, River Cess, River Gee, Bomi and Gbarpolu counties hold the least population totals. The distribution of the Liberian population among the counties is shown in **Figure 7.15**.

Figure 1.3: Spatial Distribution of the Population



8.2.1 Sinoe County Demographics

Sinoe is the third original County in the Republic and one of the signatories to its Declaration of Independence on July 26, 1847. The County is rich in terms of timber, agricultural land and fishery, but has very little road or basic services infrastructure, and acute and chronic malnutrition rates are alarmingly high. Sinoe County has an average household size of 5.5 persons and a dependency ratio of 1.37. Like the rest of Liberia, the society is largely patriarchal, thus accounting for an 89% rate of male household heads. The Kru vernacular, followed by the Sapo are the most commonly spoken dialects in the County with percentage distributions of 52% and 39% percent respectively.

8.2.2 Grand Kru County Demographics

Located in Southeastern Liberia, Grand Kru is one of the nation’s most underdeveloped counties. The County is a land of vast forests irrigated by many rivers. Households in Grand Kru County were recently reported to have an average membership of 5.8 persons, while nationally the rate is slightly lower at 4.3 persons. The County’s dependency ratio is 1.61. Families or households in the County are headed mostly by males (90%).

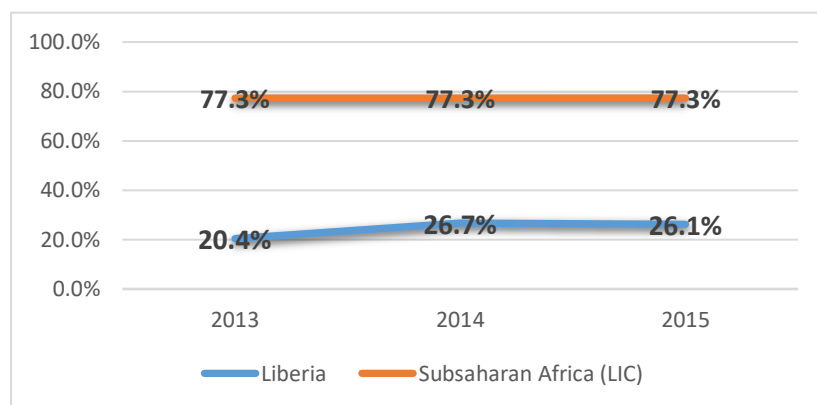
8.2.3 Maryland County Demographics

Maryland County is one of the first four counties of the Republic of Liberia. Initially this County was not part of the Republic of Liberia during its founding. The County was established by a resolution of the Legislature of the Republic of Liberia in 1857. Maryland County is located in the Southeast most corner of Liberia and borders the Atlantic ocean to the South; the Cavalla River representing the international border with the Republic of Ivory Coast to the East; Grand Kru County on the West; and River Gee County to the Northwest. The estimated population of Maryland at 165,923.

8.3 Education

Progress has been made in increasing school enrollment; but Primary Net Enrollment Rate (NER) in Liberia is significantly lower than for Low Income Countries (LIC) in Sub-Saharan Africa.

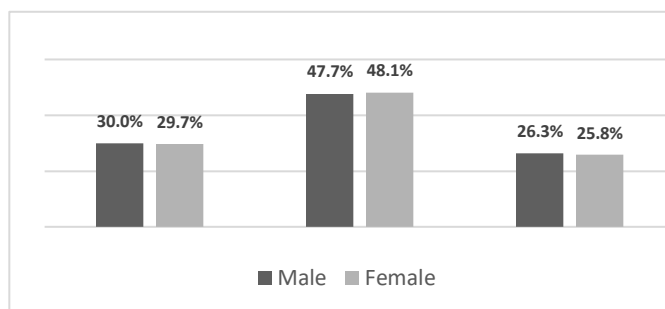
Figure 2.1: Liberia vs Sub-Saharan Africa LIC Net Enrollment Rates



Sources: MOE EMIS 2016 and World Bank databases

Figure 2.1 displays a persistent gap in NER from 2013 to 2015. Moreover, approximately 82 percent of primary students and 75 percent of children in Early Childhood Education (ECE) are overage for their grade levels because of interruptions caused by the EVD outbreak.

