AN ENVIRONMENTAL AND ECONOMIC APPROACH TO THE DEVELOPMENT AND SUSTAINABLE EXPLOITATION OF NON-TIMBER FOREST PRODUCTS (NTFP) IN LIBERIA

By

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ABSTRACT OF THE DISSERTATION

An Environmental and Economic Approach to the Development and Sustainable Exploitation of Non-Timber Forest Products (NTFP) in Liberia

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Forests have historically contributed immensely to influence patterns of social, economic, and environmental development, supporting livelihoods, aiding construction of economic change, and encouraging sustainable growth. The use of NTFP for the livelihood and subsistence of forest community dwellers have long existed in Liberia; with use, collection, and local/regional trade in NTFP still an ongoing activities of rural communities.

This study aimed to investigate the environmental and economic approaches that lead to the sustainable management exploitation and development of NTFP in Liberia.

Using household information from different socio-economic societies, knowledge based NTFP socioeconomics population, as well as abundance and usefulness of the resources were obtained through the use of ethnobotanical survey on use of NTFP in 82 rural communities within seven counties in Liberia. 1,165 survey participants, with 114 plant species listed as valuable NTFP.

The socioeconomic characteristics of 255 local community people provided collection practice information on NTFP, impact and threats due to collection, and their income generation.

Traditional and environmental sustainable harvesting methods on the collection of two leading NTFPs – *Griffonia simplicifolia* and *Xylopia aethiopica* – were conducted and assessed. Results show an environmental sustainable harvesting method that minimizes damage/destruction to plant species and population yet allows for efficient product harvest and yield procurement.

Domestic value chain study for three leading NTFP in Liberia: Griffonia (*Griffonia simplicifolia)*, West African Black Pepper (*Piper guineense*) and Country Spice (*Xylopia aethiopica*), investigated 140 stakeholders who were mainly agents and subagents through survey interviews to provide comprehensive knowledge on selected NTFP from collection to consumer.

Resource inventory of *Griffonia simplicifolia* in Liberia concentrated on the distribution, abundance and the population structure of Griffonia, thereby providing full ecological inventory information on Griffonia as fundamental for assessing conservation status of wild populations.

Enhancing germination of *Griffonia simplicifolia* seed for forest enrichment was assessed using simple tools for seed germination. Seedlings were also introduced in natural habitat to monitor growth habits of transferred plant into local habitat and found that Griffonia has high survival (92% - 95%) in new habitat.

Developing quality standards and new products, physico-chemical characterizations of the Liberian spices were analyzed along with those from Ghana. These qualities could set standards for trading of individual product that are used as spices in Liberia and other West African countries. *X. aethiopica* seeds were chemically characterized for new product development.

Dedication

To my mother, Mother Nancy E. Masaline, for her untiring and steadfast support throughout my life, instilling in me the virtues of uprightness, integrity, respectability, hardwork, and love that made it possible for me to have reached thus far. I couldn’t have asked for a better role model. I love you mother; though being a single mother, you never gave up on me; you are highly appreciated.

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1 Chapter I: Introduction

Historically, forests have contributed immensely to influence patterns of social, economic, and environmental development, supporting livelihoods, aiding construction of economic change, and encouraging sustainable growth (Tewari, 1993; FAO, 1995; Shahabuddin and Prasad, 2004). Forests continue to provide high levels of commercial benefits to households, companies and governments globally (Agrawal *et al.,* 2013).

In developing countries, forest products other than timber and other industrial round wood have always constituted a large part of the forest economy, with individual products providing inputs and income directly to vast number of rural and urban households (Sunderland and Ndoye, 2004). For example, more than 70 percent of rural communities in Liberia are reliant on forest and forest-related products for their livelihoods (Deshmukh *et al.,* 2009). The Millennium Ecosystem Assessment of 2005 estimated about 96% of the value of forest being derived from non-timber forest products and services, while also been recognized internationally as an important element in sustainable forestry (MEA, 2005). Further, in 1992, The United Nations Conference on Environment and Development identified sustainable forest management as a key element in sustainable economic development with inclusion of NTFP (Jones *et al.,* 2004). While it may be true that forests often serve as the ‘pharmacy’ and ‘supermarket’ for most rural communities, more than 5,000 commercial forest products fall within the category of being non-timber forest products, including pharmaceuticals and food (Secretariat of the CBD, 2009).

Non-Timber Forest Products, or NTFP, refer to a wide collection of materials and/or products that come from forests, excluding timber, with social, cultural, economic, and other ethnobotanical uses (Ghimire *et al.,* 2008). Since the term ‘Non-timber forest product’ (NTFP) was coined originally by de Beer and McDermott (1989), they defined it as "*encompassing all biological materials other than timber, which are extracted from forests for human use*". Similar term includes Non-Wood Forest Products (NWFPs). These include fruits, nuts, mushrooms, essential oils, florals, medicinal products, herbs and spices, dyes, resins, and animal products such as honey, fish and wild game, as well as fuelwood. With this and over time, NTFPs generally also include fuelwood and small woods and wood products used locally for fencing and posts, shelter but not for timber extraction (FAO, 1999; van Rijsoort, 2000). FAO (1999), however, proposed the following definition for NWFP to exclude all woody raw materials and services: "*non-wood forest products consists of goods of biological origins other than wood, derived from forests, other wooded land and trees outside forests*". Other definitions have also been proposed for the term NTFP or NWFP (Wickens, 1991; Chandrasekharan, 1995; Wong, 2000; van Rijsoort, 2000). In recent years, the Center for International Forestry Research (CIFOR) also defined NTFP as *"any product or service other than timber that is produced in forests"*. This definition includes wood products such as those used for woodcarving, woodcrafts or fuel (CIFOR, 2011), similar to the de Beer and McDermott's (1989) definition of NTFP.

For this research, we use a modified definition of that proposed by the CIFOR (2011), considering fibers and building materials to be inclusive within NTFP but in this study; we purposefully exclude fuelwood and small wood. Hence, the working definition of NTFP for this research is as follows: Any N*on-Timber Forest Product or service other than timber that is produced in forests, excluding fuelwood and small wood*. These forest products range from exudates (gums, resins and latex) to canes, fruits, flowers, seeds, seed derivatives, entire plants, leaves, roots or stem bark, fungi, animals, birds and fish for food, fur and feathers and insects, as well as products such as honey, lac and silk (Panayotou and Ashton, 1992; Tewari, 1994; Wickens, 1994).

In forests, it is the NTFP that provide essential food, nutrition, medicine, fodder, construction materials and mulch, thus meeting the immediate needs of human societies and communities (FAO, 1995). Many NTFP are collected from their various habitats to serve local markets, family, national, regional, or international market needs (Wilkinson and Elevitch, 2004). NTFP produced in tropical forests can be grouped into four main categories. These include (i) fruits and seeds, with plant parts harvested mainly for fleshy fruit bodies, nuts and oil seeds; (ii) plant releasing liquid such as latex, resin and floral nectar; (iii) vegetative structures such as apical buds, bulbs, leaves, stems, barks and roots; and (iv) small stems, poles and sticks harvested for housing, fencing, and craft and furniture materials. For use in this research, the NTFP have been clustered into four main divisions; (**a) food and food additives** – seeds, leaves, fruits, and nuts; (**b) aroma and flavor** – seeds, leaves, stems, and bark; (**c) floral and decorative** – stems, leaves, poles, stick, cones, seed pods, flowers, and branches; and (**d) medicinal** – seeds, leaves, barks, roots, stems, and resins (Conelly, 1985; Peters, 1990; Grundy and Campbell, 1993; Cunningham, 1996).

From the past decade to present, there have been increasing appreciation and recognition of the importance of Non-Timber Forest Products (NTFP) for their role in socio-economic welfare of rural communities as well as contributing to environmental objectives including biodiversity conservation and export earnings (Falconer, 1990; FAO, 1995b; Shackleton & Mander, 2000; Arnold and Perez, 2001; Cunningham, 2001; Sunderland *et al*., 2004; Hembram & Hoover, 2008). The increase in the importance in NTFP has been a result of a number of shifts in developmental efforts. Among these, the importance of rural development and poverty alleviation coupled with consistency of development activities with environmental integrity have provided growing concerns in how forests and forest products contribute to households' food and livelihood security (Arnold and Ruiz-Perez, 2001; Choudhury, 2008; Chakravarty *et al.,* 2015). Studies have shown that long-term financial return from sustainable NTFP harvest could be more important for the communities residing in the forests than the net economic benefits of timber production or the conversion of the same area of land to agricultural fields (Peter *et al.,* 1989; Chopra, 1997). This could be in contrast when viewing the profitability from the timber and processing sectors perspective. Such recognition and perspective stimulates the conservation community about the potential of establishing sustainable forest management systems that could help maintain biodiversity, at the same time providing sustainable economic returns to local people and governments (Evariste and Bernard-Aloys, 2016). Monlar *et al.* (2004) had reported that global trade of NTFP has been estimated to about US$11 billion, while accounting for as much as 25% of the income of close to one billion people. The financial benefits that add values to the many NTFP can only be feasible over timber industry if their collection and harvesting is ecologically sustainable. Most NTFP are harvested from wild sources, the natural forest, other wooded land and trees outside forests (Taplah, 2002). One of the challenges even after recognizing the economic importance of NTFP and its direct impact to families and communities for their food and health security, is that in part because NTFP represents or is inclusive of such a wide and diverse range of species and products, many whom are considered 'boutique and niche crops' it can be seen as diffuse, lacking industry advocates as found in the timber, mining and agriculture which each advocate for public policy and investment that further support those sectors.

In some African countries, such as Cameroon and Ethiopia for example, there is enormous importance of NTFP in rural and forest economies, contributing to the improvement of the livelihoods of rural communities to meet subsistence needs by providing food, medicine, additional income, as well as cultural artifacts (Awono and Ngono, 2002; Lescuyer, 2010; Ingram *et al.,* 2012; Melese, 2016). The NTFP sector offers a basis for managing forests in a more sustainable manner, thereby supporting biodiversity conservation (Solomon, 2016) and sustainable economic development of the rural peoples that live in these vulnerable ecosystems.

Geologically, the land cover of Liberia is remarkably diverse, with high rates of endemism and one of the 14 centers of plant endemism globally (Halton, 2013). The country lies in the heart of the Upper Guinean Rainforest in West Africa and containing the largest block (43%) (Taplah, 2002). With more than one third (35.9%) of the land cover categorized as forest and another 23.6% composed of agriculture degraded forest and mixed agricultural and forest areas, the Liberian forests contain a significant amount of biodiversity, with over 2,900 different vascular plant species (FDA, 2000; Taplah, 2002; UNEP, 2004; Lomax, 2008; Deshmukh *et al.,* 2009; Geo Ville and Metria, 2011). The Liberian forests play an important direct and indirect role in the daily lives of most of its population, with about two-third of the population (70%) living in rural settings and depends on forest for their sustenance (Lomax, 2008; Methot and Veit, 2008). The use of NTFP for the livelihood and sustenance of community forest dwellers have existed long in Liberia (Cotton, 1996; Taplah, 2002); with use, collection, and local/regional trade in NTFP still an ongoing activities of rural communities in Liberia (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013; Kpadehyea *et al.,* 2015).

Traditional knowledge is known to play an important role in the rural economy (Cotton, 1996; Taplah, 2002). Studies addressing traditional knowledge classification of NTFP ensures the translation of local values into rational use of resources and effective conservation of biological diversity and cultural knowledge (Ibrar *et al.,* 2007). Knowledge on local use and collection of indigenous NTFP in Liberia may be limited. The management and sustainability of natural resources entail comprehensive knowledge of the ecology, spatial distribution and abundance of the resources (Wong, 2000). Rural and native people are in general well informed about the ethnobotany of local plants, including their utilization and habitat (Rist, 2009). Juliani *et al.* (2013) had reported the possession of traditional societies with a wealth of knowledge accumulated as a result of interactions with the natural world, and that local communities have utilized this knowledge to their advantage to a wide variety of plant products for their daily needs. Such knowledge as the importance, uses and effects of products in different societies promotes economic and environmental development, while supporting sustainable exploitation (Cotton, 1996; Taplah, 2002; Deshmukh *et al.,* 2009; Kim *et al.,* 2009; Manvell, 2011; Kpadehyea *et al.,* 2015) and aiding in poverty alleviation and biodiversity conservation (CIFOR, 2004; IUCNNR, 2008). Therefore, the need for satisfactory indigenous knowledge on the botanical use of resources is essential to ensuring sustainable development and management of natural resources (Wong, 2000).

With the emerging and evolving perception of the increasing importance of NTFP, the state of knowledge about the various aspects of NTFP activities may however be limiting, or lacking, especially in Liberia. Adelaja *et al.* (2003) has acknowledged that the West Africa's natural products industry is constrained by many factors, among which are the lack of technical, infrastructure, and financial resources necessary for promoting efficient industry development. Of most importance are the lack of appreciation for economic potential, ignorance of the importance of NTFP to rural societies and the general lack of knowledge on NTFP which have impeded the establishment of sufficient and acceptable policy direction to develop practical management programs for NTFP in Liberia (FDA, 2006). Addressing such conditions can create potential for sustainable development and management of product, commercialization of natural products in local, regional and international markets, with benefit returns to socio-economic development (FDA, 2006; IMF, 2008). Further, although domestic markets may afford a relevant economic base in natural product trade in other African countries, due to low population and weak purchasing power in Liberia, there is need for regional trades to be encouraged as a major driver for economic growth and trade development (Govindasamy *et al.,* 2007).

1.1 The hypotheses

In addressing issues relating to the sustainable development and management of NTFP, several major concepts have been developed and as such we hypothesize that:

- Traditional knowledge on use of NTFPs is essential in the development and sustainability of the NTFP industry as a potential contributor to the livelihood of rural communities;
- Traditional collection and harvesting practices of local communities meet their livelihood needs but may have adverse impact on plant species population and biodiversity;
- Sustainable exploitation of NTFPs can provide a stimulus to the conservation of forest biodiversity and increased longer-term economic benefits for forest-dwelling people;
- The commercial extraction of NTFP that adds value to the forest may provide an incentive to conservation and sustainability of forest management;
- An ecological survey is fundamental to the assessment of the conservation status of wild populations, and prerequisite for addressing harvesting sustainability of major or target species;
- Forest enrichment planting ensures increases in population of plant species and the conservation of forest biodiversity; and that
- The development of core quality control programs and processes that include the chemical analysis of the natural plant products and development of standards for local products creates potential for commercialization and contribute to developing new products.

1.2 The Aim of this Research

The overarching aim of this research is to develop processes to ensure the continued production and sustainability of NTFP as factors for the promotion of management and biodiversity conservation, natural resource governance, and poverty reduction. This study aimed to investigate the environmental and economic approaches that lead to the sustainable management exploitation and development of NTFP in Liberia.

1.3 Structure of the Dissertation

This study first includes an introduction to analyze the state of the art and formulate hypothesis and objectives, followed by seven studies, presented as chapters, each describing the main findings of this studies, main conclusions and recommendation for further research. The first study, the traditional botanical uses of forest species in seven counties in Liberia, addresses traditional knowledge on the local use of indigenous plant species in Liberia. A comprehensive knowledge on the ecology, spatial distribution and abundance of local plants and their products ensures sustainable management and development of natural resources. Using household information from different socio-economic societies, knowledge based NTFP socioeconomics population, as well as abundance and usefulness of the resources were obtained through the use of ethnobotanical survey on use of NTFP in 82 rural communities within seven counties in Liberia. In this study, we interviewed and collected data from 1,165 survey participants whom provided information on use of NTFP, with 114 plant species being listed as valuable NTFP in various communities in the seven counties. Resource species were categorized, with individual use of plant species identified. Such knowledge is important in promoting economic and environmental development, with sustainable management and biodiversity conservation.

The second study, assessing collection practices, their impact and economic benefits of NTFP for rural men and women in seven counties of Liberia, investigated local traditional practices of NTFP harvest and their impact of the population using household local collector survey. This study assessed the socioeconomic characteristics of 255 local community people who provided information on NTFP collection practices, impact and threats due to collection, and their income generation. The information gathered supports informed decisions on collection habits of local communities and their impact on population for the sustainable management and development of the resources.

The third study, assessing traditional and sustainable harvesting methods on collection of two leading NTFPs – *Griffonia simplicifolia* and *Xylopia aethiopica*, described and assessed local traditional methods of harvesting of two important NTFP in Liberia and suggested alternative sustainable technique of harvesting. Through this means, the study assessed the impact of harvesting methods on species population and yield production to understand and incorporate behavior change in harvesting patterns of local collectors. The benefit of such behavior change is longer-term sustainable exploitation of the NTFP and income generation, with preservation of the resources as ecological bonus.

The fourth study, assessed the domestic value chain for three leading NTFP in Liberia: Griffonia (*Griffonia simplicifolia)*, West African Black Pepper (*Piper guineense*) and Country Spice (*Xylopia aethiopica*). Using these three leading Liberian NTFP, we investigated their value chain and the potential for international market. The study investigated 140 stakeholders who were mainly agents and subagents through survey interview to provide comprehensive knowledge on each NTFP from collection to consumer to disposal after use. The study also examined the trade value and potential of the three leading NTFP in order to provide value chain descriptions for these NTFP. These NTFP have econo-commercial potential for local, regional and international markets;

their promotion for development can enhance the economic status of local communities and all stakeholders involved in the value chain.

The fifth study, resource inventory of *Griffonia simplicifolia* in Liberia: a case study in the Lepula Community Forest in Nimba County, concentrated on the distribution, abundance and the population structure of Griffonia, which serves as prerequisite for addressing harvesting sustainability of plant species. The study provided full ecological inventory information on Griffonia as fundamental for assessing conservation status of wild populations. New seedling growth were measured in forest and plantation areas and compared; vines growing near trees for support in climbing were also measured, and measurement estimated per hectare for the idea of distribution and abundance of population in the area. These information are necessary for strategic and management planning, especially for plants with great potential for regional and international commercialization.

The sixth study, enhancing germination for forest enrichment of *Griffonia simplicifolia*, investigated the seed germination biology of Griffonia using simple tools for seed germination. The study also assessed introduction of seedlings in natural habitat to monitor growth habits of transplanted plant in habitat other than original habitat and found that Griffonia has high survival in new habitat. With the lack of information on germination process for Griffonia, this study provided a baseline for incorporation of seed germination process to local farmers for the multiplication of population of the plant species, for increased yield generation. The study also substantiate that cultivation of resources reduces associated threats on population, while enhancing yield of product.

The seventh study, developing quality standards and new products for Liberian spices, analyzed the macroscopic and biochemical characterization of the Liberian spices. These qualities set standards for trading of individual product. These products are used as spices in Liberia and other West African countries. Providing quality standards increases their potential for more vibrant commercialization nationally, regionally as well as internationally. Further, the study also characterized the chemical qualities within the seeds of *Xylopia aethiopica* for the development of a new product.

The last part provides the conclusion of the entire study and comprehensive picture of the socio-economics of NTFP-extraction in local communities in Liberia, and provide possible policy recommendations for the promotion and development of NTFP in Liberia amongst others.

2 Chapter II: Traditional Botanical Uses of Non Timber Forest Species in Seven Counties in Liberia

2.1 Introduction

The importance of NTFP has been well recognized in rural livelihoods and forest biodiversity conservation as they provide income generation opportunities to millions of people globally (Ticktin, 2004; Belcher *et al.,* 2005; Rasul *et al.,* 2008; Steele *et al.,* 2015). In Liberia, NTFP harvest is known to contribute significantly to the local economy (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013). Some NTFP play an important role in traditional health care systems (Kpadehyea *et al.,* 2015), while others have major cultural values and are used for food, fodder, and building materials (FAO, 1995; Chettri *et al.,* 2005; Pradhan and Badola, 2008; Juliani *et al.,* 2013).

The indigenous ethnobotanical knowledge of plants is helpful to a variety of users, including nutritionists, health care professionals, biologists, ecologists, pharmacologists, taxonomists, wildlife enthusiasts, and the academic audience in a variety of disciplines (Kuhnlein and Turner, 1991; Ibrar *et al.,* 2007). Richard Evans Schultes, Harvard University educator (often called the father of ethnobotany), simply defined the term ethnobotany as […] investigating plants used by primitive societies in various parts of the world (Schultes, 1979). The Naturenomics Team (2016) also provides a suitable definition of ethnobotany, the study of how people of a particular culture and region make use of indigenous (native) plants. The terms traditional knowledge, indigenous knowledge, and local knowledge are interchangeably used and are generally refer to knowledge of systems embedded in the cultural traditions of regional, indigenous, or local communities (Kala, 2004; Acharya and Anshu, 2008; Kala, 2012). In many cases, traditional knowledge has been orally passed for generations from person to person. Some forms of traditional knowledge find expression in stories, legends, folklore, rituals, songs, and laws (Turner *et al.,* 2000; Kala, 2004; Kala, 2012).

Local communities have utilized the wealth of knowledge accumulated from traditional societies to their advantage to a variety of plant products for their necessities (Taplah, 2002; Deshmukh *et al.,* 2009). The use of such knowledge for economic growth can encourage traditional people to protect their resources and strengthen their cultural survival, while conserving local traditional knowledge of plants (Cotton, 1996; Taplah, 2002). More than 70% of the population in Liberia live in rural forest areas and are dependent on forest and forest-related products for their sustenance and welfares (Lomax, 2008; Deshmukh *et al.,* 2009), and many living in these rural forested areas have not been formally educated in public schools. Traditional knowledge on NTFP can play important roles in rural economy of Liberia (Kim *et al.,* 2009; Manvell, 2011; Juliani *et al.,* 2013; Khadehyea *et al.,* 2015).

Ahrends *et al.* (2011) have stressed that in order to conserve wild plant species, there is need for reliable data on their distribution and level of use. Documenting indigenous knowledge is essential in conservation management and sustainable use of biological resources (Munthu *et al.,* 2006). Identifying local names, botanical names and indigenous uses of plants not only preserves indigenous knowledge but also enables future research on protection and efficacy of the uses of the plants that lead to management and sustainability of biological resources (Bagai, 2000). Moreover, establishing preference for plant species through relevant information about its importance promotes and improves species acceptability to local communities for other projects such as agroforestry (Egbe *et al.,* 2012).

