# The Vulnerability of the Coast of Liberia to Marine Oil Spills:

# Implications for Biodiversity and Renewable Natural Resource Utilization

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## ABSTRACT

The West African coastline has become a “hotspot” for oil production, and 17 oil exploration blocks have been designated off the Liberian coast. Liberia’s 579 km coastal zone supports almost 60% of the country’s human population and is endowed with natural resources of both biological and socioeconomic significance, leading to the potential for conflict between oil production, existing human activities and biodiversity. The aim of this study was to establish the level of dependency of coastal rural households of Liberia on the natural resources of the marine and coastal environment, and to assess the relationship between coastal people, biodiversity conservation and the oil industry of Liberia with an overall goal of contributing to biodiversity conservation efforts in Liberia.

Fieldwork was conducted from 19 September to 10 December 2011. Two aspects were assessed. A biological component focused on the biodiversity of the marine and coastal environments, and a socioeconomic component, which focused on natural resource utilization by, and the socio-cultural environment of, the coastal inhabitants of Liberia. A comprehensive review of published information was used to assess the vulnerability of the biotic and abiotic components of the coastal and marine environment to oil spills. Household surveys were conducted to assess the dependency of rural households on renewable coastal and marine resources and consequently, the potential threats to their livelihoods in the event of an oil spill. The surveys (N=316) were conducted in seven coastal counties adjacent to ten of the offshore oil exploration blocks that have been contracted for oil exploration activities. The coastline was divided into three regions with a total of 316 households surveyed: Western (N=76), Central (74) and Eastern (166). Average household size (N=10) was similar in all regions.

The coastal zone of Liberia comprises sensitive environments including estuaries, coastal lagoons, mangroves, sandy beaches and rocky shores, all of which are vulnerable to oil pollution to varying degrees. Mangroves, estuaries and coastal lagoons are important spawning, roosting and breeding sites for fish and other wildlife, whereas sandy beaches are used for recreation and serve as breeding grounds for five species of marine turtles. Coastal inhabitants rely heavily on the utilization of coastal and marine resources for their livelihoods and income. Fishing was most important, contributing 70% of income across all households, followed by farming (19%) and mangrove harvesting (8%). The remaining income was derived from hunting, petty trading, gathering of wild resources and sand mining. The number of households engaged in fishing and non-fishing activities differed between the three regions. There was more fishing in some regions than others. The Eastern Region constituted the greatest (87%) proportion of fishing households and derived the highest monthly proportional income from all livelihood activities. The Western Region constituted the highest (71%) proportion of farming households by region and derived the lowest monthly income among the regions. Fishing and several other sources of income might be lost in the event of a large oil spill, increasing poverty and food insecurity in the region. There is urgent need for the development of an oil spill contingency plan and a waste management plan for the oil industry. Local inhabitants also need to be trained so that they can respond to minor spills and related forms of pollution.

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## CHAPTER 1: Literature Review

Oil wealth in most oil-rich nations is playing a decisive role in defining the politics and status of those nations and providing revenue that enables their governments to execute ambitious national and economic development plans (Brownfield and Charpentier, 2006). This is why oil production has become a concern of many governments worldwide and is a vital ingredient in their political and diplomatic strategies. Yet, despite this oil wealth, often little is done about the potential impacts oil spills have on biodiversity, the environment and the socioeconomic conditions of people who depend on natural resources for their food, economic and social requirements. This has been the situation in some oil-rich West African states, such as Nigeria, where oil wealth has played a pivotal role in piloting their socioeconomic and political development, but spills have had devastating impacts on the natural environment (e.g. in the Niger Delta; Amnesty International, 2009).

The coastal and marine environment of West Africa comprises diverse natural habitats and biological resources that support several key socioeconomic activities for coastal inhabitants (Allersma and Tilsmans, 1993). The West African region, comprising 16 nations from Senegal to Nigeria, has important hydrocarbon resources (Brownfield and Charpentier, 2006), most of which are still unexploited. A United States Geological Survey report estimated that the oil and natural gas resources in West Africa are around 71 billion barrels of oil, 187 trillion cubic feet of natural gas and 11 billion barrels of natural gas liquids (Brownfield and Charpentier, 2006). Together with North Africa, West Africa has more hydrocarbon and "good petroleum and geological conditions" than do southern and East Africa (Brownfield and Charpentier, 2006).

West Africa is currently experiencing an oil boom linked to sharp increases in the prices of oil and promising discoveries in the region. For example, the Jubilee Oil Field in Ghana is

believed to have a 50% chance of producing a total of 370 million barrels of oil (Tullow Oil, 2010). Also in Sierra Leone, Liberia's western neighbour, Anadarko Petroleum Corporation has made offshore discoveries in the Venus and Mercury oil fields. The latter discovery is of particular interest to Liberia because of its proximity (approximately 20 km) to Liberian waters (Global Witness/LOGI, 2011). Oil production has a long history in Liberia's eastern neighbour, Cote d'Ivoire, where drilling has occurred since the 1970s. Fortunately, no major oil spills have occurred in this region in the last few decades. However, historical information on oil spills indicates that the West African coastline has experienced several incidents, ranging from well blow-outs to ship wrecks, which reportedly impacted coastal environments. With simultaneous oil exploration and production activities underway along most of the West African coast, there is an increased likelihood of oil spills in the region.

The coastal zone of Liberia supports almost 60% of the country's human population and is endowed with natural resources of both biological and socioeconomic significance, resulting in the potential for conflict between oil production, existing human activities and biodiversity. Liberia's coastal zone consists of a variety of biodiverse and vulnerable ecosystems including mangroves, which are important spawning and breeding sites for fish, and beaches that provide breeding grounds for five species of marine turtles. However, the coast faces a variety of serious threats including sand mining, beach erosion, removal of mangroves, overexploitation of marine resources and dumping of wastes (USAID, 2008). Offshore oil exploration is underway in Liberia and occasional spills are highly likely. Most coastal inhabitants are fishers, farmers, wood dealers or charcoal producers who rely heavily on resources from the coastal zone for food and income generation.

Seventeen offshore oil exploration blocks have been designated along the Liberian coast. Ten blocks have been awarded to four oil companies: Anadarko Petroleum (4 blocks); Chevron Liberia (3 blocks); African Petroleum (2 blocks); and Broadway-Peppercoast Petroleum (1

block). One onshore production sharing contract has been awarded to Simba Energy (Global Witness/LOGI, 2011).

Oil exploration in Liberia is a fairly new activity using the latest technology, but accidents can occur despite the best efforts to avoid them (e.g. BP's Gulf of Mexico spill in 2010 and Nigeria's Bonga oil spill in 2011). The process of prospecting for and subsequent production of oil, if done with due consideration for the protection of the environment, can have minimal local impacts on coastal, marine and terrestrial biodiversity (Sharma, 2009). In the past, however, some operations have been undertaken with little concern for the environment (e.g. in the Caspian Sea, the Niger Delta in Nigeria and Lake Maracaibo in Venezuela; Amnesty International, 2009; ITOPF 2003).

Liberia has a poor record in responding to oil spilled from shipwrecks and other accidents in the last two decades. More than ten shipwrecks occurred along Liberia's coast between 1990 and 2003 (UNEP, 2004) spilling oil and other toxic chemicals into the marine and coastal ecosystems which eventually affected marine and coastal lives as well as the fragile coastal habitats of Liberia. Neither the government of Liberia nor any environmental institution has responded to the impacts to date.

Oil spills can devastate wildlife and ruin ecosystems in many ways, depending on the type and quantity of oil spilled, the seasons and weather, the type of shoreline, and the type of waves and tidal energy (Michel *et al.*, 1992). When oil is spilled or leaked offshore, it spreads rapidly under the influence of winds, waves and currents. The wind and wave conditions off the coast of Liberia come predominantly from the south (Chapter 2), suggesting that offshore oil spills are likely to travel towards the coast. The most significant impacts of an oil spill at sea are likely to be felt by biodiversity within the coastal environment, especially surface dwelling species (Carter *et al.*, 2006).

*Objectives of the study*

This study attempts to ascertain the level of dependency of Liberia's coastal inhabitants on marine and coastal resources and systematically assess the relationship between these people, biodiversity conservation and the oil and gas industry. The ultimate goal is to ensure the consideration of the coastal inhabitants' livelihood activities and biodiversity in the planning stages of oil industries and also contribute to environmental conservation by providing suggestions for management and mitigation actions in the event of an oil spill. Specifically, the study assess the vulnerability of biodiversity of the Liberian coastline to marine oil spills in both a national and regional context; and also assess the dependency of local inhabitants on renewable coastal and marine resources and the environment and consequently, determine the potential threats to their livelihoods in the event of an oil spill.

The study consists of two main components:

1. A desktop study describing the biodiversity of the Liberian coastline including Important Bird Areas (IBAs), Ramsar sites, conservation areas, landforms and shoreline types, habitats, areas of socioeconomic significance including fishing communities, mangrove harvesting sites and other resource utilization areas.
2. An interview/questionnaire survey targeting heads of households at selected representative communities in the coastal region to determine the scale of utilization of, and dependency on, renewable marine and coastal resources by inhabitants of the coastal zone.

The findings of this study are integrated to form the basis for oil spill response planning in Liberia. The report consists of three chapters following this introduction. Chapter 2 provides a synopsis of the main features of the coastal and marine environment of Liberia and a synthesis of biodiversity conservation information in Liberia. Chapter 3 assesses the level of

dependency on and determines the scale of utilization of renewable natural resources. Chapter 4 assesses the potential sources of oil spills, predicts the behaviour of spilled oil, and estimates the vulnerability of coastal resources to oil spills.

## CHAPTER 2. Liberia's Marine and Coastal Environment

This environmental overview provides information on the biotic and abiotic components of the marine and coastal environment of Liberia from two perspectives: 1) a description of environmental conditions that affect the movement of spilled oil, and 2) components of the biotic and abiotic environment that are likely to be affected by an oil spill. The study area (Figure 2.1) extends from the border of Liberia with Sierra Leone in the west (11°20'W) to the boundary between the south-eastern counties of Sinoe and Grand Kru close to the border with Cote d'Ivoire in the east (8°43'W). The seaward limit of the study area coincides with the boundary of the 200 nm Exclusive Economic Zone.