Figure 2.2: Net Enrollment Rate by Gender 2015



Source: MOE EMIS 2016

On a more positive note, NER was even for male and female students across all academic levels as can be seen in Figure 2.2; but nearly two thirds (61.5%) of schools do not have a library. Media centers with computers are virtually non-existent or nonfunctional. Only 58 percent of schools have latrine facilities segregated for boys and girls. At higher grade levels, retention of female students is a challenge.

students is a

Women remain woefully under-represented in the makeup of the instructional staff. Overall, less than 10 percent of teachers are female creating a potentially demotivating absence of appropriate gender role models in the classroom environment during critical stages of the physical, psychological, and emotional development of girls.

Only 48 percent of schools are owned and operated by the government. The average number of students per teacher in public schools range from as high as 158:1 in primary grades to 93 to 1 in Senior High School. The estimated deficit of qualified public-school teachers in 2017 was 7,600.

Thirty-four Higher Institutions of Learning (HIL) comprise the network of degree granting institutions in Liberia. Table 2.7 shows the breakout by ownership and specialization. Five are specialized institutions in health and education and one is a distance learning program. HIL will continue to face a litany of challenges throughout the near future.

Category	Number
Public University	2
Private University	7
Private Colleges	12
National Teachers College (public)	2
Specialized Health Institutions (public and private)	3
Distance Learning Center (public program)	1
Community colleges (public)	7

8.5 Poverty

Poverty and vulnerability in Liberia have both geographic and demographic dimensions because of the historical patterns of growth and development. Even these national aggregates mask the full story of poverty and vulnerability and how they undermine the potential of the country. Figure 1.5 shows absolute poverty by regions of Liberia and the table below shows the distribution by county.

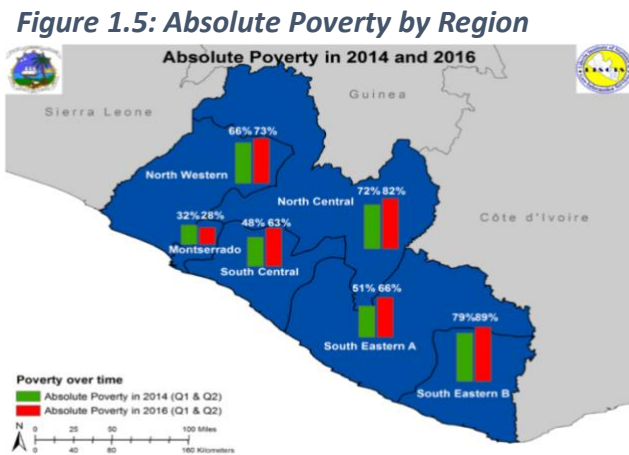


Table 1.3: Absolute, Food, and Extreme Poverty by County

	Absolute Poverty %	Food Poverty %	Extreme Poverty %
Monrovia/Montserrado	20.3	20.2	2.7
Bomi	64.3	44.8	22.2
Bong	71.3	55.9	24.7
Grand Bassa	61.8	45.0	21.9
Grand Cape Mount	53.7	35.3	19.5
Grand Gedeh	63.7	47.8	17.5
Grand Kru	74.4	50.1	26.8
Lofa	68.7	55.0	26.9
Margibi	52.2	39.6	14.1
Maryland	84.0	71.5	47.5
Nimba	66.5	45.2	20.6
River Cess	66.4	45.2	23.3
Sinoe	46.3	19.4	7.6
River Gee	81.9	68.7	39.4
Gbarpolu	60.5	43.2	19.8

Source: LISGIS

Table 1.4: Liberia Multidimensional Poverty Index 2018

Region	MPI	H	A
	(H X A)	(Incidence)	(Intensity)
Liberia	0.374	71.2%	52.5%
Urban	0.290	60.5%	48.0%
Rural	0.481	84.9%	56.6%
Montserrado	0.250	54.2%	46.2%
Grand Gedeh	0.349	74.9%	46.6%
Margibi	0.364	72.7%	50.1%
Nimba	0.377	72.0%	52.4%
Maryland	0.388	77.3%	50.2%
Bomi	0.407	79.1%	51.4%
River Gee	0.433	81.4%	53.1%
Sinoe	0.445	84.4%	52.7%
Lofa	0.457	83.1%	55.0%
Grand Kru	0.480	90.6%	52.9%
Grand Cape Mount	0.482	85.6%	56.3%
Gbarpolu	0.505	86.3%	58.5%
Bong	0.508	83.9%	60.6%
Grand Bassa	0.527	86.7%	60.7%
Rivercess	0.536	94.5%	56.7%