Applications and knowledge of ethnobotany differ with socio-economic levels, and demographics (geographical origin, age, gender, ethnicity, level of education and profession) (Pfeifer and Butz, 2005). Ethnobotany is known as an integral part of indigenous knowledge of a particular society (Osawaru and Danin-Ogbe, 2010). Studies have shown farmers with remarkable knowledge of flora species; with their involvement in data collection relating to plants being essential due their critical knowledge and preference (Haugerud and Collinson 1990). Majority of NTFP users and collectors are often farmers (Luintel, 2002) who have lived and interacted with plants for the most part of their lives. Chepape *et al.* (2011) have expressed that many farmers are illiterate, but knowledgeable and involved in various aspects of NTFP. The Forestry Development Authority (FDA) of Liberia reported that lack of appreciation for the economic potential, ignorance of importance to rural communities, and the general lack of knowledge of NTFP has hindered the delivery of adequate policy to develop practical management programs for NTFP sector in Liberia (FDA, 2006). Several studies in Africa have found NTFP to be an essential income generating source for rural household economy (Heubach *et al.,* 2011). For instance, 15% of total income obtained from wild and planted fruit trees on common land in Malawi (Kamanga *et al.,* 2009); wild plants contribute 10% to household's total food consumption in the Congo Republic (de Merode *et al.,* 2004); the provision of consumptive forest environmental products constitutes 27% of the income in northern Ethiopia (Babulo *et al.,* 2009). Cavendish (2000) found wild foods, medicinal plants, forage plants, and various wood and grass uses to account for 35% of the average rural income, the average income from NTFP in Northern Benin accounted for 39% of total household income (Heubach *et al.,* 2011). Studies done in Liberia have focused on the importance of Liberian NTFP, but with limitation in scope and origin such as location and specific group of plants. Juliani *et al.* (2013) conducted an ethnobotanical studies in four communities in Lower Nimba County and two communities in Bassa County and listed 51 individual NTFP.

Kpadehyea *et al.* (2015) also conducted ethnobotanical studies on medicinal plants use by the Wonegizi people in Ziama Clan, Lofa County and listed 101 medicinal plant species. Though most of these studies merely investigated a certain set of forest products, they confirm the economic relevance of NTFP.

NTFP are categorized into various clusters according to their origin and/or processing, or applications (Juliani *et al.,* 2013). Among these categories, medicinal plants have received much focus (Kpadehyea *et al.,* 2015), while little or no information on the contribution of the other categories, such as nuts and edible oils, edible fruits, indigenous vegetables and mushrooms, and building materials (Juliani *et al.,* 2013) have been provided. This may be similar in other countries. In Nepal for example, the contribution of wild edible plants towards food security and income generation has been undervalued (Uprety *et al.,* 2012) and the FAO conducted a study on edible mushrooms and found it to be a million dollars annual industry for sub-Sahara Africans (FAO, 2004). Wang and Hall (2004) had reported that a few species of edible mushrooms dominate the world market with an estimated annual value of more than US$2 billion. A large number of NTFP and associated traditional knowledge on uses with a broader ecological boundary still waits proper documentation (Tabuti *et al.,* 2003).

This study, which aims at documenting traditional knowledge on the ethnobotany of NTFP in Liberia, enhances existing knowledge of West African settings. This is in concurrence with the TEEB-study (The Economics of Ecosystem Services and Biodiversity) that identified lack of respective studies from several developing African regions (Sukhdev *et al.,* 2010). The ethnobotany of NTFP in Liberia is not fully documented (Juliani *et al.,* 2013), leading to a limitation of understanding of their relevance within the livelihood strategies of rural communities.

Knowledge about plant use is higher within indigenous populations, with women often considered as repositories of indigenous knowledge relating to the uses of plants, especially medicinal plants, (Gibb *et al.,* 2007; Kpadehyea *et al.,* 2015). Also, traditional knowledge in a given society, such as Liberia, cuts through geographical boundaries with migration of communities and subsequent interactions among two or more identical yet apart societies (Dattagupta and Gupta, 2014), as the diffusion of knowledge is one benefit of migration across societies (Thompson, 2014). However, local knowledge on the traditional use of plants is liable to be distorted or completely lost if transfer is not done constantly (Chepape *et al.,* 2011). Liberia is known for its diverse yet unique cultural identity given the interactions with human societies across various communities. Meanwhile, the increasing movement of the younger generation to urban areas in search of quality education with more lucrative occupations and employment opportunities may lead to adverse effects of traditional knowledge on plants such as the rapid decline of traditional knowledge on plants use, collection and processing (Dattagupta and Gupta, 2014). Also the lack of interest of young people has led the concentration of traditional knowledge of plant use in the hands of the few experts (elders) in the region (Teklehaymanot *et al.,* 2007). This creates an impairment to the transfer of local traditional knowledge on plants between generations (Silva *et al.,* 2011). Further, studies have suggested the lack of knowledge amongst young people may be influenced by modernization (Caniago and Siebert, 1998; Quinlan and Quinlan, 2007). As a bedrock for this study, documentation will ascertain traditional knowledge about uses of NTFP is conserved, while also enabling the discovery of new sources of important NTFP and promoting sustainable use of the resources in Liberia (Manvell, 2011). Collecting and disseminating the indigenous knowledge on use of NTFP to the wider audience of stakeholders involved in trade, policymaking and implementation provides the likelihood of success of conservation biodiversity and/or poverty alleviation (Arnold *et al.,* 2001; Ticktin, 2004; Belcher *et al.,* 2005; Kusters *et al.,* 2006; Belcher and Schreckenberg, 2007). In addition, conserving the ethnobotanical knowledge of NTFP adds value to the recreational environment as well as livelihood improvements through sustained ecosystems (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013).

This objective of this chapter is to 1) record indigenous knowledge regarding plants and their traditional uses and to assess how this knowledge is distributed across communities within seven counties in Liberia; 2) to assess, categorize and record indigenous plants of Non-Timber Forest Product and their traditional uses using local, common, and scientific names; 3) to determine the habitat of the plant species, and investigate the part(s) of the plant being used; and 4) to identify new and emerging NTFP.

2.2 Materials and methods

Ethnobotanical information on the use of NTFP was collected through interviewing 1,165 respondents, using a standardized structured questionnaire with both close-ended (90%) and open-ended (10%) questions. A full copy of the questionnaire is included in Appendix A. Ethnobotanical surveys to identify NTFP of Liberia and their uses were prepared and pretested weeks prior to the actual field study to authenticate the survey. The actual survey was conducted from February 2016 to July 2016 in 82 communities from seven counties in Liberia, including Bong, Nimba, Grand Bassa, Lofa, Bomi, Margibi, and River Cess Counties (Table 2.1 and 2.2).

Prior to the beginning of the survey study, the Committee for the Protection of Human Subjects, the Institutional Review Board (IRB), at of Rutgers, The State University of New Jersey, reviewed and approved the study protocol, Protocol #: E16-235 (Appendix D). Approval to conduct interviews was also obtained from local authorities at each survey site/community. Oral informed consent and approval from the town chiefs and/or local community leaders often in the presence of community members was obtained for studies in the community. With a welcoming approval, questionnaire was read out to community leader/chief mostly in the presence of community members with the objectives and intents clearly explained. The written consent form (Appendix E) approved by Rutgers IRB Committee was also read to inform participants of their rights and confidentiality thereof. Upon acceptance, each participant was given a copy of the consent form and endorsed before interview began. Participation was purely on a voluntary basis; neither monetary nor material incentives were offered for participation.

Table 2.1: Communities visited within each of the seven counties in Liberia during the ethnobotanical survey on the use of NTFP in Liberia

No.	County	Communities
1.	Bong	Balamah, Raymond town, Gokai, Gbonota, Sanoyea, Zeanzue, Palala, Gold Camp, Kolila, Donfah, Zoweinta, Fehneitoli, Gbartala, Beletanla, Gbonoi, Gbonkonnema, Tototа, Fehlerla, Salala, Bong Mines, Heindii, and St. Paul Island
2.	Bomi	Tubmanburg city, Coleman town, Yomoto, Klay, Jenneh, Bonja, Be Mole, Be William, Mulbah town, and Gayah Hill
3.	Grand Bassa	Bokay’s town, Tobli, Buchanan city, Pegabli, Barcoline, Louiza town, District 4-Bold Dollar, Doe Bar, Upper Buchanan, Mayeseah town, and Boye town
4.	Lofa	Gbalatoah, Gollu, Salayea, Sukolomu, Kiliwu, Zorzor, Fisebu, and Telemai
5.	Margibi	German Camp, Weala, Marshall, Smell-No-Taste, and Cotton Tree Community
6.	Nimba	Ganta, Kpein, Gbedin, Sokopa, Bunadin, Flumpa, Zuluyee town, Yarmie, Tombu town, Sanniquellie, Zorgowee, Karnplay, Lepula, Toweh, Kiayea, Yourpeah, Duo, Dialah, Saclapea, and Tappita
7.	River Cess	Rivercess town, Cesstos city, Cephas town, Kwabli, and Galobli

The questionnaire comprised two sections, including the demographics of the participants and the ethnobotanical survey on the use of NTFP in Liberia. The survey collected information about the demographic and socio-economic characteristics of various community households, the diversity and use of NTFP per each household. Household respondents were chosen through stratified randomized sampling whereby a household was selected randomly as the team walked along paths in each community, with selection based on every other household that was involved in some forms of NTFP activities. Interviews were conducted using door-to-door and face-to-face approach. Participants selected from household, one interviewee per household (defined as a group of people normally sleeping under the same roof and eating together) or knowledgeable in traditional use of plants within the group. One or more team members fluent in the local language served as interpreter during the process. The ethnobotanical survey questionnaire (Appendix A) was used to collect NTFP data on the following: local name, botanical name (if known), Family, part(s) used, main use or category of use, and habitat, among others.

All data collected was tabulated into excel worksheet and analyzed both qualitatively and quantitatively; $p<0.05$ considered statistically significant. An Analysis of Variance (ANOVA): Single Factor analysis was used to determine the significance between the sex groups of the respondents.

Rural communities provided local and in most cases common names for plant species. Two trained forest specialists and botanists (one from the Cuttington University and the other from the Forest Development Authority, FDA, in Liberia) knowledgeable in traditional uses of plants assisted in obtaining the scientific names of plants from the local names. Field guides and manuals from the

Department of Plant Biology and Pathology at Rutgers, The State University of New Jersey, and from the FDA were used to identify and authenticate the scientific names.

For analysis, list of plant species were categorized according to Juliani *et al.* (2013) classification of category, in cluster according to their origin and/or processing or applications; however, with few modifications based on use. These clusters include spices, medicinals, indigenous vegetables and mushrooms, colas and edible fruits, nuts and edible oils, and building materials (modified to building materials and fibers, included fibers).

2.3 Results and discussion

The survey collected information from 1,165 household respondents (42% females and 58% males, Table 2.3) in 82 communities within 7 Counties in Liberia (Table 2.1 & 2.2), who provided information on socio-economic characteristics of various community households and on the ethnobotany of NTFP in Liberia.

A total of 114 plant species were cited by respondents from the ethnobotanical survey and were categorized into six clusters (Figure 2.1) based on their use, origin and/or processing or applications (Juliani *et al.,* 2013).

2.3.1 The demographics of household respondents

Considering gender influence on local knowledge of plant use, the knowledge of botanical use cited by household respondents did not differ between males and females (P = 0.150), with number of male respondents 676 (58%) and female respondents 489 (42%). This indicates women are equally knowledgeable in the traditional use as men in the ethnobotany of their local plants. These results corroborate with previous findings that women are repositories of traditional knowledge on local plant uses (Gibb *et al.,* 2007; Kpadehyea *et al.,* 2015). In Liberia, both genders are equally involved in or knowledgeable about local plant uses (Table 2.3).

Table 2.2: Number of communities with percentage of respondents in each County visited

County	Communities #	Respondents #	Respondents %
Bong	22	228	19.6%
Nimba	21	267	22.9%
Bassa	11	174	14.9%
Lofa	8	185	15.9%
River Cess	5	82	7.0%
Bomi County	10	117	10.0%
Margibi	5	112	9.6%
Total	**82**	**1165**	**100%**

The influence of age on traditional knowledge of plants use was assessed. Respondent age was grouped in five ranges of age group, including ages under 20yrs, 21–35yrs, 36–50yrs, 51–65yrs, and above 65yrs. The age range of 51 – 65yrs recorded slightly higher number of respondents (41.4%) compared with the other age ranges (36 – 50yrs, 25.8%; >65yrs, 14.2%; 21 – 35yrs, 11.2%; and <20yrs, 7.5%) (Table 2.3). The low percent number obtained for age group below 20yrs, which can be considered as young generation, may be due to a number of factors. Firstly, the migration to urban areas for educational and employment opportunities is seen highly among young generations (Caniago and Siebert, 1998 Quinlan and Quinlan, 2007; Dattagupta and Gupta, 2014). Secondly, the lack of interest of young people in local knowledge of traditional uses of plants, thereby leaving the knowledge to the experts (Teklehaymanot *et al.,* 2007) who are the old age groups in age range 51yrs and above, as is considered in Liberia that a person with age 51yrs or above is elder. The low percent number of young people recorded in the study creates a worrisome condition whereby the transfer of wealth of knowledge on plant use from elder to the future custodians of such knowledge may be drawing to a close. Previous studies by Silva *et al.* (2011) have cautioned the impairment of the transfer of local knowledge on the traditional use of plants between generations from lack of interest of young people about traditional plant use; while modernization may be an influencing force on young generation (Caniago and Siebert, 1998; Quinlan and Quinlan, 2007) leading to undesired interest in local traditional knowledge of plant uses. Hence, the need to strengthen and encourage young people who are the future upkeep of the wealth of knowledge from elders cannot be overemphasized.

The influence of education on local knowledge of plant use in rural communities is essential for the development and sustainable management of NTFP and biodiversity conservation. Level of academic achievement was assessed from the respondents, and was shown that 53.2% of respondents did not have any form of educational training (none), compared to 7.0% of respondents combined (5.3% up to high school level, and 1.7% 2yr college degree level) as the highest level of education for the household respondents. The lack of formal educational training corresponds well with the status on respondents' ability to read or write, with 57.9% respondent can't read nor write (Table 2.3). Further, it was shown that farmers accounted for 46.9% of household respondents, suggesting farmers as the major repository of ethnobotanical knowledge of plants, as they spend most part of their lives with the interactions of plant species. This confirms other studies done by Haugerud and Collinson (1990) that farmers have remarkable knowledge of flora species. The result also corresponds with the response on educational level, since farmers are often considered to have little or no educational experience. This affirms studies by Chepape *et al.* (2011) farmers are illiterate, but have vast traditional knowledge and involved in the processes of NTFP. Their inclusion in policies and regulation issues pertaining to forest products is necessary henceforth.

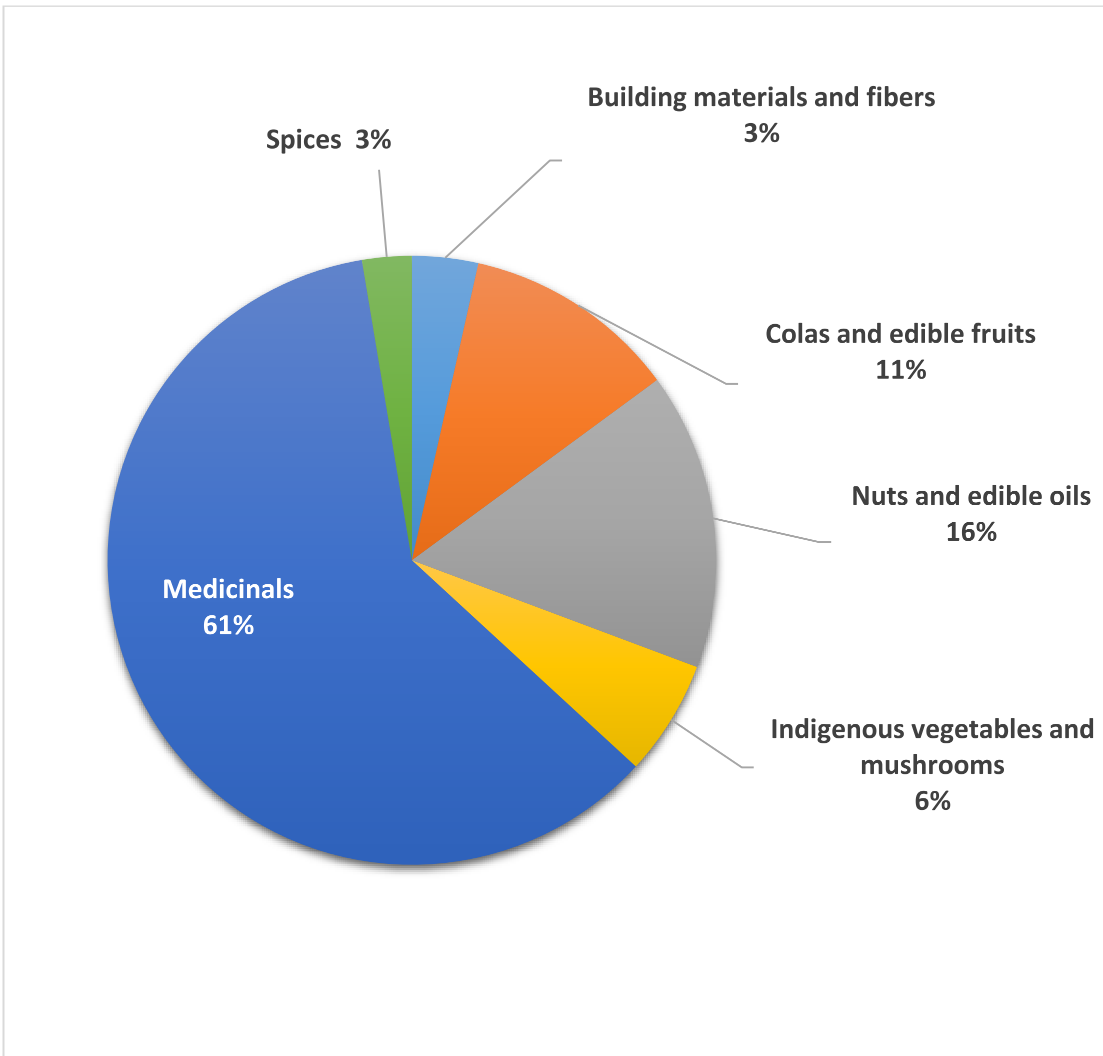


Figure 2.1: The six categories of botanicals cited by local community household respondents from seven counties in Liberia

2.3.2 The ethnobotany on botanical plants

Of the total 114 plant species cited, 69 (61%) were categorized as medicinals, 3 (3%) categorized as spices, 13 (11%) categorized as colas and edible fruits, 7 (6%) categorized as indigenous vegetables and mushrooms, 18 (16%) as nuts and edible oils, and 4 (3%) as building materials and fibers (Figure 2.1). However, as expected some of the botanicals were reported to have multiple functions. These include nine species within the colas and edible nuts category used as medicinals (*Allanblackia floribunda, Averrhoa carambola, Chrysophellum canito, Coula edulis, Garcinia kola, Maesobotrya barterii, Uapaca guineense, Cola gigantea,* and *Cola lateritia*), one species within the spices used as building materials (*Xylopia aethiopica*), all three species within the spices used as medicinals (*Piper guineense, Xylopia aethiopica,* and *Aframomum melegueta*), sixteen species within the nuts and edible oils used as medicinals (*Bussea occidentalis, Calpocalyx aubrevillei*, *Irvingia gabonensis*, *Khaya grandifolia* , *Manniophytan fulvum* , *Napoleonaea heudelotii*, *Parinari excelsa*, *Parkia bicolor*, *Pentaclethra macrophylla*, *Pentadesma butyracea*, *Pycnanthus angolensis*, *Ricinodendron heudelotii*, *Sterculia tragacantha*, *Tieghemella heckelii*, *Trichilia emetica*, and *Vitex micrantha*), and one species within the building materials and fibers also used as beverage (*Raffia vinifera*). This studies is in congruent with previous studies by Juliani *et al.* (2013) and Kpadehyea *et al.* (2015) acknowledging that Liberia has a rich diversity of natural resources.

The following discussions are exclusively based on the responses from the informants. However, factors of limitation to such an approach may arise, as many communities reported only those plants that they use or are familiar with and not being aware of the several other indigenous trees, shrubs, and vines that may be available and have great potential uses and probably commercial values and are being traded in regional and/or international markets.