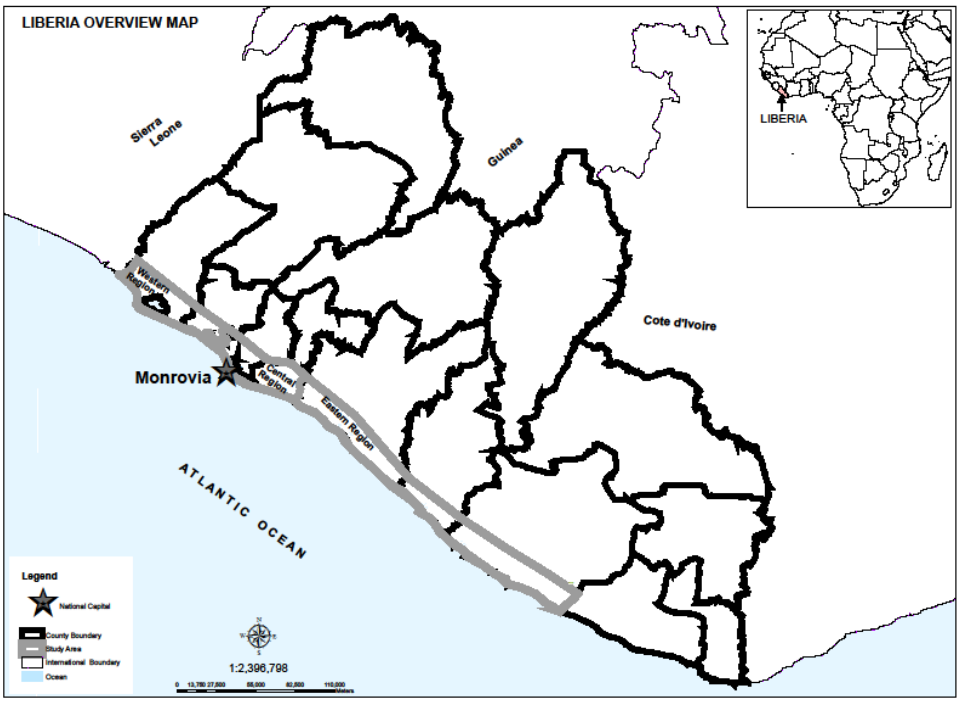


**Figure 2.1**. A map of Liberia showing the study area and the position of the Capital and the location of the country on continent of Africa.

Liberia lies on the Central West African coast and has an area of 111,369 km$^2$. The human population of approximately 3.6 million people is growing at 2.7% per year (CIA, 2010). The

economy is based primarily on agriculture which employs 75% of the total work force with 15% in services and 10% in the mining and manufacturing sectors (EIU, 2003).

Exploration for hydrocarbons in Liberia started in the 1940s with 2-D seismic surveys (Mbendi, 2011). Seven offshore wells were drilled in the 1970s and 1980s, but no commercially viable quantities were found. However, Mbendi (2011) reported the presence of oil and gas source rocks, and prospects for finding oil and gas in Liberia have soared following recent discoveries of oil in Sierra Leone, close to the Liberian border (Global Witness/LOGI, 2011). With these prospects, the Petroleum Law of Liberia (2000) was developed, followed by a model Production Sharing Contract (PSC) as a basis for negotiating petroleum agreements. Following another 2-D seismic survey, the National Oil Company of Liberia (NOCAL) divided offshore Liberia into 17 blocks for exploratory purposes. Ten blocks have been awarded to exploration companies, two blocks are still being negotiated and the five eastern blocks remain unregistered.



*2.1. Metocean conditions off Liberia's coast*

The waters offshore of Liberia are influenced by the eastward flowing Guinea Current (NOAA, 2003; Wiles and Makor, 2006). The Equatorial Counter Current (ECC) and the Canary Current (CC) contribute to the Guinea Current which runs along the West African coast at velocities close to 100 $cm.s^{-1}$ (Iba and Ajayi, 1985). Surface wind systems in the equatorial zone affect oceanographic conditions in Liberian coastal waters, and the waves over the continental shelf are wind generated with intensities generally determined by the wind velocity, duration and fetch (Wiles and Makor, 2006).

Inshore of the Guinea Current, coastal waters are influenced by a diversity of currents, including long shore, tidal, rip and ocean currents. Long shore currents are produced from

large, powerful swell approaching the coastline at an angle from the south-east direction, sweeping sediments along the coast. The velocity of the long shore current ranges from 0.32 to 1.00 $cm.s^{1}$ (D. Wiles, Guinea Current Large Marine Ecosystem, pers. comm.). Tidal currents result from semi-diurnal tides which are in phase with tidal cycles that approach from the southeast, with tidal amplitude decreasing from west to east. Extreme tides cause occasional flooding and degradation of the coastline as they progress inshore (Wiles and Makor, 2006). Along open shores, plunging waves dominate the western and central coastlines of Liberia which are characterized by steep ocean floors. Swells typically decrease in size from west to east, averaging about 1.3 m along the western coast, and 1.0 -1.2 m on the central coast during the rainy season. The eastern coastline, characterized by a gradual slope, is subjected to less intense wave action, and is characterized by spilling waves. The relatively low energy wave dynamics along the coast are linked to the wider inner shelf with a very gentle gradient that cause the waves to dissipate a large part of their energy before reaching the coastline (NOAA, 2003).



*2.2. Coastline of Liberia*

More than 90% of the coastline consists of sandy beaches, interspersed with lagoons, estuaries, bays and brackish wetlands (Ssentongo, 1987; EPA, 2007; Evans *et al.*, 1997). The beaches are mostly narrow, 20-30 m wide, but reach 60-80 m in some parts of south-eastern Liberia (Gatter, 1997). A coastal strip, consisting of isolated sharp rocks projecting from soft bottoms also extends from the capital, Monrovia, in a south-easterly direct widening to cover the sea floor to depth of up to 80 m off the coast of Cape Palmas in Maryland County (Wiles, 2005; Gauld and Buchana, 1959). The remainder of the continental shelf comprises soft sediments, with mud and sand in parallel strips along the coast.

Information on distributions and abundance of fish species in Liberia is nonexistent with nothing known about specific centres of endemism. There has also been no recent known stock assessment conducted to determine the level of exploitation of the fisheries resources. Scanty data prior to 1997 indicate that approximately 11,693 metric tonnes of fished were exported in 1988 compared to 1990 (outbreak of the civil war) where only 7,290 metric tonnes were exported. Total annual fisheries production between 1997 and 2007 (Togba, 2008; FAO, 2012) is shown in Table 2.1.

**Table 2.1.** Annual Fisheries production of Liberia, 1997 – 2007 (metric tonnes).

| Year | Artisanal | Industrial | Total |
|---|---|---|---|
| 1997 | 2,750 | 1,579 | 4,329 |
| 1998 | 3,591 | 2,700 | 6,291 |
| 1999 | 5,992 | 4,493 | 10,485 |
| 2000 | 4,663 | 2,425 | 7,088 |
| 2001 | 4,064 | 2,239 | 6,303 |
| 2002 | 4,641 | 2,201 | 6,842 |
| 2003 | 4,630 | 2,020 | 6,650 |
| 2004 | 7,126 | 3,191 | 10,317 |
| 2005 | 5,511 | 3,584 | 9,095 |
| 2006 | 5,391 | 2,894 | 8,285 |
| 2007 | 5,654 | 10,500 | 16,154 |
| TOTAL | 54,013 | 37,826 | 91,839 |
| % | 58.8 | 41.2 | 100.00 |



Estuaries are an important habitat for a diverse array of species, including the threatened *Trichechus senegalensis.* Estuaries are among the most productive habitats in Liberia's coastal zone, providing rich feeding grounds for shore birds and breeding grounds for fish

and other marine life. They support unique communities of plants and animals specially adapted for life at the border of the ocean (e.g. mangroves, shorebirds, crustaceans and some marine mammals). Estuaries also tend to be important sites for human habitation. Six major rivers and nine smaller rivers form major estuaries along the Liberian coast. The coastline also has approximately 30 lagoon, with the largest being the Lake Piso Lagoon (Wiles, 2005). Two main types of lagoons are found in Liberia; opened and closed lagoons.

The West African coast has the most extensive mangrove forests in Africa: over 25,000 $km^2$ of mangroves occur along the coast from Senegal to Angola (UNEP, 2007). Despite the importance of this region for mangroves, few areas are protected. Mangrove swamps with tidal creeks develop behind sand barriers formed by littoral transport (Allersma and Tilmans, 1993). Mangroves characterize the coastal wetlands of Liberia, from Robertsport to Cape Palmas, at the edges of lagoons, riverbanks, and river estuaries and in widespread areas of coastal swamps. Mangroves are estimated to cover 0.5% of the land surface of Liberia (Gatter, 1988). The major threats to these plants currently include cutting for fuel and poles and the conversion of mangrove swamps to agricultural land and urban expansion. To date, about 20% of the mangroves has been lost to deforestation. The United Nation's Food and Agriculture Organization (FAO, 2006) reported the elimination of *Laguncularia racemosa* along parts of the coast by extensive felling. However, mangroves can usually recover from these activities as they propagate vegetatively. Empirical information is lacking about the impact of these activities on biodiversity and coastal inhabitants in Liberia. However, an ecological consequence of the deforestation of mangroves is reduced dispersal of seedlings of principal species (Rubin *et al.*, 1998).

*2.3 Marine water quality along the coastline of Liberia*

Understanding the water quality of every nation is important for the health and safety of its people and the environment. Water quality describes the chemical, physical and biological characteristics of water, which are controlled by substances, either dissolved or suspended in water, usually in respect to its suitability for an intended purpose. Water quality is most often used by reference to a set of standards against which compliance can be assessed with the most common being related to the health of ecosystems and safety of human. The quality of marine water along the coast needs to be understood prior to projected accidental oil pollution as a result of future oil explorations and drilling operations.

The quality of water along Liberia's coastline is reported to be under immense threats (UNEP, 2004; Wiles, 2005; USAID, 2007) from various sources of pollution (oil, sewage discharges and other chemical and industrial wastes). Studies of marine water quality have shown that waters adjacent most urban settings have high level of infestation (Alemagi *et al*., 2006; Tong *et al*., 1999) and are of low quality as a result of effluent discharges from industrial, chemical, and agricultural plants. This is likely to be the case of the Liberian waters. A UNEP (2004) report on Liberia shows effluent discharges from chemical and industrial wastes into the marine environment by Firestone Rubber Company. Other studies (Wiles, 2005; USAID, 2007) of the coastal and marine environment of Liberia also shows that a significant amount of oil have been discharged into the marine waters of Liberia either from leakages from the refinery or shipwrecks. Although the quantity of oil and other pollutants entering the marine waters of Liberia is unknown as a result of the lack of empirical data, the consequences of the impact on the marine and coastal environment and biodiversity and the health and socioeconomic activities of coastal inhabitants is projected to increase with the drilling of oil off the coast of the country. Also of importance to understanding the marine water quality of Liberia in preparation for future monitoring

programs is the chemical analysis of sediments in sensitive habitats or tissues of living resources along the coastline. Unfortunately, no study have been undertaken in this direction, However, studies from elsewhere (IPIECA, 1993; ITOPF, 2003) shows that adverse environmental impacts associated with oil pollution are a concern globally because of heavy tanker and shipping traffic and offshore oil explorations along coastlines. It is therefore paramount for Liberia to adopt a marine water quality monitoring program to ensure a clean and safe environment for all.

*2.4. Coastal biodiversity of Liberia*

Information on marine reptile breeding activities in Liberia is scanty. Four species of marine turtles breed along the coast: Leatherback Turtle (*Dermochelys coriacea*), Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricate*) and Loggerhead Turtle (*Caretta caretta*) (SAMFU, 2003) and Olive Ridley Turtles also may occur in the country (Eckert *et al*., 1990).