Based on the above estimates, about 3 million Liberians (70.1 percent) were multi-dimensionally poor (deprived of development). Another 924 thousand are near multidimensional poverty. Across Sub-Saharan Africa, about 54 percent of people suffered multidimensional poverty in 2015; but 30 of the 35 countries analyzed reduced poverty significantly over time. Liberia is among the remaining five.

8.7 Health Care

The government recognizes that access to basic health care through the life cycle of all Liberians is a critical contributor to economic productivity and is a function of a healthy and thriving citizenry. Whether they are engaged in productive activities in the formal or informal sector, a healthy workforce is critical to the successful attainment of the Vision 2030 objective of becoming a united and prosperous nation. Moreover, to earn a substantial demographic dividend, our largely youthful population must live long, healthy, and productive lives to reach their economic potential. To this end, it is understood that access to basic health will be a fundamental contributor to the evolution of human capital that will drive our socio-economic development agenda.

Contraceptive prevalence increased among currently married women from 10.3 in 2007 to 19.1 percent in 2013 and among sexually active un-married women from 23.1 in 2007 to 34.6 in 2013 (LDHS). Teenage pregnancy still stands at 31 percent demanding a differentiated approach to adolescent health service. Population access to healthcare within 5KM or 1-hour walk is 71 percent--up from 41 percent in 2008 (NHPC & LDHS).

Community Health Assistance Program: Community Health Assistants (CHA's) are delivering an integrated and standardized service delivery package; which includes curative, preventive, promotive, rehabilitative and palliative services, to households located more than one-hour walk (more than 5km) from the nearest health facility. Households located within 5km of a health facility, are receiving tailored package of services delivered by other community cadres. To date, 76.2 percent or 2,904 of the overall targeted 4,000 CHAs have been recruited, trained, and deployed in 13 counties. The CHA program is a promising approach that can, potentially, change the narrative around health care delivery in Liberia.

Communicable Diseases: Malaria is endemic, and the entire population is at risk of the disease. Children under five and pregnant women are the most affected groups. According to data from the Health Facility Survey (HFS, 2013) malaria accounted for 42 percent of outpatient department attendance and 39 percent of in-patient deaths. The total number of cases reported between 2016 and 2017, however, has fallen by nearly 29 percent from 1,517,115 to 1,069,880. TB case notification improved by 24 percent in 2015; thus, placing the overall notification at 7,119 (56%) at the end of 2016. Liberia TB treatment success rate has increased from 68 percent in 2015 to 76 percent in 2016.

The Liberia Demographic and Health Survey of 2013 (LDHS) estimates the national HIV prevalence rate among sexually-active adults (15-49 years) to be 2.1 percent, with variations based on sex, age range, geography, and socio-economic status. Leprosy is still a public health concern, with prevalence (3.61/10000) above the World Health Organization (WHO) threshold.

Prevalence of other Neglected Tropical Diseases (NTD) remains very high. Mass Drug Administration for the elimination and control is ongoing in all counties for Onchocerciasis and Soil transmitted helminths. Lymphatic Filariasis Mass Drug Administration is ongoing in 13 counties except for Bomi and Gbarpolu. Schistosomiasis Mass Drug Administration is ongoing in 13 counties except for Rivercess and Grand Kru.

Non-Communicable Diseases: Liberia has only one psychiatrist, no doctoral level psychologists, and few social workers (WHO-AIMS 2017). Liberia needs over 1,000 mental health professionals. Also, WHO estimates that Liberia needs 427 trained psychiatric nurses (9.5 for every 100,000 population). There is one psychiatric referral hospital and 4 Wellness Units.