Table 2.3: Percent number of respondent characteristics for the total communities in the seven counties

Demographics	Parameter	Bong	Nimba	Bassa	Lofa	River Cess	Bomi	Margibi	TOTAL
N	N (sample size)	19.6	22.9	14.9	15.9	7.0	10.0	9.6	**100**
Gender *(p=0.15)*	Sex (Male)	12.6	15.5	7.8	8.1	3.3	6.0	4.7	58.0
	Sex (Female)	7.0	7.5	7.1	7.8	3.7	4.0	4.9	42.0
Age group	Under 20yrs	1.5	1.8	0.9	1.4	0.6	0.8	0.5	7.5
	21-35yrs	2.2	3.0	1.5	1.7	0.9	1.0	0.8	11.2
	36 - 50yrs	5.1	6.2	4.4	4.0	1.6	2.3	2.1	25.8
	51-65yrs	8.2	8.9	6.3	5.8	2.8	4.4	5.0	41.4
	Above 65yrs	2.7	3.0	1.8	2.9	1.1	1.5	1.2	14.2
Marital Status	Single	4.3	5.2	2.1	2.5	1.0	1.1	0.8	17.0
	Married	5.5	7.1	5.8	4.5	1.5	2.9	2.5	29.7
	Engaged	3.7	4.0	3.0	5.1	2.1	3.2	3.2	24.3
	Divorced/separated	2.6	2.9	1.6	1.2	1.1	0.9	1.0	11.3
	Widow/Widower	3.5	3.6	2.4	2.7	1.3	2.0	2.1	17.6
Read/ write	Yes	9.1	8.9	6.1	6.8	3.0	4.2	4.2	42.3
	No	10.5	14.0	8.8	9.1	4.0	6.0	5.4	57.9
Education level	None	10.0	12.3	9.4	7.8	3.6	5.2	5.0	53.2
	Primary	8.5	9.1	4.5	6.8	2.8	3.6	4.4	39.7
	Up to high school	0.9	1.1	0.8	0.9	0.4	0.9	0.3	5.3
	2 year college degree	0.3	0.4	0.3	0.3	0.2	0.3	0.0	1.7
	4 year college degree	0	0	0	0	0	0	0	0
	Graduate degree	0	0	0	0	0	0	0	0
Primary occupation	Retired	0.8	1.1	0.5	0.9	0.3	0.4	0.7	4.6
	Self-employed	6.3	6.6	4.2	3.5	1.6	2.7	2.2	27.1
	Employed by others	3.1	4.1	1.9	2.2	0.9	1.6	1.6	15.5
	Homemaker	1.2	1.5	0.8	0.5	0.3	0.6	0.9	5.8
	Farmer	8.2	9.6	7.6	8.8	3.9	4.7	4.1	46.9
Annual Income	<1,000	18.4	21.4	14.2	15.3	6.6	9.6	8.7	94.1
	1,000-3,999	1.2	1.5	0.8	0.6	0.4	0.4	0.9	5.9
	4,000-5,999	0	0	0	0	0	0	0	0
	6,000-9,999	0	0	0	0	0	0	0	0
	10,000 & above	0	0	0	0	0	0	0	0

2.3.2.1 The Spices

Results of the survey revealed that spices are an important group of NTFP, as they were among the most cited NTFP by local communities. *Xylopia aethiopica* (Country spice) was the most cited product (16.22%) in the survey, followed by *Piper guineense* (West African pepper, or Bush pepper) as the second most cited NTFP (14.16%); while *Aframomum melegueta* (7.0%) was the fifth most cited (Table 2.4). The results showed that the parts used as spice are the seeds; while the seeds, leaves and bark were being used as medicine (Table 2.5). These plants can be found in open and closed dense forest, evergreen forest, lowland rainforest, farmlands, as well as secondary and old growth forests (Table 2.5).

2.3.2.2 Building materials and fibers

An important category of NTFP mentioned by local communities included plants that were considered building materials and fibers, since they are often used for such purposes (Juliani *et al.,* 2013). These include plants used for thatching, round poles, and rafters; the leaves are mainly used for roofing purposes. The leaves and branches are used for roofing huts and/or building, especially in rural communities; the leaves and branches used for furniture; the stem (i.e. *Xylopia aethiopica*) used as poles for building. These plants include Reef (*Bambusa vulgaris*), thatch palm (*Howea forsteriana*), rattan (*Laccosperma spp*.), raffia/bamboo palm (*Raffia vinifera*), and country spice (*Xylopia aethiopica*). Among these, the country spice is one plant type that has many uses including medicinal and spice. It was also noted how *Raffia vinifera* brings another quality to the group of NTFP with its sweet bamboo wine as beverage (Juliani *et al.,* 2013). These plants can be found in various habitats including river banks, roadsides, open grounds, swamp and wetlands, secondary and lowland rainforest areas (Table 6).

2.3.2.1 Colas and edible fruits

The colas and edible fruits category was also cited as one of the most used NTFP by local communities. A total of thirteen plant species were listed under this category (Table 2.7), with 10 being used as medicinal (Table 10). Within this category, *Garcinia kola* was mostly cited (6.4%) by the local communities, followed by Kola ntida (6.0%), *Maesobotrya barterii* (5.1%), *Coula edulis* (3.7%), *Chrysophellum canito* (3.3%), *Cola gigantea* (3.3%), *Uapaca guineense* (3.1%), *Thaumatocossus danielli* (2.6%), *Heritiera utilis* (2.2%). *Cola lateritia* (2.0%), *Sherbourinia colycina* (2.0%), *Averrhoa carambola* (1.8%), and *Allanblankia floribunda* (0.3%) (Table 2.4). The parts of the plants used as cola and fruits as well as medicinals include the fruit, seeds, leaves, and bark. These plants can be found in many habitats including primary and secondary forest areas, evergreen forest, moist-secondary forests, old growth forest, marshes, swamps, and wetland in open and closed dense forests (Table 2.7).

2.3.2.1 Indigenous Vegetables and Mushrooms

Seven local plants were reported and considered under the category of indigenous vegetables and mushrooms category (Table 2.8), with Edible nightshade (*Solanum spp.*) being mostly cited within this category (2.4%), followed by paddy straw mushroom (*Volvariella volvacea,* 2.3%), Snow puff mushroom (*Flammulina velutipes,* 2.3%), tree-ear mushroom (*Auricularia auricular-judae,* 2.1%), bush yam (*Dioscorea spp.,* 1.5%), Cinnamon cap mushroom (*Hypholoma sublateritium,* 1.5%), and chanterelle (*Cantharellus cibarius,* 0.9%) (Table 2.4). This category of NTFP is unique as a potential group for food security and income generation. These plants can be found in various habitats including open forest, high bush, forest edges, wasteland, secondary forest, old farmland, as well as forest beds (Table 2.8).

2.3.2.1 Nuts and edible oils

Another important group of NTFP was the category that includes the nuts and edible oils. Within this category, the African oil palm (*Elaise guineensis)* was most cited (7.8%) and third most cited in the overall citation (Table 2.4); others that were mostly cited included the African cherry (*Tieghemella heckelii* – 6.5%), Bussia (B*ussea occidentalis* – 5.8%), Christmas bell (*Trichilia emetica* – 5.5%), and African oilbean (*Pentaclethra macrophylla* – 5.2%); thirteen others were also being cited, with Napoleon's button (*Napoleonaea heudelotii* – 1.5%) as the least cited. Sixteen species within this category were also reported to be used as medicine. These included *Bussea occidentalis, Calpocalyx aubrevillei, Irvingia gabonensis, Khaya grandifolia, Manniophytan fulvum, Napoleonaea heudelotii, Parinari excels, Parkia bicolor, Pentaclethra macrophylla, Pentadesma butyracea, Pycnanthus angolensis, Ricinodendron heudelotii, Sterculia tragacantha, Tieghemella heckelii, Trichilia emetic,* and *Vitex micrantha* (Table 2.9).

These botanical plants have many valuable uses besides being used as medicinal. For instance, the nuts of *Beischmiedia mannnii* are used in cuisine to make slippery soup, often a favorite in Nimba County; while its flowers are used to spice rice. The nuts of *Elaise guineensis* are used for the production of oil and palm butter, is a soup that is most commonly known throughout Liberia. The nuts of *Irvingia gabonensis* are also used as soup for food. The extracted from the nuts of *Pentadesma butryacea* contain fine gold or yellow shea butter, which can be used in food, or moisturizing cream and soap. The oil extract from the nuts of *Pycnanthus angolensis* are used for candle; while the oil extract from the nuts of *Trichilia emetica* are used as cream the skin, or as conditional in hair. The many valuable uses of these indigenous plants suggest their potential for commercial opportunities; hence, the development can support rural economies and help to alleviate poverty, while contributing to biodiversity conservation.

2.3.2.2 Medicinals

From the 114 listed NTFP, 97 plant species were recorded as having medicinal properties (Table 2.10). These include plants from three other categories (Colas and edible fruits, Nuts and edible oils, and Spices). This is because many NTFP have more than one use, and those with multiple uses often included medicinal qualities. For example, Country spice (*Xylopia aethiopica*) was commonly cited as a spice, medicine, and building material; while Bush pepper (*Piper guineense*) and Melegueta pepper (*Aframomum melegueta*) were cited as spices and also as medicine (Table 2.5). With more than half the total number of cited NTFP considered as medicinals (61%) suggests that these plants are important for local communities to meet their health care needs (Table 2.10).

Seven of the ten top most cited NTFP were recorded to have medicinal uses (*Xylopia aethiopica* – 16.2%, *Piper guineense* – 14.2%, *Terminalia superba* – 7.7%, *Aframomum melegueta* – 7.0%, *Tieghemella heckelii* – 6.5%, *Garcinia kola* – 6.4%, and *Griffonia simplicifolia* – 5.9%). Previous studies have been conducted in Liberia to record NTFP with medicinal values (Kpadehyea *et al.,* 2015; Juliani *et al.,* 2013). The current and previous studies results suggest that local communities are well knowledgeable in the use of their indigenous plants especially in meeting their healthcare needs.

Various parts of the plant species are used as medicine. Plant parts utilized showed that leaves are mostly used, followed by bark, seeds/fruits/nuts, roots, stems, exudates (resin, and milky exudates), and whole plant. These parts can also be used as combined; they include leaves and bark, leaves and stems, leaves and roots, roots and stems, roots and barks, bark and stem/bark-stem, and seed and stem-bark (Table 2.10).

Various illnesses and conditions were reported as being treated with local plant species using plant parts. More than 100 different illnesses and conditions were reported. These include pains (knee pain, side pain, analgesic, body pain, bone pain, back pain, rheumatism, and arthritis), respiratory problems (sore throat, cough bronchitis, and tuberculosis), bowel movement (diarrhea, dysentery, amoebic/bloody dysentery), abdominal pain, and genital conditions (genital-urinary conditions, infections, hematuria, discharges, urethra discharges, swollen testicles, and women aching). Others include dental hygiene (toothache, mouth health, and gingivitis), aphrodisiacs, wounds (skin sore/wounds, baby navel wound, baby skin peel wound, and ulcer wound), headache (fever and migraine), skin diseases (craw-craw, itch, skin fungus, rash, and ringworm), stomach and intestinal problems (ulcer, clean stomach, enlarged spleen, digestion, and gastro-intestinal disorders), and snake bites. Other conditions and illnesses treated are worms (jiggers, hookworm, and other stomach worms), gonorrhea, malaria, jaundice, eye problem (inflamed eye, filarial), heart and chest problems (heart conditions, chest pains, and hypertension), hemorrhoids, hemorrhage, piles, infertility (in men and women), leprosy, inflammations (swollen joints, skin inflammations). Others include measles, chickenpox, smallpox, menstruation pain, labor and delivery pain and bleeding, after birth pain, bladder and kidney ailments, anemia, convulsions, fatigue, baby open mole, yellow fever, burns, breast milk and breast pain, speed up child birth in pregnancy women, child walking treatment, vomiting, constipation, poison, ear problem, and pneumonia. Yet, others still further included diabetes, purgative, scabies, asthma, epilepsy, mental disorders, prevent abortion, ensure pregnancy, treat growing tumor, stroke, prostate gland, bleeding nose, weight loss, hernia, hunchback, stop congestion, blood clotting, involuntary urinating in bed, women to bear child, ovarian problems, and sleeping sickness (Table 2.10).

The many conditions and illnesses that can be treated from local plant species suggests a potential for development by local industry and depending upon the science behind the indigenous species potential pharmaceuticals and dietary supplements (e.g. as Griffonia is used today). Further research needs to conduct for detailed evaluation of the chemical constituents for some of the prominent plant species that are known to treat some common but deadly illnesses, such as malaria, heart and chest problems hypertension). Respiratory problems pains and genital conditions are among a few of the additional major health conditions and ailments that face both old and young. Processes such as development of any one of these plants into products can increase rural economic growth and livelihood sustenance, while good management strategy would be for sustainable exploitation and conservation of biodiversity.

Table 2.4: List of NTFP from 82 communities in 7 counties of Liberia based on their frequency of citation by respondents (percentage of frequency)

No.	Botanical name	Family group	Local name	Bong	Nimba	Bassa	Lofa	Margibi	Bomi	River Cess	Total (%)
1.	*Acorus calamus*	Arecaceae	Palm bitter root	0.34	0.60	0.43	0.17	0.26	0.26	0.17	**2.23**
2.	*Aframomum mellegueta*	Zingiberaceae	Duandin, mala	2.15	1.89	0.43	1.55	0.26	0.34	0.34	**6.95**
3.	*Agelaea pentagyna*	Connaraceae	Gbo; Tia-tee-leh	0.00	0.17	0.34	0.43	0.09	0.00	0.17	**1.20**
4.	*Ageratum conyzoides*	Asteraceae	button grass	0.86	1.12	0.94	0.86	0.43	0.60	0.34	**5.15**
5.	*Albizia adianthifolia*	Fabaceae	Kpaan-leh	0.26	0.43	0.09	0.26	0.00	0.17	0.09	**1.29**
6.	*Alchornea cordifolia*	Euphorbiaceae	Fana-leh, geekee, obumi	1.03	1.20	0.77	1.12	0.34	0.43	0.34	**5.24**
7.	*Allanblackia floribunda*	Clusiaceae	Gba-pain , Gba-chu	0.00	0.09	0.09	0.00	0.00	0.00	0.09	**0.26**
8.	*Alstonia boonei*	Apocynaceae	yung, Yolo	0.17	0.17	0.26	0.43	0.00	0.17	0.17	**1.37**
9.	*Amphimas pterocarpoides*	Fabaceae	Gbea wondor-yelee	0.26	0.17	0.34	0.17	0.17	0.00	0.09	**1.20**
10.	*Anopyxis klaineana*	Rhizophoraceae	Bodioa, uweng	0.00	0.34	0.17	0.00	0.34	0.17	0.00	**1.03**
11.	*Anthonotha spp.*	Fabaceae	Gbekay	0.26	0.52	0.17	0.43	0.00	0.26	0.09	**1.72**
12.	*Auricularia auricula-judae*	Auriculariaceae	Old lady ear mushroom	0.34	0.43	0.17	0.69	0.09	0.17	0.26	**2.15**
13.	*Averrhoa carambala*	Oxalidaceae	Star fruit	0.34	0.26	0.17	0.43	0.17	0.26	0.17	**1.80**
14.	*Bambusa vulgaris*	Poaceae	kwintofi	0.17	0.26	0.17	0.34	0.17	0.17	0.26	**1.55**

No.	Botanical name	Family group	Local name	Bong	Nimba	Bassa	Lofa	Margibi	Bomi	River Cess	Total (%)
15.	*Beilschmiedia mannii*	Lauraceae	Bambooo	0.60	1.03	0.34	1.12	0.26	0.17	0.26	**3.78**
16.	*Bridelia grandis*	Euphorbiaceae	doando, gbai, gooslowee	0.09	0.34	0.26	0.26	0.09	0.00	0.09	**1.12**
17.	*Bryophyllum pennatum*	Austeraceae	Ka	0.17	0.52	0.09	0.34	0.17	0.09	0.17	**1.55**
18.	*Bussea occidentalis*	Fabaceae	pah-kloh	1.46	1.20	0.69	1.55	0.26	0.34	0.26	**5.75**
19.	*Calpocalyx aubrevillei*	Fabaceae	Deh	0.69	0.52	0.77	1.12	0.09	0.00	0.43	**3.61**
20.	*Canarium schweinfurthii*	Burseraceae	beeng	0.17	0.26	0.09	0.43	0.09	0.17	0.00	**1.20**
21.	*Cantharellus cibarius*	Cantharellaceae	Pain-zo-tee	0.17	0.26	0.00	0.34	0.00	0.09	0.09	**0.94**
22.	*Chidlowia sanguinea*	Fabaceae	Doe-leh	0.34	0.26	0.17	0.60	0.09	0.26	0.17	**1.89**
23.	*Chromolaena odorata*	Asteraceae	Star apple	0.26	0.52	0.17	0.34	0.00	0.17	0.00	**1.46**
24.	*Chrysophellum canito*	Sapotaceae	She-peh	0.43	0.60	0.34	0.77	0.69	0.34	0.17	**3.35**
25.	*Cleistopholis patens*	Annonaceae	ouara, wara	0.17	0.43	0.17	0.43	0.00	0.26	0.09	**1.55**
26.	*Cola lateritia*	Malvaceae	cola nut	0.60	0.43	0.17	0.60	0.09	0.00	0.09	**1.97**
27.	*Cola gigantea*	Sterculiaceae	Cuman – bea	0.69	0.43	0.60	0.86	0.26	0.26	0.17	**3.26**
28.	*Costus dubius*	Costaceae	sla, she	0.34	0.60	0.26	0.26	0.43	0.17	0.17	**2.23**
29.	*Coula edulis*	Olacaceae	Gbake	0.77	1.03	0.26	1.12	0.17	0.26	0.09	**3.69**
30.	*Craterispermum laurinum*	Rubiaceae	Guo	0.26	0.60	0.26	0.43	0.00	0.00	0.09	**1.63**
31.	*Cryptosepalum tetraphyllum*	Fabaceae	Sanfukle-leh,Guo	0.34	0.60	0.17	0.69	0.17	0.26	0.43	**2.66**
32.	*Dialium dinklagei*	Fabaceae	country yam	0.26	0.34	0.17	0.34	0.00	0.17	0.17	**1.46**
33.	*Dioscorea sp.*	Dioscoraceae	Gbokala-leh;Bealon-leh	0.34	0.26	0.09	0.34	0.09	0.17	0.17	**1.46**
34.	*Dracaena calocephala*	Asparagaceae	seah	0.17	0.34	0.34	0.43	0.00	0.17	0.26	**1.72**

No.	Botanical name	Family group	Local name	Bong	Nimba	Bassa	Lofa	Margibi	Bomi	River Cess	Total (%)
35.	*Elaise guineensis*	Arecaceae	Wengban-leh	1.80	1.55	1.12	2.15	0.69	0.34	0.17	**7.81**
36.	*Eremomastax speciosa*	Acanthaceae	Golo	0.09	0.26	0.17	0.34	0.17	0.17	0.26	**1.46**
37.	*Ficus spp.*	Moraceae	Oldlady hair mushroom	0.26	0.43	0.43	0.34	0.00	0.00	0.26	**1.72**
38.	*Flammulina velutipes*	Physalacriaceae	Sekelay, bobo	0.43	0.60	0.26	0.69	0.09	0.17	0.09	**2.32**
39.	*Funtumia africana*	Apocynaceae	Bitter cola	0.00	0.26	0.17	0.34	0.00	0.26	0.09	**1.12**
40.	*Garcinia kola*	Guttiferae	Gbekay	1.29	1.46	0.60	1.80	0.69	0.43	0.17	**6.44**
41.	*Gilbertiodendron limba*	Fabaceae	Black diamond,at ooto, poopoo	0.17	0.43	0.17	0.60	0.00	0.34	0.26	**1.97**
42.	*Griffonia simplicifolia*	Fabaceae	Pateh-pateh-leh	0.00	2.32	1.89	1.72	0.00	0.00	0.00	**5.92**
43.	*Guibourtia ehie*	Fabaceae	Yoengo	0.34	0.60	0.52	0.77	0.26	0.60	0.26	**3.35**
44.	*Harungana madagascariensis*	Hypericaceae	Niangon or whismore, dahmlu	0.00	0.34	0.09	0.17	0.00	0.17	0.00	**0.77**
45.	*Heritiera utilis*	Malvaceae	peasawa	0.43	0.60	0.26	0.52	0.17	0.17	0.09	**2.23**
46.	*Howea forsteriana*	Arecaceae	kuokola-leh	0.17	0.34	0.09	0.17	0.09	0.17	0.00	**1.03**
47.	*Hymenocoleus hirsutus*	Rubiaceae	small mushroom	0.26	0.17	0.00	0.34	0.00	0.00	0.09	**0.86**
48.	*Hypholoma sublateritium*	Strophariaceae	Fala-leh	0.17	0.43	0.17	0.26	0.17	0.09	0.17	**1.46**
49.	*Impatiens nzoana*	Balsaminaceae	Gborzay; kohsu	0.26	0.26	0.17	0.43	0.17	0.34	0.17	**1.80**
50.	*Ipomoea involucrata*	Convolvulaceae	Bush mango, dika	0.60	0.43	0.43	0.77	0.17	0.26	0.26	**2.92**

No.	Botanical name	Family group	Local name	Bong	Nimba	Bassa	Lofa	Margibi	Bomi	River Cess	Total (%)
51.	*Irvingia gabonensis*	Irvingiaceae	Khaya	0.86	1.29	0.52	1.03	0.17	0.43	0.34	**4.64**
52.	*Khaya grandifolia*	Meliaceae	Goo	0.60	0.52	0.17	0.43	0.00	0.17	0.00	**1.89**
53.	*Kola ntida*	Malvaceae	gballer	1.46	0.94	0.86	1.63	0.34	0.52	0.26	**6.01**
54.	*Laccosperma spp.*	Arecaceae	Chicken mushroom	0.43	0.26	0.17	0.34	0.26	0.26	0.17	**1.89**
55.	*Landolphia dulcis*	Apocynaceae	Gbofeakala	0.00	0.17	0.60	0.34	0.09	0.00	0.34	**1.55**
56.	*Macaranga barteri*	Euphorbiaceae	Guu, Fowo	0.17	0.26	0.09	0.26	0.00	0.09	0.09	**0.94**
57.	*Macaranga heterophylla*	Euphorbiaceae	Maguu	0.17	0.34	0.00	0.34	0.00	0.00	0.09	**0.94**
58.	*Maesobotrya barterii*	Euphorbiaceae	Tola, kai	1.20	1.03	0.52	1.46	0.26	0.34	0.26	**5.06**
59.	*Mammea africana*	Guttiferae	Kaikumba, oboto	0.26	0.43	0.26	0.43	0.00	0.09	0.34	**1.80**
60.	*Manniophytan fulvum*	Euphorbiaceae	Fiain, Fahlen, Fehyee-leh	0.43	0.26	1.20	0.69	0.17	0.77	0.69	**4.21**
61.	*Mareya micrantha*	Euphorbiaceae	Chaw, wana, wana-leh	0.34	0.43	0.34	0.60	0.00	0.17	0.09	**1.97**
62.	*Margaritaria discoidea*	Phyllanthaceae	San-yela, Wineweleh	0.26	0.60	0.17	0.60	0.43	0.26	0.34	**2.66**
63.	*Mezoneuron bethamianum*	Leguminoceae	mezo	0.26	0.34	0.60	0.69	0.09	0.17	0.09	**2.23**
64.	*Microdesmis kaeyana*	Pandaceae	Haysay lay(Gola), salyee-leh	0.00	0.52	0.17	0.60	0.00	0.17	0.09	**1.55**
65.	*Milicia excelsa*	Moraceae	Gayee	0.26	0.60	0.26	0.43	0.17	0.00	0.00	**1.72**
66.	*Morinda morindoides*	Rubiaceae	Kojologbo	0.77	1.03	0.60	0.86	0.52	0.77	0.60	**5.15**
67.	*Musanga cecropioides*	Cecropiaceae	Wolo, delei	0.69	0.94	0.52	1.20	0.26	0.43	0.52	**4.55**