A total of 615 bird species has been reported to occur in Liberia, of which 21 species are Palaearctic migrants of global conservation concern (Robertson, 2001). Studies on the importance of Liberia's coastline for coastal and wintering birds indicate that the coastline of Liberia is of relatively low ornithological significance (Gatter, 1988). However, more than 125 Palaearctic migrants and other shore birds have been recorded along the coastline, with major concentrations at estuaries and coastal lagoons (Gatter, 1988).

*2.5. Conservation areas*

Liberia currently is party to several international agreements **(**Appendix 1). As a signatory to these agreements, Liberia has an international obligation to adhere to these laws and protect their natural resources accordingly. At present Liberia has no declared Marine Protected Areas (MPAs). Three areas in Liberia have been designated as coastal Ramsar sites, although as of yet none of these sites is formally protected (Table 2.2).

**Table 2.2**. Designated coastal Ramsar sites in Liberia (source: Environmental Protection Agency of Liberia)

| Area | Coordinates | Area ($km^2$) | Comments |
|---|---|---|---|
| Lake Piso | 06°44'N, 11°22'W | 307 | Proposed nature reserve/Ramsar |
| Mesurado | 06°18'N, 10°45'W | 89 | Ramsar site |
| Marshall | 06°08'N, 10°22'W | 155 | Proposed nature reserve/ Ramsar |

There are two coastal Important Bird Areas (IBAs) in Liberia. The Cape Mount IBA (6° 45'N, 11° 21'W, 46 $km^2$) holds a number of bird species restricted to the Guinea-Congo Forest biome that are typical of coastal habitats, unrepresented or under-represented elsewhere (Robertson, 2001). It was proposed as a Nature Reserve in 2003, but has no formal protection status. The Cestos-Senkwehn IBA (5°31'N, 9°21'W) extends inland some 70 km from the coast and includes the estuaries and lower reaches of the scenic Cestos and Senkwehn rivers. It is home to bird species of key conservation concern in the Upper Guinea Forest Endemic Bird Area (8 of 15 species) and the Guinea-Congo Forest biome (90 of 184 species; Robertson, 2001) as well as other threatened and endemic wildlife species including pygmy hippopotamus (*Hexaprotodon liberiensis*), West African chimpanzee (*Pan troglodytes verus*) and the forest elephant (*Loxodonta cyclotis*) (Verschuren, 1983). The Cestos–Senkwehn IBA was proposed as a National Park in 1983 but has still not been proclaimed.

## CHAPTER 3. Socioeconomic Importance of Coastal Resources in Liberia

Coastal zones globally support more than 50% of the human population, resulting in coastal degradation and resource depletion (Charlier and Bologa, 2003). While coastal ecosystems are highly productive and valuable ecologically and economically (Fletcher *et al*., 2004), they are extremely sensitive to development. Globally, increased human migration from the interior to the coast (Fletcher *et al*., 2004) has had inevitable impacts on biodiversity in the coastal zone. The 14 years of civil unrest in Liberia resulted in many people from the interior settling along the coast for safety. Following the cessation of hostilities, many immigrants have chosen to stay in their new homes. Similar coastal migration occurred in other conflict zones (Dixon and Woods, 2003), e.g. Angola and Mozambique. The increase in coastal populations has exerted increasing pressure on coastal resources. This chapter summarises natural resource use in the coastal zone of Liberia, then assesses the importance and value of various key resources through a regional survey of resource use and household incomes.

*An overview of natural resource use in coastal Liberia*

Humans derive benefits directly or indirectly from natural resources provided by the ecosystems (ecosystem goods and services) for their well-being. Ecosystem services are the conditions and processes through which natural ecosystems sustain and fulfil human life and include regulating (water purification, climate, flood and disease regulations); provisioning (food, fresh water, wood and fibres); supporting (nutrient cycling, soil formation, primary production, etc); and cultural (spiritual, aesthetic, educational and recreational) services. Ecosystem services maintain biodiversity and the production of ecosystem goods (food, timber, biomass fuel, natural fibres, etc).

Natural products from Liberia's ecosystems form an important part of the domestic and subsistence economy, especially for rural people. The utilization of these ecosystem goods

and services in Liberia is often unregulated as the resources typically are considered to be communal assets. Residents within Liberia's coastal zone are predominantly fishers, farmers and gatherers (USAID, 2008). Although fish and bush meat are valuable resources, a diversity of plants provide medicine and construction materials and have cultural importance. Non-renewable mineral resources also contribute, though at a lower scale, to meeting the livelihood requirements of some coastal households.

*3.1. Plant resources*

Plants have been used by humans for centuries for multiple purposes ranging from food and medicines to construction. Globally, some 150 major food plant species are consumed by humans, of which more than 110 are indigenous to Africa. Some of these plants come from West Africa (Adeboyee and Opabode, 2004). The diversity of indigenous plants in Africa has been eroded by a multiplicity of environmental, political and socioeconomic factors including increasing human population and competition for natural resources, breakdown of cultural and traditional systems of plan resource management, deforestation, salinization, desert encroachment, climate change, among others (Adebooye, 2001; Bennett, 2002). Plants provide food, construction, materials, fuel, and pharmacological, social and environmental uses to Liberians.

Information on plant utilization in Liberia is limited. Bennett (2002) reported 214 food and medicinal plants, both indigenous and exotic, to occur in part of Sierra Leone, Liberia's western neighbour. It is most likely that some or all of these species occur in Liberia. Plants used for medicinal purposes in Liberia include *Allium cepha*, *Aloe vera*, *Carica papaya*, *Chrysthemum parthemium*, *Rawuolfia caffra*, *Matricaria recutita*, *Voacanga africana*, *Zanthoxylum zanthoxyloides*, *Hypoxis hemerocallidea*, *Persea americana*, *Phaseolus*

*vulgaris*, *Psidiun guajava*, *Justicia flava*, and several other species listed as endangered in West Africa (Adebooye, 2001). These plants contain many bioactive chemical substances (alkaloids, tannins, flavonoids, phenolics, etc.) that produce physiological and biochemical reactions. Natural products derived from these plants have received considerable attention in recent years due to their diverse pharmacological properties including antioxidant and antitumor activity. Hence, plants remain the main source of medicine and are indispensable in traditional medicine for treating a number of diseases in Liberia.

In Liberia, as in other West African counties, many fruits, shrubs, spices and herbs and leafy vegetables are used as foods and food drinks. A sample of the more important species is given in Table 3.1. Most contain crude protein, fats and oil, energy, vitamins and minerals (Adebooye and Opabode, 2004) necessary to ensure a healthy body. Some plants have multiple purposes and are thus especially valuable. For example, palm trees provide palm oil, sap used as wine, leaves for roofing thatch. Overall, these plants contribute to the livelihood requirements of coastal inhabitants and are supplemented by other sources such as fishing, petty trading and farming. In addition to the goods (food and medicine) provided by plants, other plants, including mangroves, also provide construction materials, and sources of energy for coastal households.

**Table 3.1**. List of plant resources commonly used in Liberia (Source: Land Rights and Community Forestry Programme (LRCFP) of Liberia).

| Species | Nature of product | Harvest season |
|---|---|---|
| *Xylopia aethiopica* | Fruit | Dry season |
| *Piper guineense* | Fruit | Dry season |
| *Coula edulis* | Fruit | Dry season |
| *Aframomum melegueta* | Fruit | Rainy season |
| *Ricinodendron heudelotii* | Fruit | Rainy season |
| *Beilschmiedia mannii* | Fruit | Dry season |
| *Garcinia kola* | Fruit | Dry season |
| *Elaeis guineensis* | Oil from fruit | Dry season |
| *Calamus* spp. | Vine | Rainy and dry season |
| *Raphia vinifera* | Branches and sap | Dry season |
| *Raphia palma-pinus* | Branches | Rainy and dry season |
| *Dioscorea* spp. | Tuber | Rainy season |

Several other plant species found along the coastline of Liberia play significant roles in meeting the livelihood and economic needs of coastal rural people. Plant species along the coast of Liberia provide medicine, food, wood, fuel, poles, among others for inhabitants. For example, the mangroves provide the main source of energy for rural households in coastal communities and are used for cooking, and smoking or drying fish and even bush meat. The increasing demand for fuel wood in fishing and other coastal communities has created a new production system based on fuel wood trading. This employs cutters, wood retailers, and charcoal producers and retailers. Woodcutters harvest wood from nearby mangrove and community forests. The wood is split into smaller logs for firewood. Some larger trees are sawn to produce planks for wood workshops and domestic construction. Offcuts are sold to firewood dealers who split them into smaller pieces for sale, or they are transformed into charcoal. However, most charcoal is produced in large quantities and transported to major centres such as Monrovia, Buchannan and Robertsport, where it is sold for approximately US$5 per 35 kg bag.

*3.2. Animal resources*

The coastal inhabitants of Liberia have subsisted for thousands of years as hunters and fishers using various wild animal resources. Today, many communities still rely significantly on the utilization of these resources to meet their livelihood needs. Wild animals are widely hunted throughout Liberia and are a major source of dietary protein for many rural households (Anstey, 1991). The meat derived from wild terrestrial animals is estimated to provide three-quarters of all animal protein consumed in average households inland from the coast. Three major sources of wild animal protein exist in Liberia. These include wild terrestrial animal meat, referred to here as 'bush meat', freshwater and marine fish ('fish') and aquatic invertebrates. The importance of bush meat and fish is well documented and both are known to constitute major sources of protein and income (Brashares *et al.*, 2004). Although not well documented, invertebrates such as shellfish, land snails and crabs, also contribute substantially to sustaining rural livelihoods in Liberia (USAID, 2008).

Terrestrial wildlife has been used extensively as a coping and survival strategy in Liberia. Human uses of these animal products include food, security and nutritional balance, employment and cash income, medicinal and health remedies, ceremonial and spiritual cleansing and cultural and religious practices. Wildlife has been traditionally regarded as a valuable community asset linked to these benefits. Therefore, while extraction for food and income for coastal residents is significant, terrestrial wildlife resources remain an important social and cultural tradition. In Liberia, a hunter is well respected as a person who has achieved manhood and is more likely to win a bride. As a result, many men go hunting even when they have alternative sources of protein and income (Bennet and Robinson, 2000). In addition to the hunting of mammals, many amphibians, birds and reptiles, especially marine turtles, are also hunted. Traditionally, marine turtles are hunted for their meat by coastal

residents, especially in the south-eastern region (SAMFU, 2003). The men fish for turtles at sea, whereas the women search the beaches to collect eggs from nests during the dry season.

Like wild terrestrial animals, fish is a valuable source of protein food in Liberia and is generally undertaken on a commercial as well as subsistence basis. Fisheries provide jobs, means of livelihood and protein diets for thousands of rural and urban households and is widespread in coastal Liberia as the major occupation of indigenous people. This sector also exploits the inland resources from the many rivers and creeks that traverse the country. Fishing pressure is very high in coastal areas, arising from the lack of alternative employment for estuarine and coastal communities thereby putting at potential risks in the event of an oil spill. Information on the harvesting and utilization of crustaceans, molluscs and shellfish as alternative sources of protein and income in Liberia is limited. However, the collection of these resources for domestic consumption typically is carried out by women and children.