Cancer remains a serious issue. Only two (2) public and one (1) private facility are currently screening for cancer. There is little or no access to chemotherapy and radiotherapy, thus rendering cancer treatment services very inadequate. Eye health is available but at a high cost in Monrovia. Outside of Monrovia limited eye care is available at a few secondary hospitals--Ganta, Phebe, Zwedru, Fishtown, Harper, Barclayville and Greenville.

Immunization: Liberia added new antigens into its routine immunization program. The antigens are Yellow Fever - 2007; Pentavalent Vaccine - 2009 replacing DPT; Pneumococcal Conjugate Vaccine - 2014; Rotavirus Containing Vaccine, RCV - 2016; and Human Papillomavirus Vaccine Demonstration in Bong & Nimba Counties and Inactivated Polio Vaccine, IPV - 2017.

Drugs and Medical Supplies: Enormous progress has been made in setting into place the institutional framework for an effective supply chain management system. A temporary quality testing Lab will house the Liberia Medicines and Health Products Regulatory Agency (LMHRA), while the construction of a new testing lab that meets ISO standard is being planned. A central warehouse on the outskirts of the capital is 85 percent completed with pending occupancy in June. The warehouse will receive, store and distribute medicines and medical supplies throughout the Healthcare System. The LMHRA is currently receiving and evaluating medicines and health products for registration.

Diagnostic Services: Diagnostic capacity has improved over the years. Molecular diagnostic and Microbiology techniques are up and running at the National Reference Laboratory (NRL), and at Phebe and Tappita hospitals. About 70 percent of the laboratory infrastructure at JDJ hospital has been improved. Notwithstanding, capacity for diagnostic is still limited due to a combination of infrastructure deficits, inadequate human resource and technical capacities, and inadequate or lack of modern diagnostic equipment.

Integrated Disease Surveillance and Response (IDSR): Post EVD outbreak, preventing and controlling public health threats and mitigating related risks are national priorities. Among several strategies put in place to address threats is a functional public health surveillance system with an early warning system which uses the IDSR platform. The system is managed by the newly-established National Public Health Institute of Liberia (NPHI).

Eleven of the 15 counties experienced disease outbreaks and humanitarian emergencies with the most frequent being measles (20), Lassa fever (5) and pertussis (5). The high frequency of measles

outbreaks may be related to its endemicity and the high number of susceptible children in the population. Recurring outbreaks of Lassa fever were also noted particularly in Nimba and Bong counties. Two health-related emergencies involving flood and mudslides in Margibi and Bong Counties as well as an incident of chemical spills in Bong County were reported.

8.9 Civil Society

There are numerous environment-related NGOs in Liberia, many of which have played an important role in contributing information and experience to the preparation and review of laws.

The most prominent international NGOs include Fauna & Flora International (FFI), Conservation International (CI), Birdlife International, and Forest Partners International. FFI and CI have a joint project, the Liberia Forest Reassessment Project.

Local NGOs include the Society for the Conservation of Nature in Liberia (SCNL), Pollution Control Association of Liberia (POCAL), Environmental Foundation for Africa (EFA), Farmers Associated to Conserve the Environment (FACE), Centre for Environmental Education and Protection (CEEP), Liberia Indigenous Forum for the Environment (LIFE), Environmental Relief and Development Research Organization (ERADRO), Environ-Link, Liberia LTD, Society Against Environmental Degradation (SAED), Liberian Community Development Foundation (LCDF), Association of Environmental Lawyers (Green Advocates), Concerned Environmentalists for the Enhancement of Biodiversity (CEEB), Save My Future Foundation (SAMFU), and Grand Gedeh Community Servant Association (GECOMSA).

8.10 Economy and Employment

The economy grew by 8.3 percent and 8.7 percent in 2013 and 2014 respectively. The upward surge was underpinned by robust growth. By 2014, the twin shocks of the EVD outbreak and plummeting global commodity prices reduced the growth rate to 0.7 percent in 2014 and negative 1.6 in 2016 before rebounding to 2.5 percent in 2017. Table 3.1 shows selected Financial and Economic Indicators for the period 2012 to 2017.