No.	Botanical name	Family group	Local name	Bong	Nimba	Bassa	Lofa	Margibi	Bomi	River Cess	Total (%)
68.	*Mussularia accuminata*	Euphorbiaceae	Iron tay-tay, bush hytie	0.09	0.00	0.17	0.43	0.00	0.26	0.09	**1.03**
69.	*Myrianthus libericus*	Cecropiaceae	Gbalo	0.26	0.43	0.17	0.52	0.09	0.00	0.17	**1.63**
70.	*Napoleonaea heudelotii*	Lecythidaceae	Telee	0.17	0.34	0.09	0.52	0.09	0.09	0.17	**1.46**
71.	*Nauclea latifolia*	Rubiaceae	Doma – Balee, wea-yelee, opepe	0.60	0.43	0.17	0.34	0.09	0.26	0.43	**2.32**
72.	*Newtonia aubrevillei*	Fabaceae	gonlelu	0.77	0.60	0.26	0.34	0.26	0.09	0.34	**2.66**
73.	*Okoubaka aubrevillei*	Santalaceae	Yein-yelee	0.00	0.00	0.17	0.34	0.00	0.00	0.26	**0.77**
74.	*Pachypodanthium staudtii*	Annonaceae	zree-chu, ntom	0.60	0.77	0.60	0.86	0.34	0.43	0.26	**3.86**
75.	*Palisota hirsuta*	Commelinaceae	Keahkorpar-leh, kpuoke	0.34	0.34	0.26	0.43	0.17	0.52	0.34	**2.40**
76.	*Parinari excelsa*	Chrysobalana-ceae	Quein, gboh	0.69	0.60	0.34	0.94	0.09	0.17	0.00	**2.83**
77.	*Parkia bicolor*	Fabaceae	gworluu	0.77	1.03	0.60	0.86	0.17	0.26	0.17	**3.86**
78.	*Pentaclethra macrophylla*	Fabaceae	gbia, koowa	0.77	1.20	0.60	1.55	0.26	0.52	0.26	**5.15**
79.	*Pentadesma butyracea*	Clusiaceae	Kpangnan, mdayen	0.34	0.94	0.26	0.69	0.09	0.00	0.17	**2.49**
80.	*Petersianthus macrocarpus*	Lecythidaceae	Pein	0.00	0.17	0.00	0.09	0.00	0.00	0.00	**0.26**
81.	*Piper guineense*	Piperaceae	Zen-beleh, bush pepper	3.26	3.09	1.63	2.66	1.72	0.77	1.03	**14.16**
82.	*Piptadeniastrum africanum*	Fabaceae	Belah	0.34	0.60	0.77	0.60	0.17	0.09	0.34	**2.92**
83.	*Protomegabaria macrophylla*	Euphorbiaceae	Kola	0.26	0.43	0.60	0.34	0.00	0.17	0.00	**1.80**

No.	Botanical name	Family group	Local name	Bong	Nimba	Bassa	Lofa	Margibi	Bomi	River Cess	Total (%)
84.	*Psychotria peduncularis*	Rubiaceae	Kpain-leh; wengban-leh	0.17	0.43	0.26	0.34	0.00	0.09	0.17	**1.46**
85.	*Pterocarpus erinaceus*	Fabaceae	Crabwood/ camwood	0.43	0.77	0.34	0.77	0.17	0.34	0.26	**3.09**
86.	*Pycnanthus angolensis*	Myristicaceae	Deinee, gboyei	0.60	1.03	0.26	0.86	0.17	0.09	0.17	**3.18**
87.	*Quassia undulata*	Simaroubaceae	Bolo-tan-yele	0.34	0.69	0.26	0.60	0.09	0.09	0.26	**2.32**
88.	*Raffia vinifera*	Arecaceae	bamboo palm	0.60	1.03	0.86	1.29	0.77	0.94	0.69	**6.18**
89.	*Rauvolfia vomitoria*	Apocynaceae	Mon-yala-yelee	0.09	0.43	0.09	0.00	0.09	0.00	0.09	**0.77**
90.	*Rhodognaphalon brevicuspe*	Malvaceae	swa-uh	0.52	0.69	0.34	0.60	0.17	0.09	0.26	**2.66**
91.	*Ricinodendron heudelotii*	Euphorbiaceae	Cor, pongo	0.77	1.20	0.52	1.03	0.17	0.69	0.52	**4.89**
92.	*Rinorea ilicifolia*	Violaceae	Koo-leh	0.43	0.60	0.34	0.43	0.09	0.26	0.00	**2.15**
93.	*Sacoglottis gabonensis*	Humiriaceae	Ozouga, doh	0.09	0.17	0.43	0.86	0.00	0.09	0.00	**1.63**
94.	*Samanea dinklagei*	Fabaceae	San-yelah,	0.17	0.26	0.09	0.09	0.00	0.00	0.17	**0.77**
95.	*Scadoxus multiflorus*	Amaryllidaceae	Bala-ye-gbian	0.43	0.52	0.34	0.26	0.17	0.26	0.09	**2.06**
96.	*Scleria secans*	Cyperaceae	Pay-pay; bush blade	0.00	0.26	0.17	0.52	0.09	0.00	0.17	**1.20**
97.	*Senna alata*	Fabaceae	Doomon (Gola)	0.43	0.77	0.43	0.60	0.17	0.26	0.17	**2.83**
98.	*Sherbourinia calycina*	Rubiaceae	Mombeh	0.34	0.52	0.17	0.60	0.09	0.17	0.09	**1.97**
99.	*Solanum nigrum*	Solanaceae	nightshade	0.26	0.60	0.69	0.60	0.00	0.17	0.09	**2.40**
100.	*Sterculia tragacantha*	Malvaceae	Tuu	0.52	1.46	0.77	1.12	0.17	0.34	0.34	**4.72**

No.	Botanical name	Family group	Local name	Bong	Nimba	Bassa	Lofa	Margibi	Bomi	River Cess	Total (%)
101.	*Strephonema pseudocola*	Combretaceae	Gbekeh-pulu	0.43	0.77	0.34	0.69	0.17	0.34	0.43	**3.18**
102.	*Tabernaemontana africana*	Apocynaceae		0.00	0.26	0.17	0.34	0.00	0.00	0.09	**0.86**
103.	*Terminalia superba*	Combretaceae	frake	1.20	2.23	1.03	1.80	0.34	0.60	0.52	**7.73**
104.	*Tetracera affinis*	Dilleniaceae	Zoe-kpeyee-beleh	0.60	0.77	0.60	0.43	0.26	0.34	0.52	**3.52**
105.	*Thaumatococcus danielli*	Marantaceae	Sugar seed	0.43	0.69	0.26	0.86	0.17	0.09	0.09	**2.58**
106.	*Tieghemella heckelii*	Sapotaceae	Kpo, baku	1.20	1.55	1.12	1.80	0.17	0.26	0.43	**6.52**
107.	*Tiliacora leonensis*	Menispermaceae	Mene-fee-beleh;Gbeseh-leh	0.43	0.60	0.52	0.77	0.52	0.26	0.43	**3.52**
108.	*Trichilia emetica*	Meliaceae	Gay – Gbea	0.77	1.03	0.60	1.29	0.34	0.86	0.60	**5.49**
109.	*Uapaca guineense*	Phyllanthaceae	Rikio, swoang-nasa	0.52	0.77	0.34	0.60	0.26	0.43	0.17	**3.09**
110.	*Vitex micrantha*	Verbenaceae	Muu-yelee, andofiti	0.26	0.43	0.17	0.60	0.17	0.17	0.60	**2.40**
111.	*Voacanga africana*	Apocynaceae	voacanga	0.26	0.94	1.20	1.46	0.09	0.17	0.34	**4.46**
112.	*Volvariella volvacea*	Pluteaceae	straw mushroom	0.43	0.60	0.17	0.77	0.00	0.17	0.17	**2.32**
113.	*Xylopia aethiopica*	Annonaceae	Gbaan wolo	3.52	3.86	2.32	2.92	1.46	0.94	1.20	**16.22**
114.	*Zanthoxylum gilletii*	Rutaceae	Fagara, Geyee, gein	0.43	0.43	0.34	0.26	0.26	0.17	0.09	**1.97**

Table 2.5: List of botanical plants and common names of those NTFP that belong to the Spice Category with their uses and habitat

Botanical name	Family	Common name	Category	Uses	Habitat
Aframomum mellegueta	Zingiberaceae	Maleguetta pepper	Spices	**Seeds**: used as spice; also used for infection, body pain, stomach ache, heart ache, measles, menstruation	Open and closed dense forest
Piper guineense	Piperaceae	West African pepper, Bush pepper	Spices	**Seeds**: used as spice in food; also used for body and back pain, stomachache; **Leaves**: used to treat cough, intestinal diseases, worms, and rheumatism	Evergreen forest
Xylopia aethiopica	Annonaceae	Country spice	Spices	**Seeds**: used as spice in food; used to treat stomach ache, dysentery, toothache, and urinary tract, used as purifier; **Bark**: used to treat asthma, stomachache and rheumatism	Lowland rainforest, farmland, secondary, and old growth forests

Table 2.6: List of botanical plants of those NTFP that belong to Building Materials and Fibers Category with their Family, common names, uses and habitat

Botanical name	Family	Common name	Category	Uses	Habitat
Bambusa vulgaris	Poaceae	Reef, bamboo	Building materials and fibers	**Branches**: used for furniture, building; sprouts and bitter, useful in inflammation, ulcers, and wounds	On river banks, roadsides, wastelands, open ground
Howea forsteriana	Arecaceae	Thatch palm	Building materials and fibers	**Leaf**: used for roofing huts, and/or houses	Moist forest areas, creak and river banks
Laccosperma spp.	Arecaceae	Rattan	Building materials and fibers	**Leaf**: used for furniture, and building	seasonally inundated and swampy areas
Raffia vinifera	Arecaceae	Raffia, bamboo palm	Building materials and fibers	**Leaf**: used for furniture, and building; **Tree**: produces raffia wine/ bamboo wine that is a sweet drink	Along banks of creeks, streams and rivers, swamps and wetland
Xylopia aethiopica	Annonaceae	Country spice	Building materials and fibers	**Stem:** used as round poles for building huts and kitchen	Lowland rainforest, farmland, secondary, and old growth forests

Table 2.7: List of botanical plants of those NTFP that belong to the Colas and Edible Fruits Category with their Family, common names, uses and habitat

Botanical name	Family	Common name	Category	Uses	Habitat
Allanblackia floribunda	Clusiaceae	Tallow tree, lacewood	Colas and edible fruits	**Bark:** used to relieve toothache, cough, dysentery, as an aphrodisiac, treat hypertension, and pain reliever; **Leaves**: used for vegetables; **Seeds**: oil used for cosmetic	Forest areas, secondary and primary
Averrhoa carambala	Oxalidaceae	Star fruit, Carambola	Colas and edible fruits	**Fruit**: good for eating; can be used to relieve bleeding hemorrhoids	Evergreen forest
Chrysophellum canito	Sapotaceae	Star apple	Colas and edible fruits	**Fruit:** very tasty, sweet fruit; used to sooth pneumonia, treat diabetes mellitus	Moist secondary forests
Cola lateritia	Malvaceae	Bush cola	Colas and edible fruits	**Fruit**: sugary coating on fruit is eaten, **Seeds:** boost energy and stimulate digestion	Lowland montane forest
Cola gigantea	Sterculiaceae	Giant cola	Colas and edible fruits	**Fruit**: fleshy; **Nut:** good for eating; **Bark:** used for painkillers, hemorrhoids, skin diseases	Evergreen lowland forest areas
Coula edulis	Olacaceae	Walnut	Colas and edible fruits	**Seeds**: edible; **Bark**: decoction used for body pain	Forest canopy and lower floor beds of forests
Garcinia kola	Guttiferae	Bitter cola	Colas and edible fruits	**Fruit**: edible; treat malaria; aphrodisiac	Old growth forest

Botanical name	Family	Common name	Category	Uses	Habitat
Heritiera utilis	Malvaceae	Whismore	Colas and edible fruits	**Fruits:** edible; **Seeds:** produced edible oil	Evergreen forests
Kola ntida	Malvaceae	Kola nuts	Colas and edible fruits	**Fruit**: eaten as stimulant and anti-hunger; used in traditional ceremonies	Low and high forest areas
Maesobotrya barterii	Euphorbiaceae	Bush cherry	Colas and edible fruits	**Fruits:** eaten fresh or made into juice; Leaf: sap used as general healing, heart problems; **Bark**: used as pain killers, stomach problem, diarrhea, dysentery, genital stimulant, aphrodisiac, smallpox, chickenpox, and measles	Young secondary and old growth forest
Sherbourinia calycina	Rubiaceae	Yellow monkey apple	Colas and edible fruits	**Fruit**: eaten fresh	Evergreen secondary forest
Thaumatococcus danielli	Marantaceae	Miracle berry/fruit	Colas and edible fruits	**Fruits**: as natural sweetener; **Leaves**: used for wrapping foods	Wetland in open and closed dense forest
Uapaca guineense	Phyllanthaceae	Sugar plum	Colas and edible fruits	**Fruits**: edible, give drink a flavor; **Leaves and root-bark**: used to treat migraine, rheumatism, and late walking children; **Roots**: used as aphrodisiac, to treat male impotence, good for chest and lungs cleaning, relieve fever, headache and pains; other species of plant used to treat yellow jaundice, and malaria	Marshes, swamps, secondary forest

Table 2.8: List of botanical plants of those NTFP that belong to Indigenous Vegetables and Mushrooms Category with their Family, common names, uses habitat

Botanical name	Family	Common name	Category	Uses	Habitat
Auricularia auricula-judae	Auriculariaceae	Tree ear mushroom	Indigenous vegetables and mushrooms	**Whole plant:** edible mushrooms good in soup	Evergreen and wet evergreen forest
Cantharellus cibarius	Cantharellaceae	Chanterelle, girolle	Indigenous vegetables and mushrooms	**Whole plant:** edible mushrooms good in soup	On dead and mature hardwoods in forest and farmlands
Dioscorea spp.	Dioscoraceae	Bush yam	Indigenous vegetables and mushrooms	**Tuber**: good as food	Open forest, high bush, forest edges
Flammulina velutipes	Physalacriaceae	Snow puff mushroom	Indigenous vegetables and mushrooms	**Whole plant:** Edible mushrooms good in soup	Saprobic, fruiting in clusters on deciduous trees, logs, and stumps
Hypholoma sublateritium	Strophariaceae	Cinnamon cap mushroom	Indigenous vegetables and mushrooms	**Whole plant:** edible mushrooms good in soup	On decaying hardwood, stumps and logs in forests and farmlands
Solanum spp.	Solanaceae	Edible Nightshade	Indigenous vegetables and mushrooms	**Leaves**: an edible vegetable	Wasteland, secondary forest, farmland
Volvariella volvacea	Pluteaceae	Paddy straw mushroom	Indigenous vegetables and mushrooms	**Whole plant:** edible mushrooms good in soup, and also roasted	Woodchips, compost piles, old dumpsites, forest beds

Table 2.9: List of botanical plants of those NTFP that belong to the Nuts and Edible Oils Category with their Family, common names, uses and habitat

Botanical name	Family	Common name	Category	Uses	Habitat
Beilschmiedia mannii	Lauraceae	Wollor	Nuts and edible oils	**Nuts**: used to make slippery soup; **Flowers**: used to spice rice	Secondary and old growth forest
Bussea occidentalis	Fabaceae	Samata, Bussia	Nuts and edible oils	**Seeds**: eaten fresh or roasted **Bark**: used for treating sleeping sickness and jaundice	Old growth forest
Calpocalyx aubrevillei	Fabaceae	Calpocalyx	Nuts and edible oils	**Seeds**: eaten; **Leaves**: used for toothache, used to treat women aching breasts	Forest areas, in valleys and river banks
Elaise guineensis	Arecaceae	African oil palm	Nuts and edible oils	**Nuts**: used for production of oil and palm butter for soup	Young secondary and open forest
Irvingia gabonensis	Irvingiaceae	African mango	Nuts and edible oils	**Fruit**: used as soup for food; **Seeds** used to treat weight loss, diabetes	Old growth forest
Khaya grandifolia	Meliaceae	African mahogany	Nuts and edible oils	**Seeds**: can be eaten; **Bark and seeds:** used to treat malaria	Open and closed dense forests
Manniophytan fulvum	Euphorbiaceae	Gasso nut	Nuts and edible oils	**Seeds**: edible; also good for hemorrhoid and blood problems	Closed forests, or mixed deciduous

Botanical name	Family	Common name	Category	Uses	Habitat
				Leaves, stem, bark: Treat diarrhea, stomach-ache, cough, bronchitis, stop blood on open wounds, dysentery, piles, hemoptysis, painful menses, gonorrhea, snake bite and infection, medicine to ensure pregnancy;	evergreen forest, both primary and secondary forests, roadsides, abandoned area, and fallow areas
Napoleonaea heudelotii	Lecythidaceae	Napoleon's button	Nuts and edible oils	**Fruit**: used to treat hernia; **Fruit and bark**: used to treat snake bite, and persistent coughs	Forest, in regrowth forest
Parinari excelsa	Chrysobalanaceae	Guinea plum	Nuts and edible oils	**Fruit**: edible; **Seeds**: eaten when roasted; **Bark**: decoction used for stomach ache, heart problems, anemia, diarrhea, hookworm; **Leaves**: applied to fresh wounds, toothache; **Roots**: used to treat migraine, stomach pains, chest pains, and rheumatism	Secondary and old growth forest
Parkia bicolor	Fabaceae	African locust bean	Nuts and edible oils	**Fruit**: edible; used as painkiller, treat measles, smallpox, and chicken pox	Open and closed forest
Pentaclethra macrophylla	Fabaceae	African oilbean	Nuts and edible oils	**Seeds**: eaten when roasted;	Streams areas, edge of damp depressions, roadsides farms

Botanical name	Family	Common name	Category	Uses	Habitat
				leaf, stem-bark, seed and fruit: used to treat inflammatory, gonorrhea, , dysentery, convulsion, and leprosy	
Pentadesma butyracea	Clusiaceae	Butter tree	Nuts and edible oils	**Seeds**: contain fine golden or yellow shea butter; **Butter**: used for skin treatment and moisturizing, food oil, and soap	Evergreen and semi-deciduous forest
Pycnanthus angolensis	Myristicaceae	African nutmeg, false nutmeg	Nuts and edible oils	**Fruit**: is edible; **Seeds**: oil used for candle; **Bark**: used to treat toothache, stomachache, stop bleeding; used to treat anemia, leprosy, gonorrhea, malaria, infertility, toothache, and snake bite **Leaf**: decoction used for inflammation on skin, filariasis in the eye	Secondary forest
Ricinodendron heudelotii	Euphorbiaceae	Bush peanut	Nuts and edible oils	**Nuts**: eaten when cooked or patched; used to treat bones, menstruation, gonorrhea	Evergreen secondary forest
Sterculia tragacantha	Malvaceae	Sterculia	Nuts and edible oils	**Seeds**: eaten roasted or cooked; **Gum**: used to treat urinary tract infection, snake, bleeding, open mole on baby's head, burns, and suppress tumors	Swamps, or marshes forest types
Tieghemella heckelii	Sapotaceae	Cherry mahogany,	Nuts and edible oils	**Fruit**: edible and produces oil;	Open and closed dense forest

Botanical name	Family	Common name	Category	Uses	Habitat
		African cherry		**Buds**: used to treat snakebite **Bark**: treat toothache	
Trichilia emetica	Meliaceae	Natal mahogany, Christmas bells	Nuts and edible oils	**Seeds**: eaten dried or patched; **Oil from seeds**: used on skin as cream and as condition in hair, used to treat rheumatism and wounds	Evergreen riverine forest and secondary forest
Vitex micrantha	Verbenaceae	Vitex	Nuts and edible oils	**Fruits**: eaten raw or cooked; **Leaves and bark**: used to treat craw-craw; fruit used to treat fertility, anemia, jaundice, leprosy, diarrhea, and dysentery, headache, measles, rash, fever, chickenpox, and eye problems; **Root**: decoction used to treat gonorrhea, gastro-intestinal disorders, jaundice, backaches, and wound and burns	Lowland evergreen forest, understory closed forest

Table 2.10: List of the botanical NTFP plants that belong to the Medicinals Category with their uses, plant part and habitat

Botanical name	Family	Common name	Category	Uses	Habitat
Acorus calamus	Arecaceae	Calamus root, Palm bitter root	Medicinal	**Rhizome**: used as stimulants, as aphrodisiacs, analgesic, overcome hunger and fatigue, upset stomach; also used as ingredient in soup	River sides, marshes, swamps and wetlands
Aframomum mellegueta	Zingiberaceae	Maleguetta pepper	Medicinal	**Seeds**: used as spice; also used for infection, body pain, stomach ache, heart ache, measles, menstruation	Open and closed dense forest
Agelaea pentagyna	Connaraceae	Gbo, Tia-tee-leh	Medicinal	**Bark and roots**: decoction used as treatment for snake bite and knee pain	Open and close dense forest; along margins of forest areas
Ageratum conyzoides	Asteraceae	Goatweed, chickweed	Medicinal	**Whole plant**: used to treat bloody dysentery, stomach ache and bleeding	Open forest, high bush
Albizia adianthifolia	Fabaceae	Flat-crown, pampena, Kpaan-leh	Medicinal	**Bark**: used to treat skin diseases, side pains, bronchitis, heal baby's skull mold; treat stomach, convulsions, and chill **Roots**: extract treat snakebite, inflamed eye	Forest areas, secondary and old growth forest
Alchornea cordifolia	Euphorbiaceae	Christmas bush	Medicinal	**Leaves**: used to treat a variety of respiratory problems, including sore threat, cough and bronchitis, genital-urinary conditions, intestinal problems including ulcers, diarrhea, amoebic, dysentery, and worms; for baby open mold	Farmland, savannah, and young secondary forest