*3.3 Non-renewable resources*

Liberia is one of the least explored, though highly promising, African countries for minerals (UNEP, 2004). Economic concentrations of iron ore, diamonds, gold and barite have been found in Liberia, and prospects for platinum, palladium, nickel, manganese and uranium are high (USAID, 2008). Mining is a major contributor to the economic growth and development of the country. Prior to the civil war, mining contributed more than 60% of export earnings and about 25% of GDP, with iron ore the major contributor (USAID, 2008). Mining is expected to have grown from zero production in 2005/2006 to 12% of GDP by 2010, contributing significantly to employment, income generation and infrastructural development (USAID, 2008). Currently, 26 exploration companies hold 53 licenses for gold and diamond mining in Liberia. This number is expected to increase as the Government of Liberia plans to

issue an additional 44 new licenses by 2013 (USAID, 2008; UNEP, 2004). In addition to the formal mining sector, some households are involved in illegal exploitation of alluvial gold and diamonds by to meet some of their livelihood requirements.

Beach sand extraction is a common activity in most coastal urban communities, especially Monrovia, performed by individuals for both domestic and economic reasons. Beach sand is generally used in construction, as it is believed that concrete made out of a mixture of beach sand and cement is superior to ordinary sand. Domestic uses include building houses and pavements. However, most sand mining is done on a commercial basis. Construction companies contract the services of young men to provide sand for their projects. In some instances, women and children are involved in the mining and selling of sand to meet their personal needs aside from the income provided by the household head. Alternatively, household heads organize their children into teams to increase income derived from mining. A truckload of sand sells for US$100–150 in Monrovia and its surroundings, and the group loading a truck is paid US$20-30 per truckload, which is substantial daily income for a household. Currently there are no regulatory measures in place to guard against the mining of sand from beaches in Liberia. Sand mining occurs throughout the year, but most intensively during the dry season when major construction works are undertaken.



*3.4 Resource use survey: Study Area and Methods*

A questionnaire survey was conducted with household heads in communities along the coastline of seven coastal counties (Grand Cape Mount, Bomi, Montserrado, Margibi, Grand Bassa, Rivercess and Sinoe) where 10 of the designated 17 offshore oil exploration blocks have been contracted. Given logistical constraints, the area was subdivided into three regions (Figure 2.1): Western Region (Grand Cape Mount and Bomi counties), Central Region

(Montserrado and Margibi counties) and Eastern Region (Grand Bassa, Rivercess and Sinoe counties). The Central Region includes the capital, Monrovia, whereas the Western and Eastern Regions are largely rural with important areas of conservation significance and diverse livelihood activities.

*General information on the study regions*

The Western Region has abundant mangroves and coastal rain forest that are greatly utilized by the local people to meet their livelihood needs. There are also areas of conservation significance including the Cape Mount Important Bird Area and Lake Piso lagoon, the largest lagoon in Liberia that forms the core of the proposed Lake Piso Multiple Sustainable Use Reserve as well as the Lake Piso Ramsar site. The coastline is dominated by sandy shores and is reported to serve as nesting and breeding grounds for marine turtles and resident and migratory coastal birds. The Western Coastline is also noted to have the best beaches for surfing and other water sports in Liberia. There are several major fishing communities. Farming centres on the production of cassava for domestic and commercial purposes.

The Central Region is the most populated area in Liberia with the largest fishing communities (West Point and New Kru Town). The region has more than a million coastal inhabitants living within 10 km of the coast. This region also contains some significant mangrove forests, including the proposed Mesurado and Marshall Ramsar sites that are home to numerous coastal birds and other biodiversity. This coastline is predominantly sandy, and the beaches are used for many recreational activities and support numerous hotels and lodges.

In the Eastern Region, households engage in farming and fishing, as well as other coastal resource harvesting. This region contains two major port cities with relatively large population concentrations, Buchanan (50,000) and Greenville (13,000). This region also hosts the Cestos-Senkwen IBA that is reported to be home to many near threatened and threatened

bird species as well as several other vulnerable wildlife species (Robertson 2001). The coastline is dominated by rocky shorelines.

*Household Interviews*

Within each region, communities resident within 10 km of the coast (Figure 2.1) were selected to represent a typical set of coastal resource users. Due to the relative sizes of the three regions, 12 communities were sampled in the Western Region, 12 in the central region and 18 in the Eastern Region. The resource-use questionnaire (Appendix 2) was tested in two communities; one right on the coast and one farther inland (but still within 10 km of the coast). Attempts to conduct a systematic survey contrasting the responses of coastal versus inland communities proved futile due to difficulty of access to most inland communities during the rainy season when many access routes are flooded. Site visits were undertaken between 19 September and 10 December 2011 with the help of a research assistant. A total of 316 household heads (the person responsible for making household decisions) were interviewed regarding the composition of household income and natural resource utilization. Observations were also made of the everyday life of the households visited.

In densely populated communities (Robertsport, West Point, New Kru Town, Buchanan and Greenville) every third household was sampled, whereas in sparsely populated communities, every second household was sampled. Interviews were conducted in "Liberian English" as this is widely spoken. There were, however, a few problems encountered due to sensitivity of certain issues. Given the current conservation policy against the illegal killing of marine turtles and exploitation of mangroves in Liberia, coupled with the principal researcher's former status as Park Warden of a Protected Area, questions dealing with mangrove and marine turtle utilization often resulted in a lot of suspicion. This complicated the gathering of information, especially in the Western Coastline where the researcher formerly worked.

Often, it took a long conversation to win the confidence of the respondent and to enable them feel comfortable enough to answer to questions honestly. Another problem encountered was the fact that the survey was conducted during the campaigning for Liberia's 2011 presidential and legislative elections, when communities expect politicians to give them handouts. Some household heads refused to be interviewed because they were not going to benefit directly.

***Results***

The 316 heads of households interviewed were spread over the three regions as follows: Western Region (N=76), Central Region (N=74) and Eastern Region (N=116). Households (people eating from the same source) were large throughout, with an overall mean of 8.1 ± 4.0. Households typically comprised of a husband, wife and children, although some polygamist households had several wives. Most (73%) of the households interviewed were natives of the study area while the remainder were internal immigrants along with few Fantis who had settled in the area over ten years for reasons including economic opportunities, marriages and as refugees.

*Livelihood composition*

Households were engaged in a range of livelihood activities (Table 3.2) at various levels (Figure 3.1). More than 60% of households engaged in, and derived income from, fishing in combination with other livelihood activities. Only 5% were exclusively engaged in fishing and a fewer than 5% were exclusively trading or farming. Four respondents claimed to earn their primary income from employment (approximately US$200/month), although they also engaged in farming, fuel wood and other resource collection, and trading. There were three retired and/or pensioned household heads who claimed they were not receiving pension benefits from the government, but depended solely on farming.

**Table 3.2**. Proportions (%) of Liberian households engaged in various livelihood activities by region.

| Activity | Western Region | Central Region | Eastern Region | Average |
|---|---|---|---|---|
| Fishing | 38 | 65 | 87 | 60.4 |
| Farming | 71 | 47 | 56 | 57.6 |
| Mangrove harvesting | 28 | 14 | 11 | 16.1 |
| Hunting | 24 | 13 | 19 | 19.0 |
| Wild resources | 37 | 26 | 30 | 31.0 |
| Petty trade | 72 | 56 | 81 | 73.7 |

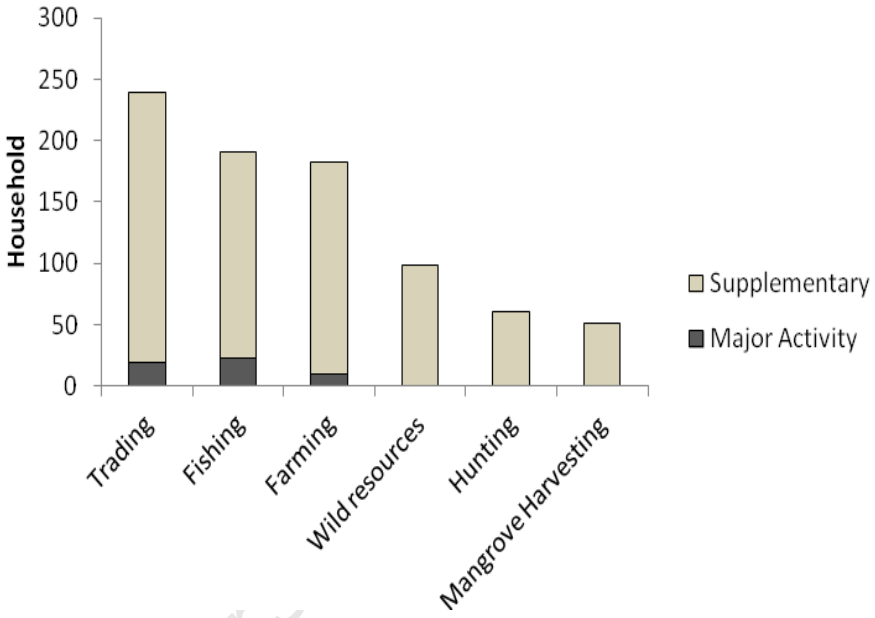


**Figure 3.1.** Proportions of households engaged in various livelihood activities in the coastal zone of Liberia. Only a few respondents indicated that any given activity contributed overwhelmingly to their livelihoods.

Households derived majority of their monthly income from three major activities; fishing, farming and mangrove harvesting, although other activities like trading, sand mining and other wild resource harvesting also contributed to income (Table 3.3). On average, households derived over 75% of their income from natural resource utilization, i.e. fishing, mangrove and other wild resource harvesting, 29% from farming alone and 6% from other activities (trading, sand mining and employment). Monthly household income increased from west to east (Table 3.3).

**Table 3.3.** Monthly household income (US$) derived from various livelihood activities in coastal Liberia

| Resource | Western | Central | Eastern | Average |
|---|---|---|---|---|
| Fishing | 695 | 1225 | 1446 | 1122 |
| Farming | 455 | 270 | 242 | 322 |
| Mangroves | 192 | 108 | 127 | 142 |
| Other activities | 75 | 150 | 90 | 105 |
| Total Income | 1417 | 1753 | 1905 | 1692 |

Fishing, farming (cassava production) and mangrove harvesting (charcoal production) were the major sources of income for households in the study area (Figure 3.2). Fish sales constituted the highest (70%) source of overall income derived, followed by sales of *fufu* (19%; a product made from cassava which is a staple food in Liberia). Income derived from mangrove harvesting came from the sale of charcoal (8%), as it is the major source of energy in coastal Liberia.