Table 3.1: Selected Economic and Financial Indicators 2012 to 2017

INDICATOR	2012	2013	2014	2015	2016	2017
	(Annual percent change)					
Real GDP	8.3	8.7	0.7	0.0	-1.6	2.5
Real GDP excluding mining sector	3.4	4.3	0.3	2.6	2.6	0.2
Consumer prices (annual average)	6.8	7.6	9.9	7.7	8.8	12.4
Consumer prices (end of period)	7.7	8.5	7.7	8	12.5	13.9
	Percentage of GDP					
Exports	27.6	28.7	22.6	12.5	11.6	13.0
Imports	-61.5	-58.9	-54.3	-57.2	-39.7	-33.2
Total revenue	26.3	27.7	23.5	22.5	14.0	14.3
Grants	1.7	2.5	3.9	10.0	19.3	16.7
Total expenditure and net lending	31.4	31.7	29.3	40.9	36.0	35.8
Current expenditure	26.7	26.8	24.3	32.0	22.8	22.9
Capital expenditure	4.7	4.9	5.0	8.8	13.1	12.9
Overall fiscal balance, including grants	-3.4	-1.6	-1.9	-8.4	-2.7	-4.8
Overall fiscal balance, excluding grants	-5.1	-4.1	-5.8	-18.4	-22.0	-21.5
Public external debt	12.3	15.1	13.2	23	17.9	22.7
Public domestic debt	17.8	16.1	14.1	14.6	0.4	2.0
Current Account Balance including grants	-28.0	-34.7	-26.9	-32.2	-18.5	-22.7
Current Account Balance excluding grants	-83.3	-84.3	-89.5	-87.4	-47.1	-44.2
M2/GDP	36.5	35	34.6	34.8	20.5	19.9
Gross official reserves (months of imports)	2.8	2.7	2.5	2.6	2.9	3.0

Source: IMF staff and Liberian Government Authority

The value of remittance inflows makes Liberia the most dependent in Africa and the sixth most dependent in the world. By 2016, remittance inflows represented 27 percent of GDP. Inflows have consistently exceeded US\$350 million annually since 2010. Preliminary figures show approximately US\$574 million as of October 2017.⁹ Given the large outflows/transfers from Liberia, these data need to be kept in perspective.

⁹ World Bank Group; *Private Transfers, Remittances, and Welfare in Liberia*; August 2018

Employment

The economically active population (EAP) is expected to grow from 1.6 million in 2018 to nearly 2 million in 2023.¹⁰ Nearly 80 percent of the EAP is in informal employment. About 35 percent of Liberian households make their living predominantly through agricultural related activities.¹¹ The population in informal employment will grow from nearly 1.3 million in 2018 to 1.6 million by 2023 without significant intervention in job creation.

In formal sector employment, 65 percent of wage earners work for private employers in the service sector. About 20 percent work for the government and 15 per work for nonprofit organizations. A higher proportion of women fall in the lower earning work categories. Figure 1.4 shows that as wage incomes rise, the share of women relative to their male counterparts falls.

Figure 1.4: Wage Earnings of Women and Men



Most household non-farm enterprises (56.1%) are run by women. Most of those enterprises (70.8%) have gross revenue of less than L\$30,000 (US\$200) monthly. Average household farm size is 1.6 hectares; but it rises to about 2.2 hectares in the North central region. Households falling in the poorest quintile cultivate 0.3 hectares while those in the richest cultivate 3.6 hectares on average. Typically, households (74%) grow a mix of food crops with Rice and Cassava predominating. At least a third of farming households have some

acreage of permanent/cash crop farms. On average, yields are about 80 percent of the regional crop yields.¹²

Despite the large proportion of the labor force in the working age category, low labor productivity and an acute shortage of workers with the appropriate skills inhibit the potential of the formal and informal sectors. This constrains a broad-based economic growth and recovery. The 2010 Labor force survey found that the formal sector employed less than 20 percent of the labor force. It also found only 56 percent of the working age population was literate; and when disaggregated, female literacy in the labor force was 44.8 percent.¹³ About 47 percent of women and girls, and 33 percent of boys and men have never attended school.