Botanical name	Family	Common name	Category	Uses	Habitat
				Roots and stems: used for dental hygiene; treatment against body pain, eye, stomach, cough, bone ache, gonorrhea, and wounds; **Fruit sap**: used to cure eye problems and skin diseases;	
Allanblackia floribunda	Clusiaceae	Tallow tree, lacewood	Medicinal	**Bark:** used to relieve toothache, cough, dysentery, as an aphrodisiac, treat hypertension, and pain reliever; **Leaves**: used for vegetables; **Seeds**: oil used for cosmetic	Forest areas, secondary and primary
Alstonia boonei	Apocynaceae	Cheese wood	Medicinal	**Bark:** used to treat malaria, snake bite, worms, yellow fever, and rheumatism	Secondary forest, damp forests
Amphimas pterocarpoides	Fabaceae	Gbea wondor-yelee	Medicinal	Used to treat swollen joints, dysentery, craw-craw	Evergreen forest
Anopyxis klaineana	Rhizophoraceae	Heartwood	Medicinal	**Bark:** concoction used for treating skin infections and ulcer	Wetter evergreen forest
Anthonotha spp.	Fabaceae	African rosewood	Medicinal	Treatment for sores, headache, worms, breast milk, and arthritis	Close and open dense forest
Averrhoa carambala	Oxalidaceae	Star fruit, Carambola	Medicinal	**Fruit**: good for eating; can be used to relieve bleeding hemorrhoids	Evergreen forest

Botanical name	Family	Common name	Category	Uses	Habitat
Bridelia grandis	Euphorbiaceae	Thorny tree, assas	Medicinal	**Bark:** used as an antidote for dysentery; **Stem, leaves, roots and fruits**: used for rheumatism, arthritis, abdominal pain, and teeth infection, oral cavity infection	High closed forests, and secondary forests
Bryophyllum pennatum	Austeraceae	Everlasting leaf	Medicinal	**Leaf**: treatment against Cough, worm expellant, baby navel wound, burns, mother breast pains	Roadsides, waste areas, coastal areas, open woodlands, forests and forest margins
Bussea occidentalis	Fabaceae	Samata, Bussia	Medicinal	**Seeds**: eaten fresh or roasted **Bark**: together with bark of *Distenmonanthus benthamianus* is used for treating sleeping sickness and jaundice	Old growth forest
Calpocalyx aubrevillei	Fabaceae	Calpocalyx	Medicinal	**Seeds**: eaten; **Leaves**: used for toothache, used to treat women aching breasts	Forest areas, in valleys and river banks
Canarium schweinfurthii	Burseraceae	White mahogany	Medicinal	**Resin:** used for candles, flares and touches; removing intestinal parasites, gonorrhea; **Bark**: used to treat leprosy	Rain forest areas, forest patches, and transitional forest
Chidlowia sanguinea	Fabaceae	Ash plant	Medicinal	**Leaves**: used to treat fever, headache, and body pains	Forest areas

Botanical name	Family	Common name	Category	Uses	Habitat
Chromolaena odorata	Asteraceae	Doe leaf	Medicinal	**Leaves**: treatment for Sores; malaria; treat skin wounds, eye pains	Open secondary forest and bushlands, abandoned or neglected fields, forest clearings, wastelands, and forest margins
Chrysophellum canito	Sapotaceae	Star apple	Medicinal	**Fruit:** very tasty, sweet fruit; used to sooth pneumonia, treat diabetes mellitus	Moist secondary forests
Cleistopholis patens	Annonaceae	She-peh	Medicinal	**Leaves**: used to treat headache and infections **Bark**: decoction is drunk to treat tuberculosis and bronchial infections; treat hunchback	Farmlands and young secondary growth forests
Cola lateritia	Malvaceae	Bush cola	Medicinal	**Fruit**: sugary coating on fruit is eaten, **Seeds:** boost energy and stimulate digestion	Lowland montane forest
Cola gigantea	Sterculiaceae	Giant cola	Medicinal	**Fruit**: fleshy; **Nut:** good for eating; **Bark:** used for painkillers, hemorrhoids, skin diseases	Evergreen lowland forest areas
Costus dubius	Costaceae	Spiral flag, spiral ginger	Medicinal	**Flower extract:** used as eye drops against dull sight; **Stem:** used to treat jaundice	Wetlands, forest areas

Botanical name	Family	Common name	Category	Uses	Habitat
Coula edulis	Olacaceae	Walnut	Medicinal	**Seeds**: edible; **Bark**: decoction used for body pain	Forest canopy and lower floor beds of forests
Craterispermum laurinum	Rubiaceae	Gbake	Medicinal	**Bark, leaf, or root infusion**: used to treat gonorrhea, jaundice, yellow fever, urine, toothache, infection **Bark, leaf or root powder**: applied to wounds and sores	Deciduous forest and banks of rivers, and savannah areas
Cryptosepalum tetraphyllum	Fabaceae	Guo	Medicinal	**Leaves and bark**: treatment against stomach pain	Deciduous forest areas, wet evergreen forests, along riversides
Dialium dinklagei	Fabaceae	Eyoum, Dina	Medicinal	**Bark**: used as purgative; treat against stomach pain and headache; arthritis **Leaves**: decoction treat jaundice, hematuria and fever	Evergreen and moist semi-deciduous forest
Dracaena calocephala	Asparagaceae	Gbokala-leh;Bealon-leh	Medicinal	**Leaves**: treatment against ear-ache and speed up child birth	Open and close dense forest
Eremomastax speciosa	Acanthaceae	Wengban-leh	Medicinal	**Leaves**: used as treatment for child walking, and infection; treat fracture, hemorrhoids, and urinary tract infection; internal heat, infertility, burns, hemorrhage in women, skin disease	Lowland forest areas and open farmland

Botanical name	Family	Common name	Category	Uses	Habitat
Ficus spp.	Moraceae	Fig tree	Medicinal	**Milky exudates:** used as tooth pain killer and for extraction	Open and closed dense forests
Funtumia africana	Apocynaceae	Silkrubber tree	Medicinal	**Roots**: treat urine problems, anemic dysentery; **Leaves**: treat snake bite, infection, stomach ache and jaundice	Secondary and deciduous forests
Garcinia kola	Guttiferae	Bitter cola	Medicinal	**Nuts**: edible; treat malaria; aphrodisiac	Old growth forest
Gilbertiodendron limba	Fabaceae	Gbekay	Medicinal	**Leaves**: used as treatment against sores headache, worms, induce breast milk and cure arthritis	Marshes and swamp forests
Griffonia simplicifolia	Fabaceae	Griffonia	Medicinal	**Stem and roots**: used as chewing sticks; **Leaves**: used to heal wounds, bladder and kidney ailments; **Stems and leaves**: decoction used to stop vomiting, stop congestion; **Seeds and stems**: give men stamina, aphrodisiac, treat diarrhea, stomachache, and dysentery	Open and closed dense forests
Guibourtia ehie	Fabaceae	Black hyedua, African walnut	Medicinal	**Bark**: used as treatment against menstruation pain and wounds	Closed forests

Botanical name	Family	Common name	Category	Uses	Habitat
Harungana madagascariensis	Hypericaceae	Dragon's blood tree, orange milktree	Medicinal	**Bark**: sap and gum as aphrodisiac; used to treat gonorrhea, diarrhea, and blood clotting; treat babies suffering from constipation; **Resin**: sap treat leprosy, sore, itch, scabies, skin diseases, craw-craw **Leaves**: used for stomach ache	Young and secondary forest areas
Hymenocoleus hirsutus	Rubiaceae	kuokola-leh	Medicinal	**Root and leaves**: used to treat children's stomach pain, infection, labor & delivery pain and bleeding	Farmland and forest
Impatiens nzoana	Balsaminaceae	Fala-leh	Medicinal	**Leaves**: used in treatment against involuntary urinating in bed	Gallery forest
Ipomoea involucrata	Convolvulaceae	Gborzay; kohsu	Medicinal	**Leaves**: used to treat asthmatic cough	Secondary and old growth forest
Irvingia gabonensis	Irvingiaceae	African mango	Medicinal	**Fruit**: used as soup for food; **Seeds** used to treat weight loss, diabetes	Old growth forest
Khaya grandifolia	Meliaceae	African mahogany	Medicinal	**Seeds**: can be eaten; **Bark and seeds:** used to treat malaria	Open and closed dense forests
Landolphia dulcis	Apocynaceae	Gbofeakala	Medicinal	**Leaves and bark**: treatment against Infection, back ache, stomach ache, heart and eye problem **Root and stems**: treat arthritis and kidney problems;	Mostly savannah areas, lowland forest, secondary forest

Botanical name	Family	Common name	Category	Uses	Habitat
				Root: as an aphrodisiac; treat sores	
Macaranga barteri	Euphorbiaceae	Guu, Fowo	Medicinal	**Leaves**: used as treatment against stomach ache and gonorrhea	Secondary and young growth forest
Macaranga heterophylla	Euphorbiaceae	Maguu	Medicinal	Treatment against Cough	Secondary forest
Maesobotrya barterii	Euphorbiaceae	Bush cherry	Medicinal	**Fruits:** eaten fresh or made into juice; **Leaf:** sap used as general healing, heart problems; **Bark**: used as pain killers, stomach problem, diarrhea, dysentery, genital stimulant, aphrodisiac, smallpox, chickenpox, and measles	Young secondary and old growth forest
Mammea africana	Guttiferae	Mammea apple	Medicinal	**Fruit**: used to expel worms from stomach; **Bark**: decoction used to treat jiggers	Mixed deciduous forest, old growth forest
Manniophytan fulvum	Euphorbiaceae	Gasso nut	Medicinal	**Seeds**: edible; also good for hemorrhoid and blood problems **Leaves, stem, bark**: Treat diarrhea, stomach-ache, cough, bronchitis, stop blood on open wounds, dysentery, piles, hemoptysis, painful menses, gonorrhea, snake bite and infection, medicine to ensure pregnancy;	Closed forests, or mixed deciduous evergreen forest, both primary and secondary forests, roadsides, abandoned area, and fallow areas

Botanical name	Family	Common name	Category	Uses	Habitat
Mareya micrantha	Euphorbiaceae	Number one	Medicinal	**Bark:** used against snake bite, treat constipation, stomach pains, treat jaundice, cough, epilepsy, bones; **Leaves**: used to treat hypertension, malarial illness, cough and general weakness	Closed and open forests
Margaritaria discoidea	Phyllanthaceae	Pheasant berry	Medicinal	**Bark:** used for toothache, afterbirth pain, stomachache, kidney complaints, relieve swelling and inflammation; **Leaves and roots:** decoction used to treat discharges	Mixed evergreen forest and dense rainforest
Mezoneuron bethamianum	Leguminoceae	mezo	Medicinal	**Stem**: extract used as eye drops against inflammation; **Leaves and root bark:** decoction used for erectile dysfunction and manhood enhancement, dysentery, gonorrhea, hookworms, and malaria	Open and closed dense forest
Microdesmis kaeyana	Pandaceae	Microdesmis	Medicinal	**Leaves**: infusion to induce menstruation; treat diarrhea; chest complaints, fatigue, side pain, kidney pain, stiffness; treat skin diseases; anti-cough snake bite, back pain, yellow fever, stomach ache **Leaf and roots:** as an aphrodisiac **Fruit**: chew to treat ulcer	Young secondary and old growth forest , moist rainforest

Botanical name	Family	Common name	Category	Uses	Habitat
Milicia excelsa	Moraceae	African teak	Medicinal	**Leaf**: decoction used to remove snake poison; **Bark**: powder used for cough, heart problems; **Latex**: used to clear stomach and throat obstructions	Secondary and old growth forest
Morinda morindoides	Rubiaceae	Morinda	Medicinal	**Leaves:** used to treat malaria and induces bowel movement, expelling worms, skin diseases, stomach ulcers	Young and secondary forest areas
Musanga cecropioides	Cecropiaceae	Umbrella tree	Medicinal	Treatment against Fever, cough, worm, vomiting, snakebite and toothache; **New buds**: used for woman to bear child	Secondary young growth forest and farmland forest
Mussularia accuminata	Euphorbiaceae	Chewing stick tree	Medicinal	**Stem:** used to improve mouth health, anti-malaria, aphrodisiacs; **Leaves**: used to ease muscle pain, aphrodisiac, and decrease fat mass, and increase energy	Open and closed old growth forests
Myrianthus libericus	Cecropiaceae	Giant yellow bulberry	Medicinal	**Leaves**: used to cure body pain, fertility in women, mole on a baby's head and stomach ache	Secondary forest
Napoleonaea heudelotii	Lecythidaceae	Napoleon's button	Medicinal	**Fruit**: used to treat hernia; **Fruit and bark**: used to treat snake bite, and persistent coughs	Forest, in regrowth forest

Botanical name	Family	Common name	Category	Uses	Habitat
Nauclea latifolia	Rubiaceae	Pin cushion tree, African peach	Medicinal	**Roots and bark**: used to treat malaria, increase potency in man, aphrodisiac and analgesic; **Leaves**: used for baby's bath against skin peel wounds; measles **Bark**: decoction used to treat poison, cough, anemia, stomachache, indigestion, jaundice, gonorrhea;	Secondary old growth forest
Newtonia aubrevillei	Fabaceae	Pellegrin	Medicinal	**Bark:** used as an aphrodisiac	Dry savannah, undisturbed fringing forest and closed savannah woodland
Okoubaka aubrevillei	Santalaceae	Sacred zoe tree, magic tree, death tree	Medicinal	**Bark:** used to treat many kinds of poisoning, skin problems, leprosy, boost system from tiredness, depression and allergies, used as fish poison	Open and closed dense forest
Pachypodanthium staudtii	Annonaceae	Gpala-duo	Medicinal	**Bark**: used as worm medicine, pain and inflammations	Old growth forest, wetland forest
Palisota hirsuta	Commelinaceae	Swollen knee plant	Medicinal	**Leaves**: used for ear treatment, pain killers, nose and skin infections, diarrhea, dysentery, kidney problems, hemorrhoids conditions; **Leaf sap**: used to treat skin diseases; **Roots**: used for genital stimulant; swelling	Open and closed dense forests, moist areas

Botanical name	Family	Common name	Category	Uses	Habitat
Parinari excelsa	Chrysobalanaceae	Guinea plum	Medicinal	**Fruit**: edible; **Seeds**: eaten when roasted; **Bark**: decoction used for stomach ache, heart problems, anemia, diarrhea, hookworm; **Leaves**: applied to fresh wounds, toothache; **Roots**: used to treat migraine, stomach pains, chest pains, and rheumatism	Secondary and old growth forest
Parkia bicolor	Fabaceae	African locust bean	Medicinal	**Fruit**: edible; used as painkiller, treat measles, smallpox, and chicken pox	Open and closed forest, along riverbanks
Pentaclethra macrophylla	Fabaceae	African oilbean	Medicinal	**Seeds**: eaten when roasted; **leaf, stem-bark, seed and fruit**: used to treat inflammatory, gonorrhea, , dysentery, convulsion, and leprosy	Streams areas, edge of damp depressions, roadsides farms
Pentadesma butyracea	Clusiaceae	Butter tree	Medicinal	**Seeds**: contain fine golden or yellow shea butter; **Butter**: used for skin treatment and moisturizing, food oil, and soap	Evergreen and semi-deciduous forest
Petersianthus macrocarpus	Lecythidaceae	Soap tree	Medicinal	**Bark:** used to treat jaundice, stomach pain, pneumonia, cure cough, clean and heal wounds, muscle soreness;	Secondary and old growth forest

Botanical name	Family	Common name	Category	Uses	Habitat
				Leaves: decoctions used for hemorrhoids, constipation, ulcer wounds, and dysentery	
Piper guineense	Piperaceae	West African pepper, Bush pepper	Medicinal	**Seeds**: used as spice in food; also used for body and back pain, stomachache; **Leaves**: used to treat cough, intestinal diseases, worms, and rheumatism	Evergreen forest
Piptadeniastrum africanum	Fabaceae	Dahoma	Medicinal	**Bark:** used to treat wounds, fungus, and yellow fever; cough, bronchitis, headache, mental disorders, hemorrhoids, genital infections, stomachache, male impotence; decoction used to treat fever, toothache, pneumonia, rheumatism	Open and closed dense forest
Protomegabaria macrophylla	Euphorbiaceae	Kola	Medicinal	**Bark**: used to treat cough, stomach, painkiller, child walking	Open and closed dense forest
Psychotria peduncularis	Rubiaceae	Kpain-leh; wengban-leh	Medicinal	**Leaves**: used to treat toothache, convulsion, yellow jaundice, stomach, ear, back; stomachache, skin infection	Understory of sub montane and riverine evergreen forest
Pterocarpus erinaceus	Fabaceae	Barwood, African teak, African rosewood	Medicinal	**Bark**: used for ringworm, to treat chronic ulcer, cough and fever, toothache; **Bark** and resin used to treat urethral discharges, severe diarrhea and dysentery	Open forest and wooded savannah

Botanical name	Family	Common name	Category	Uses	Habitat
Pycnanthus angolensis	Myristicaceae	African nutmeg, false nutmeg	Medicinal	**Fruit**: is edible; **Seeds**: oil used for candle; **Bark**: used to treat toothache, stomachache, stop bleeding; used to treat anemia, leprosy, gonorrhea, malaria, infertility, toothache, and snake bite **Leaf**: decoction used for inflammation on skin, filariasis in the eye	Secondary forest
Quassia undulata	Simaroubaceae	Mjoho	Medicinal	**Stem bark:** used to treat malaria, leprosy, fever, cough, and stomach problems; **Roots**: extracts used for eye, and aphrodisiac	Open and wooded grasslands
Rauvolfia vomitoria	Apocynaceae	Poison devil's pepper	Medicinal	**Root**: diarrhea, rheumatism, jaundice, snakebites, hypertension; treat epilepsy, mentally illness; as aphrodisiac; treat female sterility **Stem bark and leaf**: decoction and latex used as purgative, fever; malaria and convulsion	Secondary vegetation
Rhodognaphalon brevicuspe	Malvaceae	Alone, Kondroti	Medicinal	**Bark:** used to prevent abortion, treat sore throat, help to heal wounds; **Roots:** used to treat growing tumor; red dye from bark used to dye clothes	Dense, primary rainforest, also in open, and secondary forests
Ricinodendron heudelotii	Euphorbiaceae	Bush peanut	Medicinal	**Nuts**: eaten when cooked or patched; used to treat bones, menstruation, gonorrhea	Evergreen secondary forest

Botanical name	Family	Common name	Category	Uses	Habitat
Rinorea ilicifolia	Violaceae	Bunotu	Medicinal	**Leaves**: used to treat sores, baby headache, childbirth, cough, eye, stroke	Evergreen and riverside forest
Sacoglottis gabonensis	Humiriaceae	Bitter bark tree	Medicinal	**Stem-bark**: used to treat fever, diarrhea, abdominal pain, hypertension and diabetes, stomach ache, and as spice to produce heat in nursing and pregnant mothers	Secondary forest
Samanea dinklagei	Fabaceae	Monkey pod tree	Medicinal	**Bark and leaves**: used to treat headache, and leprosy	Near rivers in forest
Scadoxus multiflorus	Amaryllidaceae	Blood flower, Catherine wheel, Poison root	Medicinal	**Leaves**: used to treat swelling, scabies, and wounds, also taken ensure safe delivery	Swamp, wetland forest
Scleria secans	Cyperaceae	Razor grass	Medicinal	**Leaves**: used to treat after-birth pains, and treatment against infection	Farmland, young secondary forest, mountain range, woodland, and wetlands
Senna alata	Fabaceae	Candle bush, ringworm tree	Medicinal	**Leaves**: used to treat ringworm and other skin fungal infections	Secondary and old growth forest

Botanical name	Family	Common name	Category	Uses	Habitat
Sterculia tragacantha	Malvaceae	Sterculia	Medicinal	**Seeds**: eaten roasted or cooked; **Gum**: used to treat urinary tract infection, snake, bleeding, open mole on baby's head, burns, and suppress tumors	Swamps, or marshes forest types
Strephonema pseudocola	Combretaceae	Poto-poto	Medicinal	**Seed**: used to treat craw-craw; **Stem bark**: treat diarrhea, fracture Bones and rheumatism	Tropical inland swamp, wetland forests
Tabernaemontana africana	Apocynaceae	Samoan gardenia	Medicinal	**Stem and bark:** used to cure prostate gland; used as a stimulant, aphrodisiac, stimulation of appetite	Secondary and young growth forest
Terminalia superba	Combretaceae	Limba, Korina	Medicinal	**Bark**: decoction used to treat wounds, sores, hemorrhoids, diarrhea, dysentery, malaria, vomiting, gingivitis, swelling, and ovarian troubles	Secondary deciduous forest
Tetracera affinis	Dilleniaceae	Tetracera	Medicinal	**Leaves and Shoot**: used to treat stomach ache, menstruation pain, bleeding nose and sore throat	Secondary and old growth forest
Tieghemella heckelii	Sapotaceae	Cherry mahogany, African cherry	Medicinal	**Fruit**: edible and produces oil; **Buds**: used to treat snakebite **Bark**: treat toothache	Open and closed dense forest

Botanical name	Family	Common name	Category	Uses	Habitat
Tiliacora leonensis	Menisperm-aceae	Turtle - bone	Medicinal	**Root**: increases potency in man have aphrodisiac effect, also treat malaria, and used to treat stroke	Secondary old growth forest
Trichilia emetica	Meliaceae	Natal mahogany, christmas bells	Medicinal	**Seeds**: eaten dried or patched; **Oil from seeds**: used on skin as cream and as condition in hair, used to treat rheumatism and wounds	Evergreen riverine forest and secondary forest
Uapaca guineensi; Uapaca spp.	Phyllanthaceae	Sugar plum	Medicinal	**Fruits**: edible, give drink a flavor; **Leaves and root-bark**: used to treat migraine, rheumatism, and late walking children; **Roots**: used as aphrodisiac, to treat male impotence, good for chest and lungs cleaning, relieve fever, headache and pains	Marshes, swamps, secondary forest
Vitex micrantha	Verbenaceae	Vitex	Medicinal	**Fruits**: eaten raw or cooked; **Leaves and bark**: used to treat craw-craw; fruit used to treat fertility, anemia, jaundice, leprosy, diarrhea, and dysentery, headache, measles, rash, fever, chickenpox, and eye problems; **Root**: decoction used to treat gonorrhea, gastro-intestinal disorders, jaundice, backaches, and wound and burns	Lowland evergreen forest, understory closed forest

Botanical name	Family	Common name	Category	Uses	Habitat
Voacanga africana	Apocynaceae	Voacanga	Medicinal	**Bark**: used as cure for prostate gland; **Bark and seeds**: used to treat poison, as stimulant, aphrodisiac, known to enhance memory, treat hypertension; endure stamina	Marsh forest, moist woodland, riverine forest
Xylopia aethiopica	Annonaceae	Country spice	Medicinal	**Seeds**: used as spice in food; used to treat stomach ache, dysentery, toothache, and urinary tract, used as purifier; **Bark**: used to treat asthma, stomachache and rheumatism	Lowland rainforest, farmland, secondary, and old growth forests
Zanthoxylum gilletii	Rutaceae	African satinwood, African mahogany	Medicinal	**Bark**: has aphrodisiac properties; treat kidney complaints, gonorrhea, diarrhea, cough, colds, skin complaints, and smallpox, medicine for swollen testicles; **Bark-stem and roots:** used as an analgesic to treat burns, rheumatism, headache, stomachache, toothache, and pain after childbirth; **Leaves**: used to treat heart problems, snake bites, stomach problem, treat enlarged spleen; **Stem**: used as chewing to clean teeth	Young secondary and old growth forest , moist rainforest

2.4 Conclusion

This chapter investigated local knowledge on the traditional use of Liberian NTFP in 82 local communities within seven counties in Liberia. The study showed that local communities are knowledgeable about the traditional use of their natural resources. With the immense knowledge, a total of 114 plant species were listed as important local NTFP that are commonly used by the locals. These plant species were divided into six categories including medicinals, nuts and edible oils, colas and edible fruits, indigenous vegetables and mushrooms, building materials and fibers, and spices. A relatively equal number of male to female respondents showed both genders are repositories of traditional knowledge in the ethnobotany of local NTFP in Liberia. However, the low number of young people (35 years and below) and their supposedly lack of interest suggests serious concerns for continuous generational transfer of such wealth of knowledge of traditional use of the natural resources. This proposes a continual documentation of the wealth of knowledge that is bestowed in the minds of the elderly about the use of local resources, so as to pass such knowledge on to many more generations via documentation. The documentation of the traditional use of Liberian NTFP is essential in the conservation management and sustainable use of the biological resources. This also provides a means for the appreciation of the economic potential and importance to rural communities for the delivery of adequate policy to develop practical management programs for NTFP sector in Liberia.