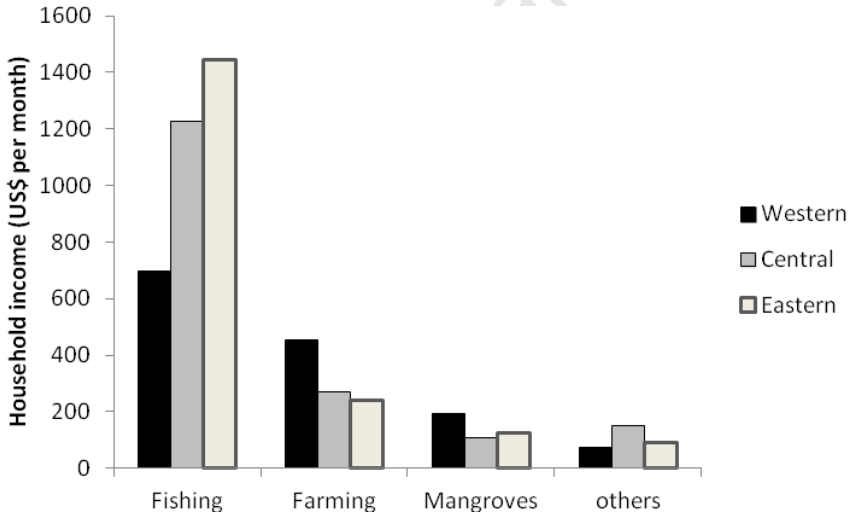


**Figure 3.2.** Major sources of household income for inhabitants in the coastal zone of Liberia.

*Petty trade*

More than half (73%) of the households surveyed engaged in trading at various levels, ranging from trading a single item at the front of a house to large provision shops and stores. Most petty trade undertaken by rural households was to earn cash income that enabled them

to respond to immediate needs or emergencies. Although only 6% of the respondents claimed to engage exclusively in petty trading, most households interviewed carried out some level of trading in combination with other livelihood activities to meet their household food and cash requirements. Goods traded included harvested products (fish, *fufu*, *gari,* fuel wood, etc.) and manufactured products (canned products, toiletries, etc.). Of all respondents engaged in petty trade, 37% traded in a market, 28% traded in front of their homes and 4% took their wares around the community. Only 2% of all the respondents owned, and sold in, shops and stores. By region, 81% of respondents in the Eastern Region engaged in petty trade and households also engaged in petty trade in the Western Region (72%) and Central Region (56%).

On average, petty trade had the greatest proportion of household engagement, followed by fishing and farming activities. Petty trading was contingent on the harvests from fishing, farming, mangroves products, hunting and gathering of wild resources. The proportion of households collecting mangroves was relatively lower than other activities, although it contributed a major proportion of income for households engaged in the activity. Most cash income came from the sale of fish, charcoal and *fufu*. Rice production, hunting, fuel wood harvesting and the collection of wild resources were mainly carried out for subsistence use, although sales of some of these resources (e.g. fuel wood and bush meat) were significant. Fuel wood collection, gathering of wild resources and hunting are three activities that generated income for less than 5% of households in the study area. Petty trade typically was carried out by housewives to generate some income for the household.

*Fishing*

Fishing provides more than 60% of employment to rural households owing to its huge demand for labor. The level of dependence and utilization of fishery resources by coastal households in the study area indicates the significance of the fishery sector to the survival of

rural coastal inhabitants. Although 60% of households engaged in fishing, the activity was important for more than 90% of households as it was the only readily available source of protein for many homes. Fishing activities included harvesting, processing and trading. Fishing also included harvesting of marine turtles. Fishing contributes significant cash to households and is carried out by indigenous Popo, Kru, Grebo and Bassa fishermen, and immigrant Fanti fishermen from Ghana. These groups constitute the artisanal fishing sector that also exploits inland resources from estuaries, lagoons, rivers and creeks. More than half (59%) of the households in the Eastern Region engaged in fishing activities while in the Central and Western Regions, less than a quarter of households engaged in fishing (26% and 15%, respectively). A kilogram of fish sells for US$1.50 and almost all of fishing households sold most of their catch, although some was used in the household.

About half of the fishing households in the Central and Western Regions and 35% in the Eastern Region only engaged in catching fish while the remainder also engaged in processing and trading. Fishing was the dominant activity in the study area. Fewer than 10% of respondents confirmed harvesting marine turtles, and most marine turtle harvesting was done in the Eastern Region. There was no confirmation of turtle harvesting in the Central Region, although respondents knew what marine turtles were. Respondents in the Western Region reported sending their wives and children to hunt turtle eggs along beaches during the dry season.

Most fishing households fished from dugout canoes with paddles. Only a few respondents used canoes powered by an outboard engine, and most of these were immigrant Fanti fishers whose sole business was fishing. Older and retired fishers and children used the traditional hand-made fishing baskets to fish in estuaries and smaller water bodies in the community. Fishing from boats took place 8-11 months per year, but fishing baskets were used all year.

*Farming*

Over half (58%) of coastal households engaged in farming activities either exclusively or in combination with other activities. In the Western and Central Regions, more than half (56% and 71, respectively) of households farmed compared to 47% in the Central Region. Nearly all of the farming households (95%) were engaged in food crop production. Most cassava was grown for sale whereas rice was farmed mainly for domestic consumption. Cassava was the second most important source of income for households. Cassava products such as *fufu* and *gari* are staple diets in Liberia. *Fufu* and *gari* obtained higher prices than the crude cassava, thus most households converted cassava into these products for sale in market in Monrovia and its environs. Few respondents (2%) produced other cash crops (coconut, domestic palm and rubber) and only one respondent was engaged in animal rearing (chickens and goats). Almost all farming was done with manual labour, although a few individuals used chainsaws.

*Mangrove harvesting*

Mangrove wood is a major resource of income for households in the coastal zone. The mangroves are primarily utilized as source of energy or poles, although three respondents use mangroves to produce dye for the fishing nets. Proportionately, more households (29%) in the Western Region harvested mangroves for various purposes than those in the Central (15%) and Eastern (11%) regions (Figure 3.3). All of the mangroves utilized in the Western and Central Coastline regions were harvested from conservation areas (Lake Piso Wetlands and Marshall Wetlands, respectively). Households in the Eastern Region however claim to harvest some fuel wood from secondary forests around their communities although they also harvested from wetlands.

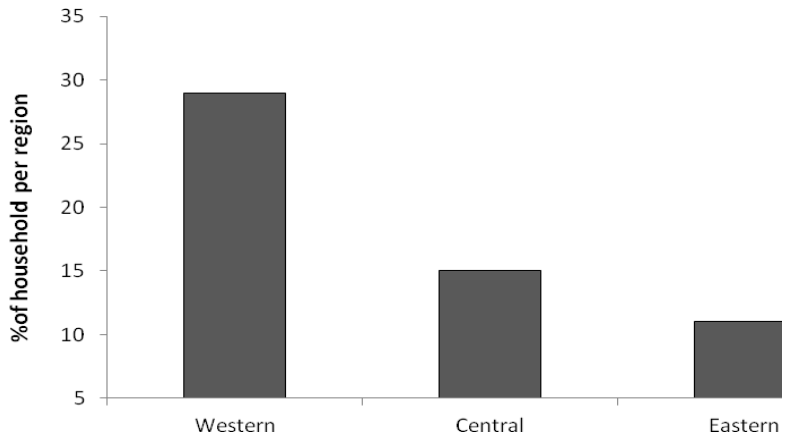


**Figure 3.3.** Percentage of households harvesting mangroves per region in the study area.

Mangroves are widely harvested year round for both subsistence and commercial purposes and provide income and livelihoods to coastal rural households. The species commonly harvested are *Rhizophora racemosa* and *Avicennia germinans,* Firewood is mainly used for home consumption or for small scale marketing including charcoal production, poles, and producing traditional medicines. Most households harvesting mangroves indicated their dependence on the resource as their primary source of livelihood and analysed their monthly income from charcoal production alone to average more than US$500 monthly (B. Massaquoi, County Agriculture Coordinator, pers. comm.). One respondent indicated using proceeds from the sale of mangrove products to pay for his children's tuition fees at a university in Monrovia. This confirms the high level of dependency of coastal rural households on mangroves as a source of livelihood and income.

Most fuel wood harvested was used for cooking and warming houses during the cold season, whereas the charcoal and poles were produced mainly for income generation. Households in the Western Region were proportionately the highest producers of charcoal and fuel wood whereas the Eastern Region constituted the highest producer of poles. Mangroves were harvested with cutlasses, axes and chainsaws.

*Hunting*

Hunting provides alternative sources of protein for coastal households in Liberia. Hunting households in the study area constituted 15% of total households interviewed, of which 12% indicated hunting shorebirds. Hunting was not a major activity in coastal Liberia. Fewer respondents in the Eastern, Central and Western Regions engaged in hunting (Figure 3.4). Respondents claimed to use wire traps (80%), shotguns (5%), poison (3%) and hunting dogs (12%) with cutlass and /or traditionally made spears during their expeditions.

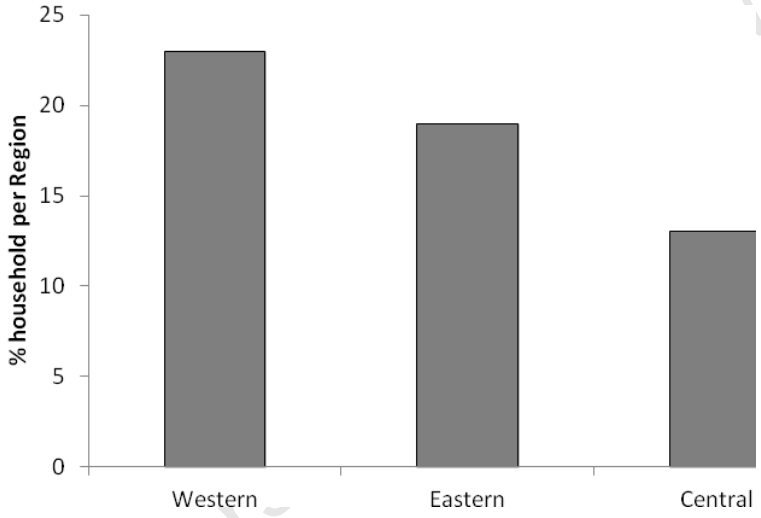


**Figure 3.4.** Percentages of households engaged in hunting in each coastal region.

Animals commonly hunted included duikers, rodents, reptiles and shorebirds. Most were hunted for food, except for shore birds that were often captured alive and sold as pets. More than half of the hunting households indicated hunting in wetlands, whereas a few, especially in the Eastern Region, hunted in nearby forests that still hold diverse wildlife populations. This was likely the reason for more hunters being found in the Western and Eastern than the Central Region. Hunting occurs year round. Capture rates were low; it often took a hunter more than a week to catch an animal in a wire trap.

*Other wild resources*

Other wild natural resources, including fruits (29% of households), honey (25%), palms (24%) and medicinal plants (23%), are important for rural households. These are mainly used for domestic purposes; fewer than one third of households (31%) gain income from harvesting and utilizing these resources. Wild palms were used to produce palm oil for commercial purposes that contributed income to households. Medicinal plants also were collected by household heads and used to cure the sick in the community who pay them some money for their services. Medicinal plants were also taken to urban areas for petty trading. Saleable wild plants and animals are reported to derive between US$100-300 per households in some rural communities (V. Konneh, Environmental Protection Agency, pers. comm.)