8.11 Infrastructure

Liberia's infrastructure was severely damaged by the civil war. Most Liberians have no access to electricity, improved water and sanitation facilities, acceptable housing, or decent roads. Weak

¹⁰ ILO, *Towards a National Social Protection Floor in Liberia*, 2017

¹¹ LISGIS, *Op Cit*, 2016

¹² LISGIS, *Op Cit*, 2016

¹³ LISGIS, *Liberia Labor Force Survey*, 2010

infrastructure undermines income earning opportunities, limits access to health and education facilities, raises the price of goods and services and weakens food security. Women and children bear a large burden as a result of poor infrastructure, as they must spend more time carrying water and other goods, are more vulnerable to crime and have less access to health facilities, raising the risk of child and maternal mortality. Persons with disabilities are also disproportionately disadvantaged.

8.12 Water and Sanitation

While significant progress has been made since the end of the civil war, many Liberians still do not have access to safe drinking water or human waste collection and disposal facilities. Most residents do not treat or boil their water, which has grave implications for the health and nutritional status of the population. Garbage collection is minimal with the availability of one open dump site located at the outskirts of Monrovia, at Whein Town.

The only functioning sewage system is in Monrovia with an under-capacity sewage treatment plant that has not functioned consistently for over ten years due to disrepair and a shortage of electricity. Raw sewage has been frequently allowed to flow directly into lagoons, rivers and the sea. Occasionally, the sewer mains are fractured causing outflow on to the streets or into the sea and local rivers. The majority of the population uses either pit latrines, toilets connected to septic tanks or open defecation.¹⁴⁵

8.15 Ports of Liberia

The National Port Authority (NPA) was created in 1967 by an Act of Legislature (amended in 1970) as a state-owned enterprise to "manage, plan, and develop all ports within the Republic of Liberia". The NPA is also responsible for the administration of all ports and provides services such as vessels handling, warehousing, and an oil jetty exclusively for petroleum products in Liberia. These ports include: the Free Port of Monrovia, the port of Buchanan, port of Greenville, and port of Harper. **Table 8.4** lists details of these ports, including county, break water length, year of establishment, and water depth.

The four ports handled about 200,000 tons of general cargo and around 400,000 tons of imported petroleum products per year prior to the conflict. The Free Port of Monrovia and the port of Buchanan handled all the bulk iron ore exports, while the ports of Buchanan and Greenville were responsible for most of the timber exports. The conflict resulted in the damage and looting to warehouse and loading facilities, shipwrecks in ports, channel siltation and spillage in petroleum storage tanks.¹⁵³

Table 8.4: The Four Ports of Liberia and Applicable Details

Port	County	Break water length	Year of Establishment	Water Depth Below Chart Datum
The Free Port of Monrovia	Montserrado	2,350m and 2,200m	1967	NA
The port of Buchanan	Grand Bassa	1,890m and 590m	1960	12.95 m
The port of Greenville	Sinoe	400 m	Early 1980s	6m
The port of Harper	Maryland	150 m	1959	NA

8.16 Energy

Liberia still has one of the highest tariff rates in the world for electricity, although considerable progress has been made in the energy sector. The cost of energy reduced from 0.55/kwh in 2012 to 0.36/kwh in 2017. In 2015, a new energy law was passed, and an energy regulator established to ensure the private sector has a viable say in developing affordable energy options. The Mount Coffee Hydro-Electric Dam was refurbished and restored. The plant's 88-megawatt capacity is still vastly under-utilized because of transmission and distribution problems. The hydro dam's run of the river nature means in the dry season, capacity plummets to a mere 20 megawatts.

The Rural and Renewable Agency (RREA) has rehabilitated mini-hydro plan delivering 60 KW in Yandohum in Lofa County; contracted 2 MW hydro plant on Kaiha River, Lofa to benefit 50,000 homes and businesses, completed feasibility studies for three hydropower sites—Gbedin and Ya in Nimba, and Gee in River Gee; and distributed 31,000 solar lanterns/lamps and solar photovoltaic (PV) systems installed in 9 facilities in Lofa County¹⁴. Opportunities for more affordable energy investments exist for private providers.

¹⁴ Rural Renewable Energy Agency Strategy Plan