3 Chapter III: Assessing Collection Practices, their Impact and Economic Benefits of NTFP for Rural Men and Women in Seven Counties of Liberia

3.1 Introduction

Local communities collect various Non-Timber Forest Products (NTFP) that seem of value if not essential for their health and food security, and in many areas, the sale, trade, exchanges/bartering of NTFP also seem to provide a high percentage of rural community's yearly income (Rijsoort, 2006). In India for example, NTFP contribute about 50 percent of forest revenue and 70 percent of income through export (Tewari and Campbell, 1995; Sekar *et al.,* 1996), while also contributing to 10 – 40 percent of income to the 50 million rural households in India (Sekar *et al.,* 1996). In Liberia many rural communities rely on forest resources for their health and income generating needs (Kpadehyea *et al.,* 2015).

The collection of NTFP are a supplement to farm production, livestock, and cash crop, providing fuel for cooking, cash income, an insurance against drought and crop failure, thereby contributing to food security (FAO, 1989; FAO, 1991). In addition to food security, the collection of NTFP in rural communities often meets the needs of rural people (Anukwa, 2003), as well as serving as tradable products (Wilkie and Godoy, 1996), thereby serving as safety net for forest communities (Arnold, 2002). With the knowledge of use and importance of NTFP in trade, collection practices have increased with increasing demands from markets and extended use (Bodeker, 1997; Schippmann *et al.,* 2002). In many cases the medicinal plants may provide the only source of medicines for such poor rural and isolated communities. Because of their importance to local economies and particularly to those communities residing in the forests, the extraction and use of NTFP can result in adverse impacts to the ecosystem and unsustainable exploitation (Peters, 1994; Neumann and Hirsch, 2000; Arnold and Ruiz-Perez, 2001; Juliani *et al.,* 2013), leading to ecological problems including resource depletion, endangerment and species extinction (Koroch *et al.,* 1997; Prasad, 2009). Other threats that have negative and significant impacts on NTFP include, but may not be limited to environmental modification (Joshi and Joshi, 2000; Tabuti *et al.,* 2003), timber logging and agriculture leading to deforestation (Ahenkan and Boon, 2008; Juliani *et al.,* 2011a), changes in traditional patterns of harvests resulting to unsustainable rates of exploitation, and overgrazing (Bodeker, 1997; Schippmann *et al.,* 2003; Wiersum *et al.,* 2006). Knowledge is shaped by the ecological diversity of the country (Vinck *et al.,* 2011), which varies across peoples with different religious, linguistic and cultural backgrounds (Bekele, 2007; Kpadehyea *et al.,* 2015).

Collection of NTFP are the habits of rural communities in Liberia, with the few studies conducted in Liberia reporting local people dependent on NTFP for their daily sustenance (Lomax, 2008; Deshmukh *et al.,* 2009; Manvell, 2011; Juliani *et al.,* 2013; Kpadehyea *et al.,* 2015). The general consensus remains that majority of rural communities in Liberia are involved in the collection NTFP for their daily livelihood needs and income opportunities (Lomax, 2008; Deshmukh *et al.,* 2009; Kpadehyea *et al.,* 2015); however, good collection practices of NTFP may be limited, with adverse consequences unknown. In Ghana for example, plant collectors have revealed plant species once sourced within short walking distances now required several kilometers away owing to the development of human settlements, farming activities, bush burning and other destructive human activities (Amujoyegbe *et al.,* 2012). Collection of NTFP may not be limited to a particular time of the year, with collection done during both rainy season (Sunderland and Oboma, 1999; Ngane *et al.,* 2012) and dry season (Campbell *et al.,* 1997; Ngane *et al.,* 2012; Woittiez *et al.,* 2013) and can even be done during famine periods at the end of the dry season (Chambers and

Longhurst, 1986), or during the peak of the rainy season (Ngane *et al.,* 2012). In Cameroon, Ngane *et al.* (2012) argued that during the peak of the rainy season, July and August (hungry period), stored food supplies decrease, while most food crops on farms are yet to mature and as such there is scarcity of food. During this period, NTFPs are important as substitutes for staple foods, additions and snacks to add to the food crop supplies. Ngane *et al.* (2012) further observed that NTFP such as *Irvingia gabonensis* was available in the rainy season (June - September) while *Irvingoa wombulu* was available during the dry season (October - February) making the product available all year round. Van Dijks (1999) showed that NTFPs collection and production can provide a source of livelihood. In India, Madegowda and Rao (2013) reported that the collection and sale of NTFP are primary source of income for the Soligas. In Cameroon, Ngane *et al.* (2012) reported that although most NTFPs are collected for household consumption, some are traded to supplement the cash income of households. Majority of NTFP collectors are farmers who often hardly have any alternative occupation to earn income (Luintel, 2002); though sometimes earning may be little. Studies have reported cases where local collectors earned very little, though immense work is required to go into the forest, find the NTFP, harvest and bring the harvestable material to the market (Bista and Webb, 2006; Babulo *et al.,* 2008; Piya *et al.,* 2011).

Being considered as a contributor to the livelihood needs of rural people, the development and sustainability of NTFP has the potential to improve the economic status of local communities (Neumann and Hirsh, 2000; Ticktin and Johns, 2002; Deshmukh *et al.,* 2009; Juliani *et al.,* 2013).

As sustainable harvesting is key to development and sustainable biodiversity conservation, it is crucial to understand the ecology, collection and value of NTFP. The major challenges for sustainable wild collection of plant products comprise the lack of knowledge about sustainable harvest rates and practices of particular species (Schippmann *et al.,* 2003), the sensitivity of plant species that are next to the NTFP and as such can be adversely impacted by trampling and damaging of the non-targeted forest species, cutting down other species to more easily reach the NTFP and more. WHO has stressed the need for sustainable harvesting practices of NTFP for the realization of more economic gains and biodiversity conservation and published a guide to the collection and sustainable harvesting of medicinal plants(GACP) (WHO, 2003). Ticktin and Johns (2002) have suggested that management of NTFP populations by knowledgeable harvesters may show high growth rates of plant species that are sources of NTFP under high harvest pressure, while the opposite may be true, management of the same species by less knowledgeable harvesters may decline even under much lower harvest levels. Changes in harvesting patterns with corresponding modifications in harvesting techniques create a win-win strategy, where local people benefit while conserving the forest biodiversity (Ghimire *et al.,* 2005). Local knowledge on harvesting of Liberian NTFP may be limited (Deshmukh *et al.,* 2009; Manvell, 2011; Juliani *et al.,* 2013); the need for increased local knowledge on collection patterns in relation to continual economic benefits to rural communities is critical for effective resource development and management of biodiversity conservation (Idu *et al.,* 2005).

In order to fully understand the nature and concept of harvest of NTPFs by local communities, knowledge on plant ecology, products and harvest techniques is essential. Chamberlain *et al.* (2002) had suggested collectors tracing heritage and relationship with NTFP back several generations, a traditional ecological knowledge critical in understanding the fundamentals of NTFP management. In Vietnam, Dine and Dieu (2012) have reported local knowledge suggesting the decrease and uncommon species that once were, due to opportunistic harvesting. Liberian NTFP may face similar impact by harvesting. Juliani *et al.* (2013) noted via local knowledge the unsustainable harvesting of some major potential NTFP such as *Griffonia simplicifolia* and *Xylopia aethiopica*.

Gender involvement in various aspects of NTFP have often been dominated by women, including collection, processing, use, and marketing (Tchatat *et al.,* 2003; Sunderland *et al.,* 2004). Idu *et al.* (2010) and Idu *et al.* (2005) have observed women as a majority of medicinal plant traders in various markets in Nigeria. In Liberia, however, studies on NTFP have shown male as the dominant group (Juliani *et al.,* 2013; Kpadehyea *et al.,* 2015). This may stem from either limited NTFP information collection due to pilot project undertakings (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013), to specific study location (Kpadehyea *et al.,* 2015), or based on the focus of study (Manvell, 2011; Kpadehyea *et al.,* 2015). Gender equity empowering women in aspects of NTFP collection and production in Liberia is a step towards the Millennium Development Goals of Liberia to ensuring environmental sustainability and poverty alleviation (GoL-MDG, 2004).

The study seeks to investigate indigenous traditional knowledge on four Liberian NTFP (*Griffonia simplicifolia, Xylopia aethiopica, Piper guineense,* and *Aframomum melegueta*). The specific objective of this study is to conduct a survey for the assessment of socio-economic demographic characteristics of local people, the collection practices of the various NTFP, the impact and threats due to collection, as well as income generation. The study also evaluated the role of gender in NTFP collection practices in Liberia.

3.2 Materials and methods

3.2.1 Study area

The study was conducted in 49 communities from seven counties Liberia including Bong, Nimba, Grand Bassa, Lofa, Bomi, Margibi, and River Cess Counties (Figure 3.1). Team of trained interviewers visited thirteen communities in Bong County (Balamah, Raymond town, Gokai, Gbonota, Sanoyea, Zeanzue, Zoweinta, Fehneitoli, Gbartala, Beletanla, Totota, Fehlerla, and Bong Mines), twelve communities in Nimba County (Sanniquellie, Zorgowee, Karnplay, Lepula, Ganta, Sokopa, Toweh, Bunadin, Yourpeah, Duo, Saclapea, and Tappita), seven communities in Grand Bassa County (Buchanan city, Bokay's town, Barcoline, Tobli, District 4-Bold Dollar, Doe Bar, and Boye town), five communities in Bomi County (Tubmanburg city, Klay, Jenneh, Mulbah town, and Gayah Hill), four communities in Lofa County (Salayea, Gbatatuah, Gollu, and Zorzor), five communities in Margibi County (Weala, German Camp, Smell-No-Taste, Marshall, and Cotton Tree Community), and three communities in River Cess County (Cesstos city, Cephas town, and Riverces town) between September 2016 to December 2016.

3.2.2 Methods

Prior to the beginning of the survey study, the Committee for the Protection of Human Subjects, the Institutional Review Board (IRB), at of Rutgers, The State University of New Jersey, reviewed and approved the study protocol, Protocol #: E16-235. Approval to conduct interviews was also obtained from local authorities at each survey site/community. Oral informed consent and approval from the town chiefs and/or local community leaders often in the presence of community members was obtained for studies in the community. With a welcoming approval, questionnaire was read out to community leader/chief mostly in the presence of community members with the objectives and intents clearly explained. The written consent form approved by Rutgers IRB Committee was also read to inform participants of their rights and confidentiality thereof. Upon acceptance, each participant was given a copy of the consent form and endorsed before interview began. Participation was purely on a voluntary basis; neither monetary nor material incentives were offered for participation; each participant was informed about his/her right to withdraw at any time without explanation or penalty.

Figure 3.1 Map of Liberia with Counties and the communities visited for survey

Ethnobotanical information on collection practices of NTFP was collected through interviewing 255 respondents (48.6% females and 51.4% males, Figure 3.3), using a standardized structured questionnaire with both close-ended (95%) and open-ended (5%) questions. The questionnaire comprised two sections, including the demographics of the participants and the ethnobotanical survey on the collection practices of four Liberian NTFP, *Griffonia simplicifolia* (Griffonia), *Piper guineense* (bush pepper or West African black pepper), *Xylopia aethiopica* (Country spice), and *Aframomum melegueta* (Grains of Paradise, GOP). Household respondents were chosen through simple randomized sampling in each community. Interviews were conducted using door-to-door and face-to-face approach; with respondents frequently heads of household (defined as a group of people normally sleeping under the same roof and eating together) or main collector of the NTFP within the group. In each of the local languages used, one or more team members fluent in a particular local language at a particular community served as interpreter during the interview process. Local languages used are listed in appendix B. The ethnobotanical survey questionnaire (Appendix A) was used to collect data on ranking order, harvest method, parts harvested, tools used, processing method, collection effort, impact, threat, as well as experience in collection for the four NTFP.

Further, market price investigation for the four NTFP (Griffonia, Bush pepper, Country spice, and Grains of Paradise) was conducted in 13 local markets (Figure 3.2), two in Upper Nimba (Sanniquellie and Karnplay markets), two in Lower Nimba (Saclapea and Tappita markets), two in Bong County (Gbarnga and Jenepleta markets), two in Bassa County (Buchanan and District 4 markets), two in Lofa County (Gollu and Salayea markets), and three in Monrovia (Redlight, Duala, and ELWA markets) to compare respondent information of the NTFP sale with that from the various markets.

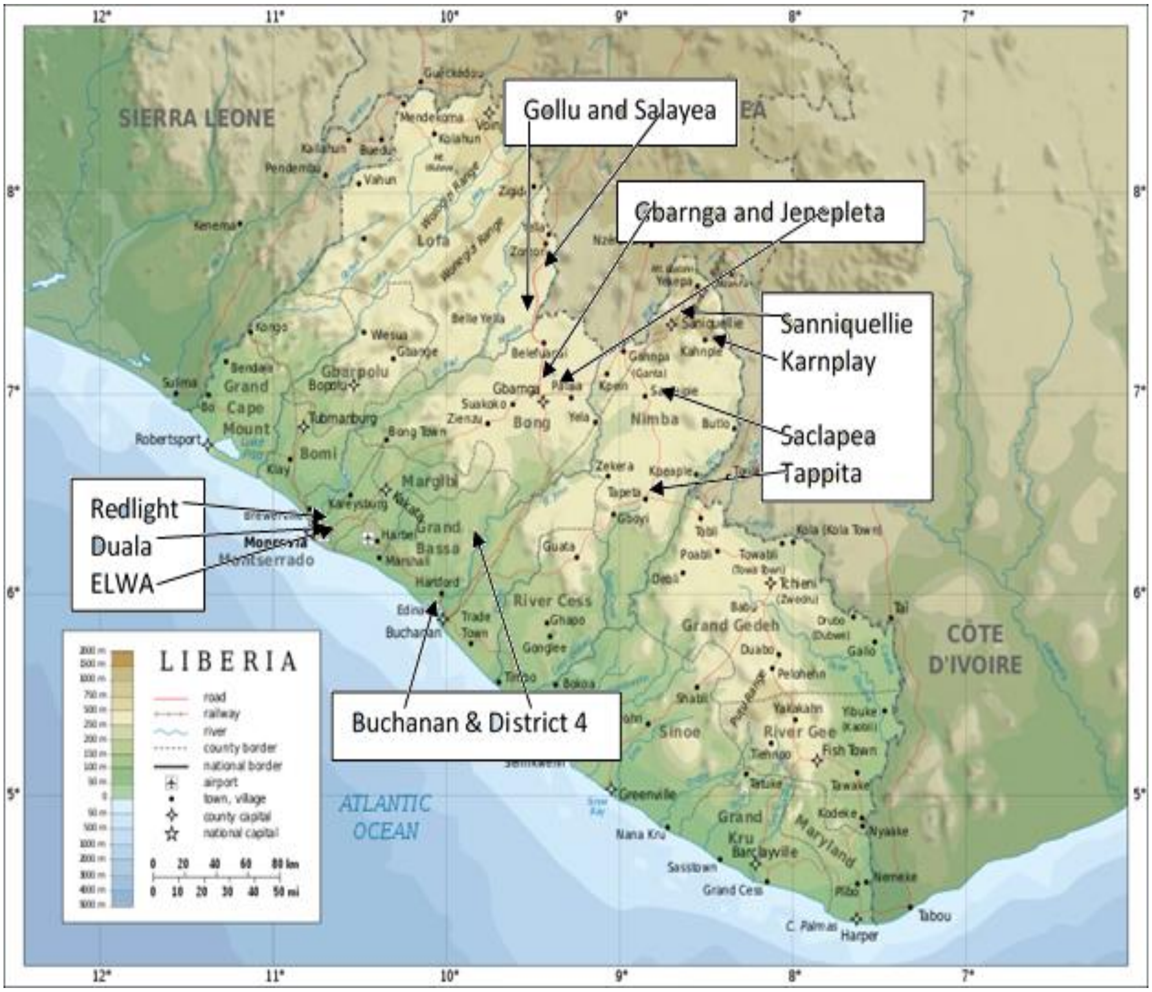


Figure 3.2: Map of Liberia showing counties and market areas that were assessed for prices of the four selected NTFP

The collected data was computerized in excel worksheet and inputted into Statistical Package for the Social Sciences (IBM® SPSS Statistics V. 21) for analysis using the descriptive statistical methods. Data was quantitatively analyzed using data tabulation (frequency distributions & percent distributions), descriptive data (mean), and ANOVA.

3.3 Results and discussion

Results for the ethnobotanical survey on collection and agronomic practices of NTFP in Liberia are based on 255 interviews in 49 communities within seven (7) Counties in Liberia (Table 3.1), with 48.6% female and 51.4% male respondents (Figure 3.3). There was no statistical difference ($p = 0.963$) in the number of male respondents compared with the number of female respondents, indicating women are equally involved in NTFP activities as men. Kpadehyea *et al.* (2015) reported women involvement in medicinal plant activities, though not dominating males in the herbal healing activities. However, other studies have reported women as dominating gender group in various aspects of NTFP (Tchatat *et al.,* 2003; Sunderland *et al.,* 2004), with women as majority in the trade of medicinal plants in various markets in Nigeria (Idu *et al.*, 2010; Idu *et al.*, 2005). The high percent frequency number of respondents for females in relation to the collection practices of NTFP (Table 3.6) support previous studies that women are actively involved in NTFP activities (Idu *et al.*, 2010; Idu *et al.*, 2005). The slightly higher number of males (51.4%) respondents suggests that within each household where the entire family would be present, the head (the man) was often allowed to provide the information on behalf of the household, which was the case for many household respondents.