*Mining and other activities*

Mining (gold, diamonds and beach sand) constituted only a very small proportion of household incomes in the coastal zone, except in Monrovia where there are organized unions and other groupings engaged in sand mining nationally. Beach sand mining was done by < 2% of households in rural coastal communities whereas only two respondents indicated mining gold. One respondent operated a barber shop but only worked there on weekends.

***Discussion***

Residents in the coastal zone are dependent upon renewable natural resources for food, raw materials and cash income. Many communities living adjacent to abundant natural resources pursue livelihoods based on the use of renewable natural resources (Dyer *et al.*, 1992). Dependence on these natural resources can shape cultural values, social networks, and occupational roles to such an extent that loss of the natural resource base can have profound community impacts (Bennett, 2002; Cinner and Bodin, 2010).

Empirical evidence on traditional lifestyles and natural resource utilization in the coastal zone of Liberia demonstrates its importance in meeting the livelihood and income requirements of residents. The coastal lifestyle is centred around the utilization of coastal and marine natural resources. Natural resource utilization, not including farming and trading, comprises over 70% of households' sources of income (Figure 3.2). This indicates a high level of reliance on natural resources. Natural resource-reliant communities tend to be socially, psychologically, culturally, and economically vulnerable to disasters that threaten their resource base (Dyer *et al.*, 1992).

Recent increases in the Liberian coastal population as a result of the civil war, coupled with open-access use of natural resources and pollution, are likely to result in the degradation of natural resources base in coastal Liberia. Oil exploration in Liberia (Chapter 2) is likely to exacerbate human impacts on coastal ecosystems and a large oil spill could have disastrous and immediate consequences (Chapter 4). Prudent management and sustainable utilization of natural resources by resource users and the development of oil spill contingency plans will serve the dual purpose of ensuring livelihood security in coastal Liberia while the country benefits from its oil wealth.

*Household characteristics*

Based on the 2010 National Housing and Population Census of Liberia (NHPC, LISGIS), the coastal zone has an estimated 2.2 million inhabitants. Like many sub-Saharan African countries, Liberia still has the extended family system where distant relatives are counted as family (Eloudou-Enyegue and Stokes, 2002). The average Liberian household consists of five individuals, with women constituting 31% of household heads in Liberia (Anadarko Liberia Company, 2011). However, the average household size in the coastal zone is larger (10) and only 5% of households are headed by women. This result accords with observations of large,

male led households in this study. Most residents in the study area are natives, although a few immigrants have lived in the area for over 10 years and have integrated into the society and culture of the residents. More than half of Liberia's coastal population, especially outside of Monrovia, are fishers and farmers who engaged in these activities to achieve their daily livelihoods requirements.

*Basic livelihood activities*

Livelihood defines the adequate stocks and flows of food and cash required to meet basic human needs (Ellis, 1998). Livelihoods in most tropical coastal communities depend on a range of occupational sectors, such as agriculture, fisheries, and informal economic activities including trading, transportation, etc. (Cinner and Bodin, 2010; Andersson and Ngazi, 2011). Natural resource-based activities, such as fishing, mangrove harvesting, hunting and gathering of other wild resources are basic sources of livelihood in coastal areas in Liberia (Wiles, 2005), especially in areas with poor soil conditions where agriculture is practiced on a smaller scale.

Livelihood activities in coastal Liberia are diversified, as is the case in most coastal communities in sub-Saharan Africa (Ellis, 2000) and in impoverished coastal communities around the world (Carter and May, 1997). Carter and May (1997) reported the seasonal variation in natural resource availability as a major driver of livelihood diversification given the need for regular household income. Coastal and marine environments in Liberia provide an important service to poor rural households by spreading the risks associated with land-based activities including farming. They function as a safety net for families suffering shocks and can be critical for poorer households that lack alternative sources of income.

Liberian households rely heavily on natural environmental resources to meet their daily needs. Carter and May (1997) reported the partial reliance of some rural households in sub-

Saharan Africa, especially in South Africa, on social security benefits. Such alternative sources of livelihood are absent in Liberia, placing additional pressure on individuals as well as on the resources on which they rely. Most rural households in coastal Liberia, including those not directly involved in the use of coastal or marine resources, are liable to benefit from the economic activity and food supply generated by fishing activities or the exploitation of other marine and coastal resources. Coastal swamps and mangroves play an important role in providing protection of coastal inhabitants from storms, tidal surges and coastal erosion, whether or not they are direct users of these resources. These people can also use a range of "wild" assets (fruits, roots, tuber, medicine, wine, etc) available in coastal areas. Or they can "convert" their produce or labour into earnings that are later converted into food.

## Chapter 4. Coastal Vulnerability to Marine Oil Spills.

Previous chapters have summarised the biological and socioeconomic environments of the coastal zone of Liberia. The coastal zone comprises a variety of sensitive environments and natural resources that are of great significance to conservation and human livelihoods. It is home to a variety of aquatic and terrestrial biodiversity including species listed on the IUCN Red Lists and hosts five conservation areas of international significance (Chapter 2). In addition, the coastal zone is home to over half of Liberia's 3.7 million people, most of who depend heavily on coastal environments and natural resources to meet their livelihood and economic needs. Thus, the coastal zone represents an important resource for biodiversity and humans, so its protection and sustainable management is essential. In combining an ecological, social and economic approach, this chapter provides an assessment of the impacts that oil spills are likely to have on various components of the coastal and marine environment, and thus on the utilization of natural resources by coastal households. It also highlights the need for an oil spill contingency plan ahead of oil exploration and, potentially, production operations.

The methods used to assess the vulnerability of coastal and marine biodiversity and environment to oil spills represent a rapid technique for identifying vulnerable environment and natural resources, especially when time and limited access to the study area are of essence. Based on empirical evidence from elsewhere (e.g. Nigeria, UK and Venezuela), oil spills are likely to occur off the coast of Liberia, with deleterious impacts on human livelihoods, economies and the environment. Estuaries, coastal lagoons, wetlands and mangroves provide key resources to rural households and are highly sensitive to oil spills, more so than rocky and sandy shores. Oil spills impacting on these habitats will have negative implications for the survival of rural households. From analysis of potential impacts of oil spills on biodiversity, the environment, livelihoods, income and other social aspects of

coastal inhabitants and natural resources in the three regions of the study area, it can be concluded that the Western Region (Chapter 3) will be most vulnerable to an oil spill event followed by the Central Region (Chapter 3). Residents in the Eastern Region, unlike the Western and Central Regions, will benefit from their alternative sources of income and livelihood, farming and other coastal resource harvesting in an event where their major resource base, fishing, is affected by an oil spill. The rocky shores dominating the eastern coastline makes it less difficult to clean up in the event of a spill compared to the sandy shores of the western and central coastlines.

*4.1. Potential sources of spilled oil*

Oil spills are likely to result from two major sources: shipping accidents and exploration and production operations during drilling and well testing (Chevron Liberia, 2011). Shipping accidents were a major concern in the 1980s and 1990s (IPIECA, 1993) and is still continued to date. Chevron Liberia, for example, intends to use the port of Takoradi, Ghana, as its main supply base while drilling in Liberia. Equipment and materials required to support drilling are expected to be delivered from Platform Supply Vessels (PSVs) sailing between Liberia and Ghana. This highlights the likelihood of potential oil spills from shipping during drilling operations. In addition, minor oil spills may occur during transfer of fuel to the drilling rig. However, the most significant impacts are likely to come from a major spill during exploration or production.

A properly managed drilling unit will have no more impact on the environment than any ocean-going vessel with a similarly-sized crew. There are, however, two potential exceptions to this: the discharge of drilling muds (in particular, those that are oil-based) and cuttings, and an accidental spill either as a result of a well blow-out or when transferring fuel to the drilling rig. Oil based muds are used for many reasons including increasing lubricity in oil wells and

discharges of them are therefore common problems associated with offshore oil drilling. The impact of the discharge of drilling muds and cuttings is site-specific and depends upon the water depth and the nature of the receiving environment. No oil-based muds (OBM) or low-toxicity oil-based muds (LTOBM) should be discharged into the sea but should be taken ashore for re-conditioning and recycling or disposal in a suitable land-fill site. In the past, oil based muds were used extensively when drilling for oil and the discharged oily cuttings could have a significant, but local impact on seafloor biota.

Most worrying is the risk of accidental oil spills during the exploration or production process due to well-head failures or other technical problems. Such spills can result in potentially huge volumes of oil entering marine systems, often with significant environmental and economic impacts (Bozeman, 2011). Given the prevailing southerly (onshore) wind and wave conditions at sea off Liberia (Chapter 2), any event of an oil spill is most likely to impact coastal biodiversity, the environment and socioeconomic activities of coastal inhabitants and resource users of Liberia. The coastal environments (beaches, wetlands, lagoons and estuaries along with their associated mangrove resources) are particularly sensitive to oil spills which will render them vulnerable and deprive the poor rural people of their livelihood and basic human rights. Consequently, oil spill contingency plans should focus on the interception and treatment of spills at sea. The use of dispersants on oil spills is controversial but in the case of sensitive coastal ecosystems such as mangroves, the need to protect the habitat and its associated biota outweigh the damage to open sea biota when a spill is treated with dispersant offshore (IPIECA, 1993). The following sections provide a preliminary assessment of the effect that a spill would have on components of the marine and coastal environment.

*Fish*

Although local mortalities especially of fish larvae and fish eggs occur occasionally, mortality of pelagic fish as a result of oil spills is limited and has not translated into measurable effects on fish stocks (Baker *et al.,* 1990). By comparison, demersal, nearshore and estuarine stocks, especially those species feeding on the sediment surface (e.g. soles and some mullets Mugilidae), may suffer mortalities through ingesting contaminated sediments. This has been observed on the Brittany coast where plaice (*Pleuronectes platessa*) stocks were adversely affected for at least two years by the *Amoco Cadiz* oil spill (Seip, 1984). These fish are mobile and can move out of the impacted areas. However, the total range can be significantly decreased by a major spill, leading to major implications for fish populations as a whole. An oil spill therefore can have a major negative impact, especially upon nearshore and shallow water fish species (Mosbecsh, 2000).

Fisheries in coastal rural communities of Liberia are complex, dynamic and adaptive. They are engaged in full time by some people, as part of a mixed farming-fishing-resource harvesting strategy by others, and range from subsistence fishing, through petty trading to fully commercial operations. Fisheries provide food security, employment, financial benefits and social and cultural benefits to rural households (Alder and Summaila, 2004). However, people involved in fishery-related activities are vulnerable to a variety of factors including pollution. Fishing as an occupation carries its own risks, due to the fugitive nature of the resource, the hostile environment of the ocean and the perishability of the resource. Liberia's coastal waters support important artisanal and industrial fishing for pelagic and demersal species. An oil spill can lead to tainting of fish rendering products unmarketable, alteration of habitats thus affecting availability and/or recruitment and oiling of gear leading to increased maintenance or replacement costs. This will have economic implications for coastal

rural inhabitants who rely fully on fishing for as a way of life and will subsequently increase poverty among coastal rural inhabitants.

*Marine turtles*

Adult and juvenile turtles can avoid oil slicks. The most vulnerable stage in the turtle life history is if an oil slick reaches beaches where hatchlings are about to emerge and migrate to the sea. As a result, the potential impacts of oil spills on Liberia's turtle populations are unlikely to be significant. However, any unnecessary mortality to these threatened species will place them at even greater risk than the situation at present.