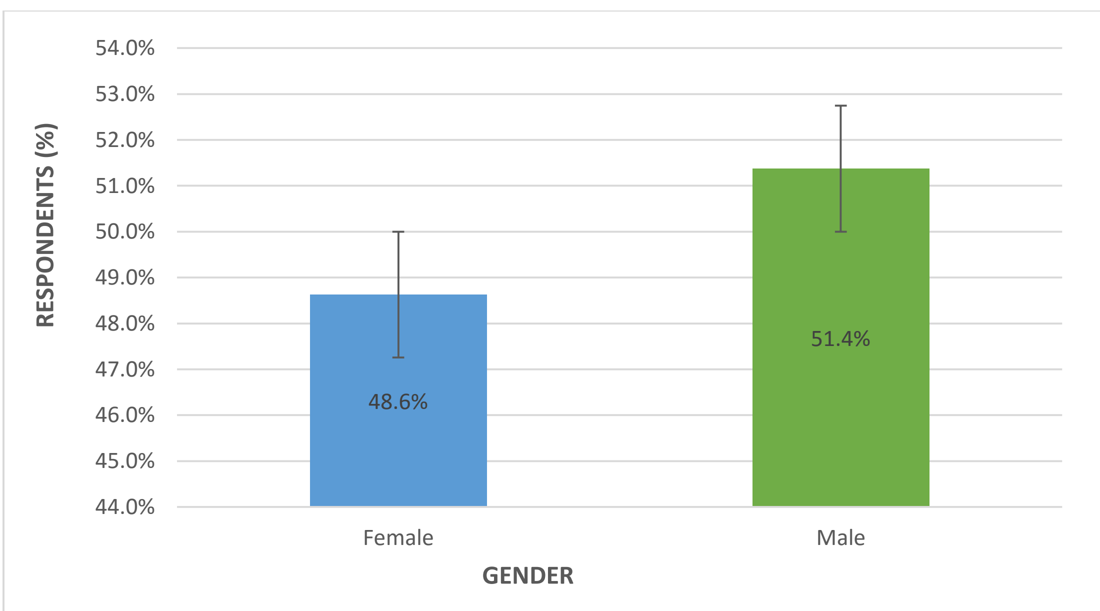
The study investigated indigenous traditional knowledge to fully understand the fundamentals of NTFP management. Chamberlain *et al.* (2002) indicated collectors tracing their heritage and relationship with NTFP back several generations, a traditional ecological knowledge critical in understanding the fundamentals of NTFP management. The age category of respondents ranged from 36 – 65 years and above, with age group 51 – 65 years slightly higher (48.2%) compared to age group 36 – 50 (15.7%) (Table 3.2). This indicates elders possess immense knowledge on NTPFs activities including collection practices; this can be passed down to younger generation through oral or written. Many of the respondents were farmers (59.6%), with little or no formal educational training (61% no educational training) and earned an annual income of less than US$1,000 (60%) (Table 3.3). This confirms report by Luintel (2002) that farmers are the major collectors of NTFP, and it is this same group who have very few alternative occupations to earn income. This study suggest that the development and sustainability of the NTFP sector and farmers inclusion can be a major potential contributor to the economy of these groups of people and their livelihoods (Neumann and Hirsh, 2000; Ticktin and Johns, 2002).

Other sources of income for the local communities include agricultural production, livestock production, cash crop (cocoa, coffee) production, palm oil production, wine (sugar cane, palm, raffia), employed (teaching), and petit business (Figure 3.4). Income from these sources are added to income generated from NTFP to make up the total income for rural communities. Given the low annual income generation suggests that the majority who are farmers only collect and sell to meet their meager daily needs. There is therefore the need to strengthen and promote the commercialization of these potential NTFP for large commercial markets.

This study also supports the hypothesis that collection of NTFP can meet community/rural household needs and generate income even during seasons of famine (Chambers and Longhurst, 1986; Ngane *et al.,* 2012). This is in agreement with responses from the Liberian participants relative to the limitation of single or yearly harvesting season when farming has only begun with slash and burn activities starting in March and planting beginning in May (Table 3.4). All four plant species bear fruit at the beginning of the year when farming has only begun, and cash is needed for agricultural inputs and more. Additionally, *Xylopia aethiopica*, which is reported to yield fruits twice yearly (December to March, and June to September) (Table 3.4) may be a promising NTFP with great potential.

Table 3.1: Number of respondents from the various communities in each county and percent frequency of respondents per county

No.	County	No. of Communities	No. of Respondents	Percent of Respondents
1	Bong	13	62	24.3
2	Nimba	12	67	26.3
3	Bassa	7	40	15.7
4	Lofa	4	24	9.4
5	River Cess	3	14	5.5
6	Bomi	5	25	9.8
7	Margibi	5	23	9.0
TOTAL		**49**	**255**	**100**



($P = 0.963$)

Figure 3.3: Percent frequency of gender respondents from the demographic category of survey

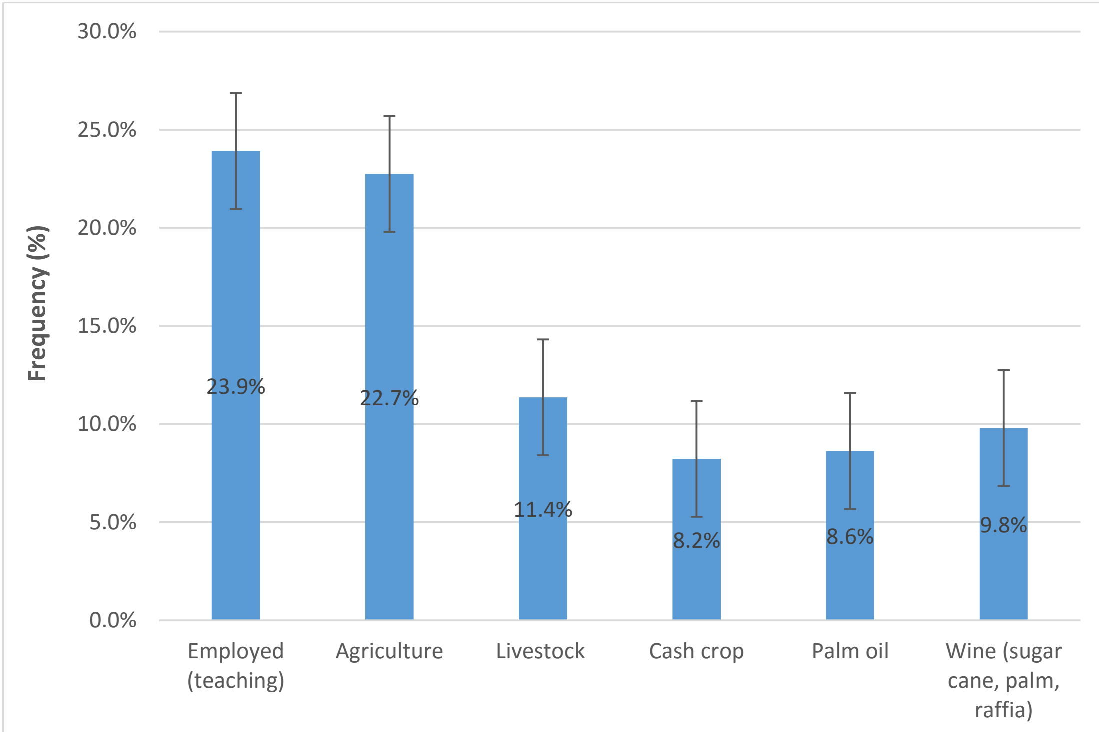


Figure 3.4: Frequency percentage of respondents on other sources of income generation

Sustainable harvesting is a major issue of concern for NTFP, as challenges for sustainable wild harvesting include lack of knowledge about sustainability (Schippmann *et al.,* 2003). The limitation to knowledge of good harvesting practices of NTPF in Liberia may be the reason for higher percentage of respondents that use the cut/pull harvesting technique to gather products (Table 3.6). Unsustainable exploitation of NTFP can have negative impact on the species population (Bodeker, 1997; Schippmann *et al.,* 2003; Juliani *et al.,* 2013). Previous studies have suggested impact of unsustainable harvesting may result to ecological problems such as resource depletion (Neumann and Hirsch, 2000) and endangerment of species (Koroch *et al.,* 1997; Prasad, 2009). Further, Amujoyegbe *et al.* (2012) revealed that plant species that were once sourced within short walking distances are now being collected several kilometers away owing among other factors the destructive human activities. This may be similar with the case in Liberia, as respondents reported a major decrease of plant population (22.7% Griffonia, 82.7% Bush pepper, 68.2% Country spice, and 85.9% Grains of Paradise), and difficulty in collecting NTFP (80.8% for Griffonia, 77.7% for Bush pepper, 75.7% for Country spice, and 77.6% for Grains of Paradise) by walking hours to collect plant products (Table 3.6).

Result from respondents on sale price per kilogram showed a sale price for each of the four plant products at LD100 – LD200 (LD100 = US$1.00) per kg (Table 3.6). Previous studies have reported cases where local collectors earned very little, though immense work is required to go into the forest, find the NTFP, harvest and bring the harvestable material to the market (Bista and Webb, 2006; Babulo *et al.,* 2008; Piya *et al.,* 2011). This prompted the need to assess market prices for the four NTFP (Table 3.5). We observed that the market price varied greatly from the local community sale prices, with prices from Monrovia very high for three of the four NTFP (Bush pepper – LD800, Country spice – LD200, and Grains of Paradise – LD600). The variation in price of products at local markets to that of the price in Monrovia may be associated with closeness of harvesting to sale points; that is, one would guess that prices in Monrovia would be far higher than something collected in Nimba County, sold in Nimba County, which may have accounted for the high price observed in Monrovia.

Several studies have reported threats to NTFP such as unsustainable exploitation (Bodeker, 1997; Neumann and Hirsch, 2000; Schippmann *et al.,* 2003; Juliani *et al.,* 2013), rural forest modification to urbanization (Joshi and Joshi, 2000; Tabuti *et al.,* 2003), logging and agriculture that lead to deforestation (Ahenkan and Boon, 2008; Juliani *et al.,* 2011a), in addition to unsustainable harvesting practices (Schippmann *et al.,* 2003; Wiersum *et al.,* 2006). This may also be similar for Liberia, as response on threats affecting plants, respondents revealed farming/agriculture, logging, mining, development and collection practices as all major threats to NTFP (Table 3.6). However, it was noted that there are no major collection or cultivation for NTFP in Liberia. There are no reports of unsustainable collection of NTFP yet in Liberia. The result from the purpose of collection (Table 3.6) showed respondents use of NTFP as an income generation to meet their immediate daily needs. This is in line with several reports on NTFP as a major source of income generation for rural communities (Neumann and Hirsh, 2000; Belcher, 2005; Juliani *et al.,* 2013).

Traditional knowledge is important to the development and sustainable management of NTFP and biodiversity conservation, to ensuring the realization of more economic gains to rural communities and the government (Neumann and Hirsh, 2000; WHO, 2003; Deshmukh *et al.,* 2009; Juliani *et al.,* 2013).

Many local communities are involved in the collection of various NTFP to meet their livelihood needs and food security including collection for food, medicine, forage, fuel, and shelter, and in many cases, to generate income through trade commercialization (FAO, 1991; Rijsoort, 2006). The study shows that majority of rural communities in Liberia rely on forest resources for their daily needs including health and income generation, with some as a supplement to farm production, providing fuel for cooking, thereby contributing to their food security (FAO, 1989; FAO, 1991). Previous studies have shown the collection of NTFP often meeting the needs of rural communities (Anukwa, 2003) and serving as safety net (Wilkie and Godoy, 1996).

Table 3.2: Distribution of respondents according to socio-economic characteristics

Demographic	Percentage	Total
N (Sample)	**100**	**255**
Gender	**100**	
Male	48.6	
Female	51.4	
Age category	**100**	
< 20yrs	0	
21 - 35 yrs	0	
36 - 50 yrs	15.7	
51 - 65 yrs	48.2	
> 65 yrs	36.1	
Marital Status	**100**	
Single (never been married)	0	
Partner/Engaged/living together	6.7	
Married (have spouse)	46.2	
Divorced/separated	44.7	
Widow/Widower	2.4	
Education level	**100**	
None	61.2	
Elementary school	31.8	
Up to high school	7.1	
2 yrs college degree	0	
4 yrs college	0	
Graduate degree	0	
Primary occupation	**100**	
Retired	2.3	
Self-employed	22	
Employed by others	15.3	
Homemaker	0.8	
Farmer	59.6	

Table 3.3: Frequency distribution of respondents based on annual income (USD) of household before taxes

Annual income before taxes (USD)	Frequency (%)
< $1,000	60%
$1,000 - $3,999	24.7%
$4,000 - $5,999	11%
$6,000 - $7,999	4.3%
$6,000-7,999	0%
$8,000-9,999	0%
$10,000-29,000	0%
Total	**100%**

Table 3.4: Yearly fruiting and harvesting season for Griffonia, bush pepper, country spice and grain of paradise and the rice farming season in Liberia

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Griffonia (*Griffonia simplicifolia*)												
Bush pepper (*Piper guineense*)												
Country spice (*Xylopia aethiopica*)												
Grains of Paradise (*Aframomum melegueta*)												
Upland rice farming season												

Table 3.5: Market prices (Liberian dollar, LD/kg) of the four NTFP products at two local markets in Upper and Lower Nimba, Bong, Lofa, Bassa Counties, and Monrovia City in Montserrado County

Plant product	Upper Nimba	Lower Nimba	Bong	Lofa	Bassa	Monrovia[1]
Griffonia (*Griffonia simplicifolia*)	300	300	0	300	300	0
Bush pepper (*Piper guineense*)	550	600	650	600	650	800
Country spice (*Xylopia aethiopica*)	50	60	100	50	70	200
Grain of Paradise (*Aframomum melegueta*)	350	350	450	300	500	600

[1]Surveys conducted at two local markets, except for Monrovia where three markets were surveyed

Other studies conducted in Liberia on NTFFP have focused on specific areas of concentration such as the use of medicinal plants by a particular group of people in a particular locality (Kpadehyea *et al.,* 2015), the focus of a pilot project to a specific of people and a particular plant species such as Griffonia (Juliani et al., 2013), or working with specific group of people to develop NTFP product (Deshmukh *et al.,* 2009). However, this study has concentrated on the collection practices of NTFP with their impact and economic benefits for rural people.

Table 3.6: Percentage of participants responding to NTFP use and status for Griffonia, Bush pepper, Country spice and Grains of paradise

Questions	Parameters	Griffonia (*Griffonia simplicifolia*)	Bush pepper (*Piper guineense)*	Country spice (*Xylopia aethiopica*)	Grains of Paradise (*Aframomum melegueta*)
Rating in Use order	Most commonly used	12.90%	34.10%	54.10%	16.10%
	Commonly used	18.40%	29.80%	35.70%	23.10%
	Used once a while	10.20%	25.90%	8.60%	14.90%
	Less used	8.20%	10.20%	1.60%	12.20%
	No response	50.20%	0.00%	0.00%	33.70%
Collection method	Collect from ground	17.30%	3.10%	7.10%	99.60%
	Cut/pull to gather	20.80%	66.30%	55.30%	0.00%
	Use stick / stand	2.70%	26.30%	10.60%	0.00%
	Climbing	7.50%	4.30%	27.10%	0.00%
	No response	51.80%	0.00%	0.00%	0.40%
Gender involvement in collection	Male	17.60%	20.80%	45.90%	20.80%
	Female	23.90%	30.60%	28.60%	62.00%
	Both	10.60%	48.60%	25.50%	17.30%
	No Response	47.80%	0.00%	0.00%	0.00%
Plant parts collected	Leaves	20.00%	22.70%	2.70%	0.00%
	Seeds	58.00%	62.40%	82.00%	100.00%
	Stems	14.90%	4.30%	15.30%	0.00%
	Bark	1.20%	0.00%	0.00%	0.00%
	Roots	2.40%	10.60%	0.00%	0.00%
	Entire plant	3.50%	0.00%	0.00%	0.00%

Questions	Parameters	Griffonia (*Griffonia simplicifolia*)	Bush pepper (*Piper guineense)*	Country spice (*Xylopia aethiopica*)	Grains of Paradise (*Aframomum melegueta*)
Processing method	Dry in sun	14.50%	23.10%	40.80%	33.30%
	Leave fresh and store	13.70%	15.30%	16.90%	22.00%
	Pick and sell directly	20.00%	61.60%	42.40%	29.80%
	Dry with fire	0.00%	0.00%	0.00%	14.90%
	No response	51.80%	0.00%	0.00%	0.00%
Collection effort	Easy/ <1hr walk	19.20%	22.40%	24.30%	22.40%
	Difficult/ =1-3hrs walk	50.20%	51.40%	38.40%	39.60%
	Very difficult/ >3hrs walk	30.60%	26.30%	37.30%	38.00%
Population development status	Decreasing	22.70%	82.70%	68.20%	85.90%
	No change	17.30%	10.20%	15.30%	8.20%
	Increasing	12.20%	7.10%	16.50%	5.90%
Threats affecting plants	Farming	14.50%	20.40%	28.60%	45.90%
	Logging	12.50%	18.00%	25.10%	29.40%
	Collection impact	15.30%	47.50%	31.00%	5.50%
	Mining	8.20%	5.10%	10.20%	11.00%
	Development	1.60%	9.00%	5.10%	8.20%
Sale price per 1kg (LD$)	5-100LD	2.70%	12.90%	67.50%	13.70%
	105-200LD	21.60%	50.60%	29.40%	38.40%
	205-300LD	16.90%	27.10%	3.10%	35.70%
	305-500LD	6.70%	9.40%	0.00%	11.40%
	> 500LD	0.00%	0.00%	0.00%	0.80%

Questions	Parameters	Griffonia (*Griffonia simplicifolia*)	Bush pepper (*Piper guineense)*	Country spice (*Xylopia aethiopica*)	Grains of Paradise (*Aframomum melegueta*)
Any cultivation	Yes	2.80%	4.30%	7.10%	5.90%
	No	97.30%	95.70%	92.90%	94.10%
Major purpose of collection	Food	0.00%	7.10%	0.00%	0.00%
	Medicine	12.20%	26.30%	0.00%	7.50%
	Spice	0.00%	38.80%	45.10%	48.60%
	Building	0.00%	0.00%	14.50%	0.00%
	Income	40.00%	27.80%	40.40%	43.90%
Income generated per season	1,000- 2,000LD	2.20%	3.60%	32.40%	5.10%
	2,050 - 3,000LD	7.60%	16.40%	58.20%	36.50%
	3,050 - 6,000LD	15.10%	70.20%	7.10%	53.70%
	6,050 - 12,000LD	12.00%	9.80%	2.20%	4.30%
	12,500LD & above	4.00%	0.00%	0.00%	0.00%

3.4 Conclusion

This chapter focused on local communities and their collection practices of NTFP. NTFP serve the livelihood needs of rural communities by meeting their health, food and security as well as income needs. The gender involvement in NTFP collection showed women are equally involved as the men, which implies both parties can support each other to a successful adherence of sustainable practices with better returns. The study also showed that elders possess immense knowledge on NTPFs activities including collection practices, and that such knowledge can be passed down to younger generation through oral or written means. Many NTFP collectors are farmers who have little or no former educational training, and most rely on NTFP for their income generation. Though there were other sources of generation of income, more than 60% respondents' annual income was below $1,000. The collection of NTFP can meet community/rural household need and generate income even during seasons of famine when farming has only begun with slash and burn and planting processes. NTFP are harvested and sold to local markets to meet their income needs. However, unsustainable exploitation of NTFP can have negative impact on the species population. The limitation to knowledge of good harvesting practices of NTFP in Liberia may be the reason for higher percentage of respondents that use the cut/pull harvesting technique to gather products for their use. This calls for a need of training to the collectors about the importance and methods of sustainable and scientific harvesting of such products.

Traditional knowledge on collection practices of NTFP has satisfied some important information gaps such as collection practices of NTFP, impact and threats due to collection, as well as income from collected NTFP, and highlighted promising directions for the management and sustainability of NTFP and further research, such the strategies for sustainability and forest biodiversity conservation. Traditional ecological knowledge is critical in understanding the fundamentals of NTFP management – there are challenges for sustainable wild harvesting that include lack of knowledge about sustainability. This can be mitigated through the shared traditional knowledge to that of the scientific knowledge on sustainability of NTFP. Hence, the commitment of this study for documentation of such valuable knowledge on NTFP.

Traditional knowledge helps to understand the nature and concept of harvest practices and paves the way for sustainability development and management of NTFP to provide longer-term economic benefits to beneficiaries. With gender balance in the collection practices of NTFP, development policies and management with gender inclusion at the local level can be met. However, the documentation of traditional knowledge on the collection practices of NTFP may be the only means of such valuable information being passed down to future generation; an information that is necessary. A key potential contributor to the economies of rural communities lies in the development and sustainability of the NTFP sector. This can be enhanced with the inclusion of farmers who are seen as a main group in NTFP activities.

4 Chapter IV: Assessing Traditional and Sustainable Harvesting Methods on Collection of Two Leading NTFPs – *Griffonia simplicifolia* and *Xylopia aethiopica*

4.1 Introduction

Traditional harvesting methods are known to be destructive and/or wasteful leading to reduction of NTFPs (Tran and Dine, 2007; Dine, 2007) and sometimes depletion of population and biological diversity (Cunningham, 2001; Juliani *et al.,* 2013). Studies have shown survival and continual production risks to NTFPs from wild harvesting due to increasing demands (Bodeker, 1997; Ahmad, 1998; Lange, 1998; Singh *et al.,* 2003) extended uses (Ticktin, 2004), and trading (FAO, 1997; Cunningham, 2001; Ahenkan and Boon, 2008). Heightening threats to NTFPs also include deforestation from logging (Cunningham, 1993), conversion to plantations (Grünwald and Büttel, 1996), pasture and agriculture (Homma, 1992; Prescott-Allen and Prescott-Allen, 1996), habitat modification due to urbanization (Joshi and Joshi, 2000; Tabuti *et al.,* 2003), and traditional patterns of unsustainable rates of exploitation (Cunningham 1993; Bodeker, 1997; Clay 1997; Tiwari, 2000; Schippmann *et al.,* 2003), coupled with the rapidly increasing human population (Ahenkan and Boon, 2008). These threats may result in ecological problems including resource depletion (Neumann and Hirsch, 2000), as well as species endangerment and extinction (Koroch *et al.,* 1997; Acharya, 2000; Prasad, 2009). Those who are most economically reliant on natural resources tend to be local community dwellers. Sustainable harvesting is therefore not only necessary for conservation of plant biodiversity, but also for the livelihoods of many rural peoples in those forests that are at risk (Ruiz-Perez and Byron, 1999; Shackleton and Shackleton, 2004a, 2004b; Ticktin, 2004).

There has been discussions and debates as to whether NTFP harvest is intrinsically, or can possibly be, sustainable and ecologically more benign (Ruiz-Pérez, 2005; Sunderland *et al.,* 2011). Ecologically, harvesting can be considered sustainable at the species level if there is no long-term deleterious effect on the reproduction and regeneration of the plant populations being harvested (Sunderland *et al.,* 2011). Equally, harvesting should also not have any visible adverse effect on other species within the same region, or on ecosystem structure or function (Hall and Bawa 1993; Ticktin 2004). The harvesting of fruits and seeds, though not immediately harmful, can affect the future regeneration of a species (Hall and Bawa 1993). The harvesting of bark and other woody parts of plants can cause short to long-term senescence and, ultimately, the death of the plant (Peters, 1994; Ros-Tonen and Wiersum, 2005). Moreover, if a plant is uprooted or felled for the collection of any parts whatsoever leads to the destruction of the plant and eventual decline overtime (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013).