*Marine mammals*

Like turtles, cetaceans can detect and avoid oil slicks, although Scholz *et al.* (1992) have seen various whale and dolphin species surfacing in oil slicks. Direct oiling of whales and dolphins is not considered to be a serious risk as their skin contains a resistant dermal shield that acts as a barrier to toxic petroleum compounds (Scholtz *et al.*, 1992). Several whale species and three dolphins (humpback *Sousa teuszi*, northern right whale *Lissodelphis borealis* and bottlenose *Tursiops trucatus*) have been observed to swim through oil slicks without apparent deleterious effects (Garaci and St.Aubin, 1988). Therefore the direct and indirect impacts upon these highly mobile animals are liable to be short term and insignificant on a regional scale (Scholz, 1992).

*Seabirds and Palaearctic waders*

Seabirds are conspicuous victims of oil pollution in the sea (Mosbech, 2000). Even moderate oiling can lead to death, due to reduced thermoregulation and/or insulation. In the longer term, the toxic effect of oil ingested while attempting to preen can reduce reproductive

success. It is also evident that direct observations of bird mortalities through oil spills probably reflect 10% at most of the actual mortalities (Volkman *et al.,* 1994). Sea and coastal birds in Liberia are thus vulnerable to oil slicks. If oil were to reach some of the major estuaries and lagoons, this high negative impact may extend to the population level as a result of their utilization of these estuaries and lagoons for various purposes.

*4.2. Potential impacts on coastal inhabitants*

Although oil wealth contributes to the growth and development of nations, it may have negative impacts on the environment and socioeconomic/cultural activities of people who rely heavily on potentially affected natural resources for their livelihoods. The development of offshore energy resources poses potential risks for humans and natural resources (Volkman *et al*., 1994). These risks include damage to the natural resource base such as fisheries and mangroves as well as coastal conservation areas resulting in the loss of income and increased poverty. The harmful effects of oil spills on living resources have been studied extensively (Geraci and St.Aubin, 1988; Carl and Meador, 2009; Davoodi and Claireaux, 2007), although only a few studies have explored the repercussions of oil exposure on human health (Aguilera *et al.,* 2010). Oil spills can have direct as well as indirect effects on human lives in oil-contaminated areas.

The lives of coastal inhabitants are intertwined with the health of these environments and the natural resource on which they rely. The impacts of oil spills on local livelihoods can be extensive, devastating the resource bases including farming hunting, wood harvesting, gathering and fishing grounds. This impact will result in loss of income in the tune of thousands of dollars per household from various natural resources, especially fishing, which contributes significantly to household incomes (Chapter 3). Most rural households have an extended family system, in which, for example, a fisherman is relied upon to provide fish for

30-40 individuals, while they might supply him with crops and other products. In the worst case scenario, a huge spill such as occurred in the Gulf of Mexico in 2010 would have devastating impacts on the lives of not only fishermen, but also their extended families. Such a situation will exacerbate existing poverty. Also of significance is the impact on farms, especially those adjacent wetlands that feed from affected estuaries and lagoons. Crops that come in contact with oil, including fumes from spills, are ruined (Amnesty International 2009; Cinner and Bodin, 2010; UNEP, 2004; USAID, 2008). Sometimes, spilled oil persists for years with the long-term effect of undermining a household's only source of livelihood. Communities in the Niger Delta have reported long-term effects of oil spills to include delayed germination, stunted growth in trees and smaller fruits, and in some areas, land being rendered unusable for years or even decades (Amnesty International, 2009). As a result, oil can devastate the lives of coastal inhabitants and deprive them of the basic rights to survival (Aguilera *et al.,* 2004; Wiles, 2005). A catastrophic oil spill in Liberia's coastal zone will likely deprive inhabitants of an adequate standard of living, rights to food and result in damage to farms, fisheries and other natural resources through the pollution of sensitive dependent environments.

The impacts of an oil spill washing ashore are not confined to rural communities. The beaches around the major cities and towns (e.g. Monrovia, Buchanan and Robertsport), offer important recreational amenities for the local population. Oiling of these beaches will negatively affect their recreational amenity value. Natural oil weathering processes transform the oil within the first month, leaving heavy residues on the beaches, which may persist for upwards of a year.

*4.3. Vulnerability of coastal and marine environments to oil spills*

Oil spills at sea have their greatest impacts on the biological resources in shallow, nearshore communities (Scarlett *et al*., 2008). Mangrove forests, estuaries and coastal wetlands are particularly vulnerable to oil spills. A Vulnerability Index (VI) has been used in combination with the modified zonal method for rapid assessment of the coastal environment (Gunlach and Hayes, 1978) to score the potential vulnerability of coastal environments to oil spill damages. This method is an effective, rapid and relatively low-cost method for providing baseline information to coastal managers and practitioners concerned with oil spill contingency planning. The following classifications and rankings are used: VI 8-10 (most vulnerable); VI 3-7 (intermediate); and VI 1-2 (least vulnerable; Gunlach and Hayes, 1978).

*Beaches*

Beaches typically have an intermediate vulnerability index (3-7; Gunlach and Hayes, 1978). Marine organisms inhabiting the inter-tidal and immediately sub-tidal zones of beaches characteristically form different communities and associations that differ in the cross shore and alongshore dimensions. The latter are due to long shore variations in sediment distributions mediated by sediment supply and wave action. Beach communities are potentially exposed to acute toxicity by direct oiling and sub-lethal effects due to incorporation of the less volatile oil fractions in the sediments. Volkman *et al.* (1994) reported high mortalities of sea urchins, cockles, razor clams and crustaceans such as amphipods and crabs on oiled beaches and adjacent sub-tidal areas. Some species show greater tolerance to oil, such as burrowing invertebrates like polychaetes, which may be able to use the oil as a source of organic material suitable for food (Scholz *et al.,* 1992). This in itself can result in highly modified benthic communities with 'knock on' effects for predators (e.g. fish and birds) and other links in the food chain.

Oiling is especially serious in low energy, coarse-grained beaches, where the effects of an oil spill may be evident in biological communities for over five years after an oiling event (Culbertson *et al.*, 2008). The duration of impact on exposed, high-energy beaches is usually much shorter, but the instantaneous mortalities may be as high (Nounou, 1980). Also, the coarse sands typical of exposed beaches may allow oil to percolate into the sand. Such oil may be re-mobilised by storms, causing further pollution effects.

Oil spill, depending on the type, quantity and metocean conditions, is most likely to have severe economic consequences on coastal wildlife and their habitats including beaches and rocky shores, recreation and tourism activities, among others. Most ocean-related industries will be affected in some way and damages to lives and property along the shoreline will be considerable making them unusable, since the storms will wash oil up beyond the normal high-tide line. Areas of cultural, economical and natural resources are likely to suffer pollution and especially on oiled beaches, fishing activities will be suspended with beach recreation and tourism suffering precipitous drop resulting in closure of businesses and loss of substantial income directly or indirectly to affected communities and stakeholders. Fishing and beach recreation jointly provide over 65% employment opportunities to rural households and contribute over 10% of Liberia's GDP (UNEP 2004). An event of an oil spill will therefore have economic implications for coastal inhabitants, beach recreational owners and users, hotels, beachfront homes and resort owners as well as the national government.

Oil spills (Chapter 1) may be due to releases of crude oil from tankers, offshore platforms, drilling rigs and wells and other sources can have devastating impacts on the environment, biodiversity, livelihoods and economies of nations. Clean up and rehabilitation, though costly, is a way forward to remedying such impacts after a spill. Disposal of oil, particularly following shoreline clean up, is a major problem, especially when large amounts of oily

debris are collected. The costs of disposal, including handling, separation and transport are also likely to be high and make up a significant proportion of the overall costs of the clean-up and rehabilitation operations.

Beach rehabilitation is labour and capital intensive and its duration will depend on several factors including the quantity of oil spilled, prevailing weather condition, and type of shoreline and / or beaches, among others. Oil can penetrate deep into the sand on beaches, making it difficult to remove and enabling the oil to continue to cause problems over time. Oil spills are easier to clean up when they are on a rocky coast as opposed to a soft and marshy shoreline or delta. Oil is more likely to stick to rocks, making it easy to see and to clean. Once the oil sinks into wet sand, there is a greater chance that it will not be completely removed from the area. Recovery time for oiled beach varies and depends on the type and quantity of oil spilled, the method used (Baker *et al*., 1990; Dyer *et al*., 1992) and the prevailing environmental conditions at the time of the cleanup.

Rehabilitating oil beaches is difficult and several methods have been recommended as follows: bioremediation which involves the use of biological agents to breakdown or remove the oil; control burning to reduce the amount of oil on the water; use of dispersants; dredging, skimming, solidifying and use of vacuum and centrifuge.



*Estuaries and coastal wetlands*

Estuarine systems typically have a high vulnerability index (8-10; Gunlach and Hayes, 1978). Their components most exposed to oiling are intertidal mudflats and mangroves. Mudflats suffer the same problems as low-energy beaches, with oil residues becoming trapped in their sediments. Mangroves are particularly sensitive to oil pollution, and spills have been reported to kill mangroves in many areas (Thorhaug, 1992; James *et al*., 2007). Volkman *et al.* (1994) reviewed the impacts of oil spills, and reported recovery times of low energy intertidal

communities such as mangroves as being 10-15 years. Experimental studies and field observations show that the impact of oil spills on mangroves can be divided into two phases: (1) the short-term mortality phase, attributed to coating with fresh oil and probably to the aromatic hydrocarbon content; and (2) the longer-term effects of weathered oil becoming incorporated into the sediment, inhibiting the growth of seedlings and larger plants (Volkman *et al.,* 1994). The Red Mangrove (*R. racemosa*) and the Avicennia species were reported to be killed by heavy or viscous oil that covered the trees' breathing pores thereby asphyxiating the subsurface roots which depend on the pores for oxygen (Agbogidi, 2011). It appears, however, that these species are not killed by oil spills that do not sink into the root systems, but only oil the bark of trees at high tide (Thorhaug, 1992). Oil slicks enter mangrove forests when the tide is high and are deposited on the aerial roots and sediment surface as the tide recedes. This commonly leads to a patchy distribution of oil. Other organisms associated with mangroves are affected in two ways. Firstly, there may be heavy mortalities as a direct result of the oil. For example, oil may penetrate burrows in the sediments, killing crabs and worms, or coat molluscs on the sediment surface and aerial roots. Secondly, those species that survive the direct impacts of the oil suffer from the impact of habitat loss, as oiled mangroves die back (IPIECA, 1993).



*The need for an oil spill contingency plan*

Liberia lacks the basic infrastructure to respond rapidly in the event of an oil spill reaching the coast. This lack of infrastructure is one of the reasons why Chevron Liberia chose to use the Port of Takoradi as its main supply base. Many vulnerable coastal communities lack access roads, making it almost impossible for response teams to reach affected areas overland from Monrovia in the event of a spill. Effective responses probably will require the mobilization of international aid teams to conduct clean-ups.

The impacts of oil on coastal resources and livelihoods need to be considered when planning any kind of response. This study recommends the development of an effective National Oil Spill Contingency Plan (NOSCP) that will define the role of the Government of Liberia in respect of its responsibility as the environmental conscience of the Nation regarding all spillages of oil, whether accidental or deliberate, from whatever source and of whatever size, which will threaten the Liberian environment. The NOSCP of Liberia should outline Liberia's arrangements for responding to oil spills in the marine environment, with the aim of protecting against environmental pollution as a result of oil contamination and where this is not possible, minimise the effects. This plan should also include details of all oil disposal techniques which can be utilised for the area covered by the plan, including details of legislative and regulatory requirements and further consider identifying sites and methods for the temporary storage of both liquid and solid waste to act as a buffer between collection of waste from the sea or shore and final disposal. There is a need for a nation-wide marine water quality study from which findings will be used to develop the National Marine Water Quality Monitoring Program to accompany the NOSCP of Liberia. The National Marine Water Quality Program will ensure the setting of standards against which compliance will be assessed. The study also recommends the development of individual oil spill contingency plans by all oil companies in Liberia which will be integrated into the NOSCP and as well ensure the training of rapid response teams, including local people in coastal communities, to respond to localized spills. Each drill unit should also have their own platforms for immediate response, and spills should be treated immediately at sea to limit impacts on the coast. There is also a need for a detailed study to investigate shoreline sensitivity, socioeconomic resources (fishing area and nursery grounds for fish and other invertebrates) and other ecological resource (turtles, birds and mammals). This study was a reconnaissance study to

highlight the need for further investigations into the potential impacts of oil spills on the coastal environment of Liberia.

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**APPENDIX 1.** International environmental and biodiversity conventions signed and/ratified by Liberia.

| Convention | Status | Year |
|---|---|---|
| African Convention on Conservation of Nature and Natural Resources | Ratified | NA |
| Convention of International Trade in Endangered Species of Wild Fauna and Flora | Ratified | 1981 |
| UN Convention on the Law of the Sea | Ratified | 1982 |
| Convention on Biological Diversity | Ratified | 2000 |
| Bio-Safety Protocol | Ratified | 2003 |
| Basel Convention | Ratified | 2004 |
| Abidjan Convention on Management and Protection of Coastal Environment | Ratified | 2005 |
| London Convention on the Prevention of Marine Pollution | Signed | 1972 |
| International Convention on the Control of Oil Pollution, Preparedness, Response and Cooperation | Signed | 1995 |
| Montreal Protocol | Signed | 1996 |
| Vienna Convention for the Protection of the Ozone Layer | Signed | 1996 |
| Convention on Desertification | Signed | 1998 |
| World Heritage Convention | Signed | 2002 |
| Framework Convention on Climate Change the Kyoto Protocol | Signed | 2002 |
| Stockholm Convention on Persistent Organic Pollutants | Signed | 2002 |
| Ramsar Convention on Wetlands of International Importance | Signed | 2003 |
| Bamako Convention | Signed | 2005 |

**APPENDIX 2.** Questionnaire used for the household interviews between 19 September and 10 December 2011 in coastal communities of seven coastal counties of Liberia.

THE VULNERABILITY OF THE COAST OF LIBERIA TO MARINE OIL SPILLS: IMPLICATIONS FOR BIODIVERSITY AND RENEWABLE NATURAL RESOURCE UTILIZATION

**SOCIO-ECONOMIC AND ECOLOGICAL SURVEY QUESTIONNAIRE**

***Introduction***
We introduce ourselves as part of the survey team and explain the purpose of the survey.

***Questions***
The interview includes questions about:
How you earn your living
Your knowledge and experience of biodiversity in your area (*we will give examples of biodiversity*)
If you have any questions, please ask as we go along.

***Timing***
This interview will take at most 40 minutes

***Confidentiality***
Your answers are confidential and will not be used against you now or in the future.
You can stop the interview at any time and skip questions you don't want to answer.
You do not have to participate

Interview Number:_____

Interviewer Name:_____

Date: _____

Start time: _____

End time: _____

Do you agree to participate in this survey? No Yes.

If "No", please complete a line on the recording sheet only.

If yes, please complete a line on the recording sheet and remember to record the information below before continuing with the survey.

**SECTION 1: DEMOGRAPHIC INFORMATION**

Name of village:_____

Age of household head: _____ Gender ( ) M ( ) F

Education: ( ) never been to school ( ) primary ( ) junior high ( ) senior high ( ) tertiary

Interviewee role: _____

Household size: ( ) adults ( ) children

How long have you lived in this village? a) native b) less than 10 years c) over 10 years

Why did you moved into this area? a) native b) farming c) fishing d) others
_____

Notes:

## LIVELIHOOD ACTIVITIES

1. As a member of a household, which activities do you carry out to sustain your livelihood?

   _____
   _____

2. Which of the following activities are carried out by members of this household?

| Activities | please tick | order of importance (top 5) | percentage % |
|---|---|---|---|
| fishing | _____ | _____ | _____ |
| agriculture | _____ | _____ | _____ |
| hunting | _____ | _____ | _____ |
| gathering | _____ | _____ | _____ |
| wood dealer/sawyer | _____ | _____ | _____ |
| petite trader | _____ | _____ | _____ |
| paid worker | _____ | _____ | _____ |
| charcoal production | _____ | _____ | _____ |
| pension/welfare | _____ | _____ | _____ |
| others (specify) | _____ | _____ | _____ |

3. How many adults in the household are
   employed ( ), self-employed ( ), not employed ( ), retired ( )

**NB. Assuming that all of your daily activities annually amount to this quantity of beans (recalling all activities cited in the above), what is the percentage of each of these activities. Using beans to illustrate**

Notes:

**FISHING ACTIVITY**

1. Is anyone in this household engaged in fishing activities? ( ) yes ( ) no

   a) If yes, how? ( ) harvesting ( ) processing (buying to dry) ( ) trading (buying and selling)
   b) If you are harvesting, what role do you play? ( ) boat owner ( ) worker/helper on the boat ( ) others. Please specify

2. What equipment do you use? _____
   No. of boats _____
   No. of nets _____

3. How many workers are there on each fishing boat? _____. How much do you pay each person? _____

4. How many trips (effort) do you make per day? _____ how many trips last month? _____

5. What is the cost of effort per trip? ( ) gallons of fuel ( ) others, please specify _____

6. What is the main type of fish or sea turtle caught? _____

7. How many bags do you catch per trip to sea? _____

8. How many bags did you catch last month? ( ) bags of fish ( ) sea turtles

9. How much of that was sold? ( ) bags of fish ( ) sea turtles

10. How many gallons of fuel do you use per trip?

11. How many months in the year do you allocate for fishing?

12. Habitual fishing grounds: _____

Notes

**Currently, what is the average proportion of people involved in fishing activity in this community? _____ Key informant question**

**HUNTING ACTIVITIES**

1. Is anyone in this household involved in hunting wild animals? ( ) yes ( ) no
2. Which equipments are used in hunting expedition? _____
3. Which types of animals do you harvest? _____ #
4. Do you also hunt shore birds? _____
5. How long does it take before you spot and kill an animal during your expedition? ( ) hours ( ) days ( ) weeks ( ) months
6. What is the cost of effort per hunting trip? ( ) gun shots ( ) others, please specify _____
7. How many animals do you kill per hunting trip? _____
8. How many animals did you kill last month? ( ) shore birds ( ) other animals
9. How much of that was sold? _____ shore birds _____ other animals, please specify
10. Which parts of the meat do you eat? _____
11. How many shots do you use per trip? _____
12. How many months in the year do you allocate for hunting? _____
13. Habitual hunting grounds: _____

Notes:

**MANGROVE HARVESTING**

1. Is anyone in this household engaged in mangrove harvesting activities? ( ) yes ( ) no
2. If yes, for what purpose do you harvest mangroves? ( ) fuel wood ( ) charcoal production ( ) poles ( ) others, please specify
3. Do you harvest for ( ) domestic or ( ) commercial reason?
4. What equipment do you use? ( ) machetes ( ) axes ( ) chain saw ( ) others, please specify _____
5. How many workers work with you? _____.
6. how much do you pay each worker? _____
7. How many head loads do you harvest per day? _____
8. How many head loads was harvested last month? _____
9. What is the cost of effort per trip for fuel wood purpose? ( ) hiring of truck ( ) hours of peddling canoe ( ) others, please specify _____
10. What is the cost of effort per trip for charcoal production purpose? ( ) hiring of truck ( ) hours of peddling canoe ( ) others, please specify _____
11. What is the cost of effort per trip for poles production purpose? ( ) hiring of truck ( ) hours of peddling canoe ( ) others, please specify _____
12. What main type/species of mangrove do you harvest? _____
13. How much of that was sold as ( ) fuel wood ( ) charcoal ( ) poles?
14. How many gallons of fuel or effort do you use per trip?
15. How many months in the year do you allocate for mangrove harvesting?
16. Habitual mangrove harvesting grounds:

    _____

Notes

**AGRICULTURAL ACTIVITY**

1. Is anyone in this household engaged in agricultural activities? ( ) yes ( ) no
2. If yes, what type of activity? ( ) food crop production ( ) cash crop production ( ) animal husbandry ( ) others, please specify
3. What staple crops are grown? _____
4. What are the main cash crops grown? _____
5. What equipment is used? ( ) machetes ( ) axes ( ) chain saw ( ) others, please specify _____
6. What are the main types of cash crop produced? _____
7. How many bags of staple crops did you produced last season? _____
8. How much of that was sold? _____

**Notes**

**GATHERING ACTIVITY**

1. Is anyone in this household involved in gathering activities? ( ) yes ( ) no

2. Here are few food species which constitute gathering of natural resources for households. Which of these resources do you gather for food and nutritional purpose and what percentage contribute to household income?

| Natural resources | please tick | order of importance | percentage |
|---|---|---|---|
| a) Fruit gathering (nuts and others) | _____ | _____ | _____ |
| b) wild vegetables/honey, etc | _____ | _____ | _____ |
| c) wine tapping (raphia, palm wine) | _____ | _____ | _____ |
| d) medicinal plants/insects/animals | _____ | _____ | _____ |
| e) others (please specify) _____ | | | |

3. What equipment do you use? _____ #

4. How much resource do you gather per day? _____ Per month?_____

5. How much of these resources do you sell? _____

6. What other purpose(s) do you gather natural resources other than timber or wild animal?

Notes:

**PETTY TRADING**

1. Is anyone in this household involved in petty trading? ( ) yes ( ) no

2. What types of goods are bought to sell? ( ) manufactured products ( ) harvested products ( )brewed products ( ) food other agricultural products ( ) others, please specify _____

3. Where do you do your petty trading? ( ) in the market ( ) in front of house ( ) others, please specify

4. What is the origin of the products you sell and what percentage is sold in your trade?

| Product | Origin of product sold | percentage in your trade |
|---|---|---|
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |
| _____ | _____ | _____ |

Others (please specify) _____

5. How much does this trade contribute to your household upkeep?

Notes.