The parts of Griffonia (Gri*ffonia simplicifolia* (M.Vahl ex DC.) Baill.) and Xylopia (*Xylopia aethiopica* [Dun.] A. Rich.) harvested are the pods, though other parts have been used in traditional medicine including the bark and leaves for Xylopia (Burkhills, 1985), and the bark, leaves, and roots for Griffonia (den Boer *et al.,* 1990; Larmie and Poston, 1991; Brendler *et al.,* 2010). In Liberia and in context to these species Juliani *et al* (2013) have reported local collectors harvesting only the pods by cutting down trees and vines of Xylopia and Griffonia, respectively, to collect pods from their branches. This may be due to the lack of knowledge of alternative sustainable harvesting practices and the benefits thereof to sustainability and conservation of the populations. Juliani *et al.* (2013) had reported that there was a lack of understanding by the local communities and collectors of the importance of sustainability since most of the plants used are wildly harvested and there was not a connection between how they harvested these species for trade and commerce with their regrowth. Khadehyea *et al.* (2015) also suggested that the idea of plant collection in the Ziama, Wonegizi Clan in Lofa County is poorly understood.

While Griffonia has a one season harvest period per year (November to May) (Juliani *et al.,* 2013), Xylopia fruits twice and thus has two season fruiting periods per year, December to March and June to September (Orwa *et al.,* 2009). The collection of products by cutting entire plant is more sensitive to the plant growth over time, even with regeneration potential. Juliani *et al.* (2013) had reported current local harvesting practices of Xylopia being destructive and involving the cutting down of the entire tree to collect the fruits, as well as using the stems for poles as building material. Similar trend has also been noted for Griffonia, as collectors employed related destructive method by pulling down vines or cutting of tree that contained the climber plant in order to gather the pods to collect the seeds (Juliani *et al.,* 2013). Thus, the harvest of these NTFPs require a practical sustainable harvesting method and a change of behavior pattern towards sustainability.

Sustainable harvesting which is increasingly acknowledged as a conservation strategy for most wild harvested plants, with long-term valuable contributions to local economies and harvesters (Schippmann *et al.,* 2003) can be employed for species plants that require only seeds harvest as product, such as Griffonia and Xylopia. Manvell (2011) had recommended exploring and developing harvesting methods for sustainable production of NTFPs in Liberia. The sustainable collection of NTFPs is important in the preservation of forest biodiversity while also benefiting longer-term productivity and income, with many scientific studies reporting ecological effects of NTFP harvesting (Peters, 1994; Cunningham, 2001; Ticktin, 2004). In Liberia, however, limited studies about the ecological effects of NTFPs harvest (Juliani *et al.,* 2013; Kpadehyea *et al.,* 2015) and rarely any systematically scientific investigation on sustainable harvesting technique have been reported. Changes in harvesting patterns with corresponding modifications in harvesting techniques can create a win-win strategy, where local people benefit while conserving the forest biodiversity (Ghimire *et al.,* 2005).

To understand and incorporate changes in harvesting patterns with sustainability of Liberian NTFPs for longer-term income generation and biodiversity conservation, the objectives of this study were to describe and assess current methods for harvesting two important Liberian NTFPs and suggested alternative sustainable technique of harvesting and to assess the impact of the harvesting methods on species population.

4.2 Materials and methods

Two field plots of forest areas with one-acre area size each were used to test the effects of two collection methods for two Liberian NTFPs, Griffonia (*Griffonia simplicifolia*, in the Zor Community forest) and Xylopia (*Xylopia aethiopica*, in the Raymond Town Community forest), over two consecutive production seasons from December 2015 to January 2017. The forest areas were selected because of the species richness visually found in the individual locations, and also because of the willingness of the community leaders and in accordance with the community members to allow the use of their forest to be used for the study. Each forest was divided into 8 blocks; 4 blocks for first collection method, and the other 4 blocks for second collection method. Three (3) trees (Xylopia) or vines (Griffonia) per block were randomly selected, marked with flag tape and used for the collection during the two harvest seasons. For the first collection method, local collectors from each of the communities followed traditional ways of harvesting the pods; collectors gathered and weighed (Kg) the harvest collected within each block from the three trees (Xylopia) or vines (Griffonia). For the second method, collectors were trained to use harvesting methods and tools that minimize damage to trees and vines. Collection impact was assessed by the visual observation and count of tree and vine damage generated by the two collection methods, in relation to the total number of plants in each block. Tools and methods used traditionally by local collectors included cutlasses and collection bags and/or tubs. With cutlass, trees or vines were easily cut down in order to reach the pods. In most cases, paths were created to get to a tree of Xylopia or vine of Griffonia; in the process, most vegetation including young growing plant species of harvest would be cut. Cutting of tree and vine often had other plant accompanying the fall. However, only plant species that were damaged were visually counted to record impact on plant species population.

For the second method which was an alternative to the traditional way of harvesting required training of collectors to practice a method that would minimize damage to plant, but generate maximum collection. For this purpose, ten (10) members from each community were selected and trained. The practice method included using an appropriate harvesting tools such as sickled serrated blades for harvesting hanging pods on tall trees, in this case, a tapping knife (i.e. a rubber tree tapping knife that is used for latex extraction) sharp from tip to curve, tied to the end of a long bamboo stick along with a collection bag attached below the knife to enable harvested pods to fall directly in bag; others falling to ground would easily be picked with hand. The long bamboo was intended to easily reach to pods at distant branches either from the ground or at a reachable climbing location on the tree. A test trial was demonstrated for further clarity and to enable trainees to grasp use concept. Each member was allowed to perform the demonstration one at a time to show proof and ascertain knowledge clarity. Purchased tapping knives were then distributed to each member who made his/her own picking stick. Each member was told to collect upon harvest as much as possible as they could reach, but be sure to let few pods on trees or vines to mature for seeds regeneration process (Hall and Bawa, 1993). By this, the plants would have more new growths to replace for old-aged plants.

For each of the four blocks, 2 trained persons were allowed to collect from the 3 trees for Xylopia or 3 vines for Griffonia. During the first harvest season, 8 trained persons collected from the four blocks; during the second collection season, trained person rotated in the various blocks, while 2 persons were left and would choose to join any one of the team of two. The season collection date for Xylopia was February 18 – 22, 2016, while second collection date was July 6 – 10, 2016. For Griffonia, first season collection was March 7 – 12, 2016, while second season collection date January 6 – 11, 2017. After each season, impact on plant species was recorded by visual observation and count of damaged plant species within each block.

All produce collected were given to local collectors who dried products in sun and sold to collecting agents at affordable price rates (LD$ 100 per kilo for Xylopia seeds, and LD$ 250 per kilo for Griffonia; LD$100 = US$1.00).

4.2.1 Experimental design and analysis

The study used randomized complete block design (RCBD) for field experiment to test effects of collection methods for NTFP harvests. Data collected were compiled, computerized in excel spreadsheet and subjected to statistical analysis. An analysis of variance (ANOVA) was performed, with $p<0.05$ considered significant.

4.3 Results and Discussion

During first collection season, local collectors harvested a total average of 28.3 kg of Xylopia pods from the total of 12 trees selected in the plots using the traditional method of harvesting (Figure 4.1). Collectors using the alternative (lets instead call it ‘proposed sustainable’ method that should minimize damage to the plants harvested slightly lower amounts (26.2 kg) (Table 4.1). However, during the second season, collectors using the traditional method harvested on average only 6.3 kg; while collectors using the alternative proposed sustainable’ method obtained similar yields (26.5 kg) as that collected during first season in relation to the traditional method (6.3 kg) (Figure 4.1). This supports the recommendation by Manvell (2011) to explore and develop harvesting techniques for sustainable production of NTFPs in Liberia and that when done correctly it need not impact yield and income generation. There were differences noted from one block to the other in yield due to tree size, height, and population density of plant species, coupled with the many other biodiversity that together made huge denseness of the forest. Environmental conditions always lead to differences in size, shape and heights of plants, which would also impact yield. Though yield collections were relatively similar in the various blocks, the little differences may have been due to plant structure due to natural environmental impact.

After the second season, collectors were able to increase the total yields from 34.6 kg for the traditional method to 52.7 kg for the improved method of collection. The results showed that collection impact on the trees was much higher using traditional methods (Figure 4.2). The improved method of collection is a practical sustainable harvesting technique that uses methods and tools that minimize damage to the plant. Thus changes in behavior pattern of local collectors to incorporating the improved method of collection lead towards sustainable practice of collection, which is evident given the ability of the plants to bear fruits, affirming statement by Schippmann *et al.* (2003).

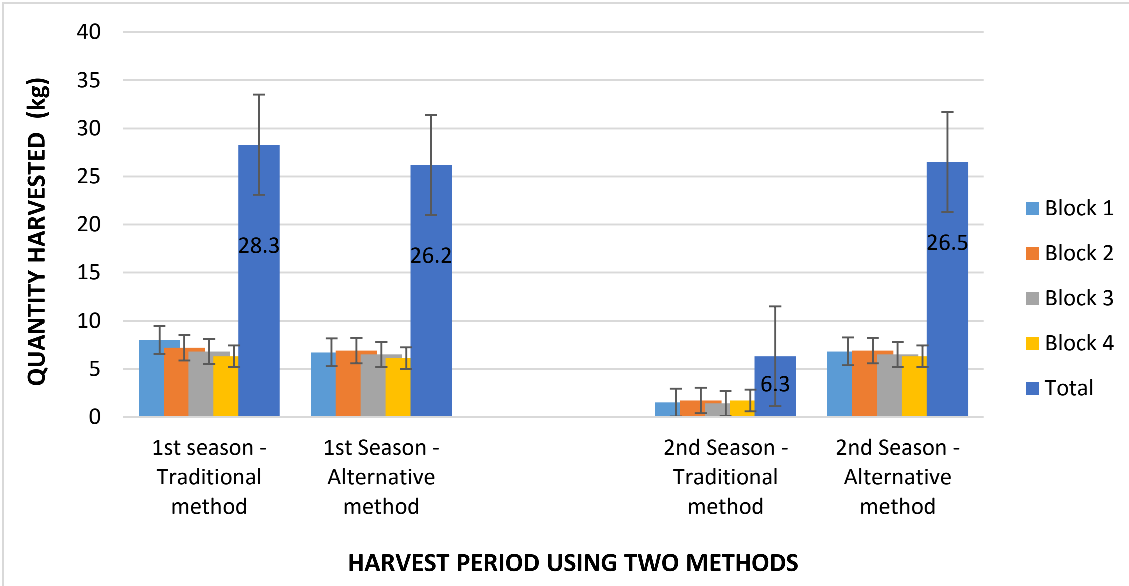


Figure 4.1: Collection of Xylopia (*Xylopia aethiopica*) using traditional and alternative methods of harvesting in a plot of four blocks each for two consecutive seasons

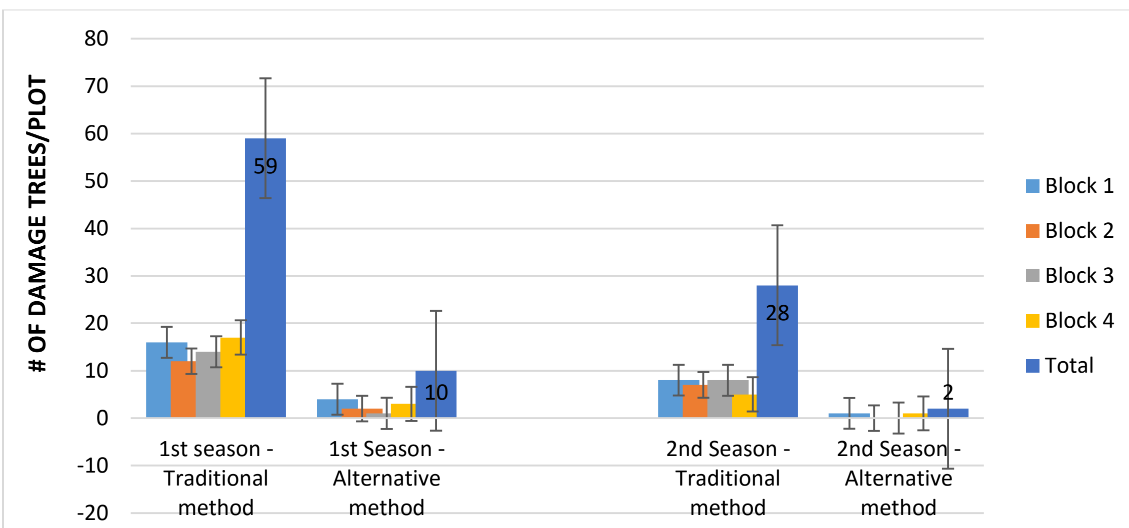


Figure 4.2: Collection impact assessed by visual observation of Xylopia (*Xylopia aethiopica*) tree damage (number of damaged trees per plot of four blocks each) using the traditional and alternative methods of harvesting in a plot of four blocks per method for two consecutive seasons

In the first season using traditional method, 59 trees were damaged, while in the second season an additional 28 were damaged (Figure 4.2) in relative to 3 trees/vines/block/4 blocks. The end result for the improved method is the fact that for two seasons increased yields were observed, with the added value of preserving the resource. These results provide support for the conclusions/recommendations of Ghimire *et al.* (2005), which states a win-win strategy when there are changes in harvesting patterns with corresponding modifications in harvesting techniques, where the local communities benefit while conserving the forest biodiversity.

For Griffonia, we observed a similar trend. By using the traditional method, higher yields were observed during the first season (18.5 kg) and a decrease in yield during second season (4.2 kg) (Figure 4.2). The improved harvesting technique yielded 17.1 kg in the first season and a similar result (17.6 kg) during the second harvest season. Overall yields were again higher for the improved method (34.7 kg vs 22.7 kg for the traditional) (Figure 4.2). The traditional way of harvesting has been practiced from time in memorial by local community dwellers who are involved in the collection of the plant product. Those using the improved methods were group of local community members who were trained to use materials and tools that would minimize damage to plant but enable maximum harvest. These people have not practiced such method before until the beginning of the study.

The results also showed that collection impact and damage to Griffonia vines was much higher using traditional methods, 55 vines damaged in first season and another 30 damaged in second season, (Figure 4.3). Due to lack of knowledge on how to harvest (Juliani *et al.,* 2013), our results (Figures 4.2 and 4.4) confirmed that traditional harvesting techniques in these Liberian counties were destructive and wasteful. Over the long-term such results could then lead to reduction of NTFP and potentially destruction or some loss of biological diversity (Tran Ngoc Hai & Dine, 2007; and Dine, 2007). The results from the collection using traditional method of harvesting (Figures

4.2 and 4.4) also substantiate studies by Cunningham (2001) and Juliani *et al.* (2013) that traditional methods can lead to depletion of population and biological diversity. Cutting of tree or vine resulted in the plant's inability to replenish over a season's period to produce desired yield. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally, with the inability to sustain life from a long-term result of degradation.

The evidence of threat due to unsustainable rates of exploitation was realized, as reported by Bodeker (1997) and Schippmann *et al.* (2003), in the assessment of impact due to traditional method of harvesting that resulted in limited yields during the second harvest seasons for both species (Figures 4.1 and 4.3). During first harvest season, local collectors harvested pods from trees by cutting the trees of Xylopia in order to obtain pods from all branches that had fruits. They were very successful in collecting high quantity of pods. However, they did not consider subsequent season for harvest, nor awareness of cuttinbg of trees and effect on plant. During the second harvest season, when they were told to only harvest from the very same trees that were harvested the previous season, it became clear that only branches that were left on bottom stems had fruits that could be harvested; hence, the decrease in yield collection in second season (Figure 4.1). Similar situation was seen for Griffonia harvest, when local collectors practicing traditional way of harvesting either cut or pulled entire vine down only to harvest hanging pods during the first season. Quantity collected was astounding; however, second harvest season saw the exact opposite for quantity obtained due to very limited fruits that that developed from the uncut vines, while cut vines were no more productive nor alive for production. They still exerted all efforts to harvest the little that were seen on left vines either by pulling to ground or cutting to reach pods. There was however very limited pods that were collected; hence, the decreased quantity (Figure 4.1). Impact on plant species and population was also seen when entering forest to collect, where a collector would make paths to reach a tree or vine to harvest, thereby cutting young growths. Also cutting of tree or vine would take along with its fall others, all of which were impacted.

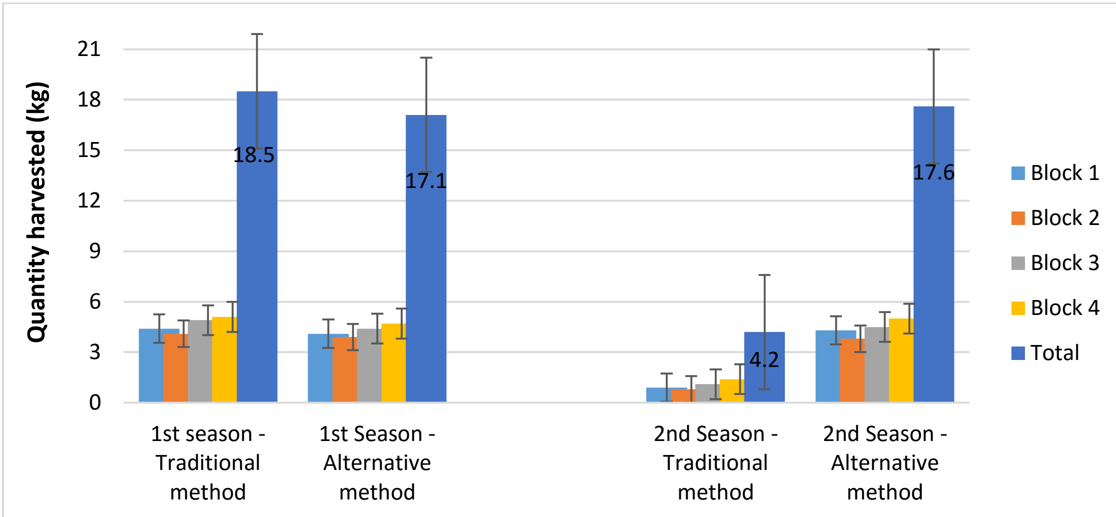


Figure 4.3: Collection of Griffonia (*Griffonia simplicifolia*) using traditional and alternative methods of harvesting in a plot of four blocks each for two consecutive seasons

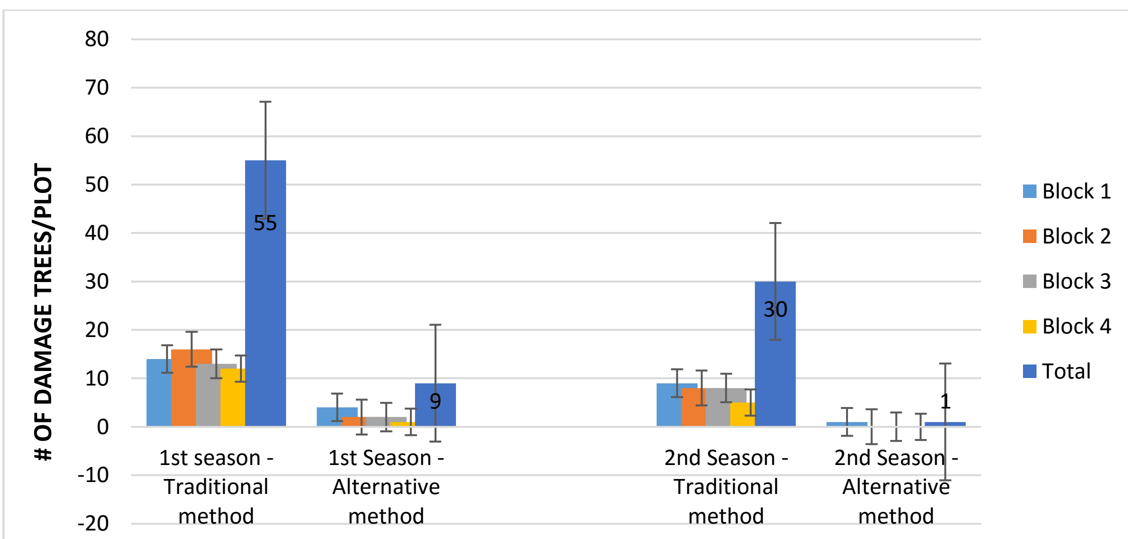


Figure 4.4: Collection impact assessed by visual observation of Griffonia (*Griffonia simplicifolia*) vine damage (number of damaged vines per plot of four blocks each) using the traditional and alternative methods of harvesting in a plot of four blocks per method for two consecutive seasons

The harvesting of fruits and seeds, though not immediately harmful, can affect the future regeneration of a species (Hall and Bawa 1993). The part of the plants being harvested as product for the two species are the seeds, which ecologically may not cause immediate harm, is known to affect the future regeneration of the species (Hall and Bawa, 1993). The method employed as alternative harvesting method (or improved method of harvesting) enabled collector to collect to maximum, but harvest such that seeds would remain to fully mature and freely fall on forest floor for regeneration of species that would replace old growth and dead trees and vines. This was evident in the results from the first harvesting seasons for both plant products using the alternative harvesting method (26.2 kg) being slightly lower than the traditional method (28.3 kg), and literally constant for the alternative harvesting method (26.5 kg) during the second season (Figure 4.1). This trend indicates that a change in behavior pattern of harvesting by local community provides a win-win situation for both the plant species population and a benefit to local collectors. However, impact from traditional method of harvesting showed the harvesting of pods by cutting down the trees of Xylopia (Fig. 4.2) and vines of Griffonia (Fig. 4.3), thus confirming report by Juliani *et al.* (2013). This may be due to lack of knowledge on the importance of sustainability therein, as the plants naturally grow in the wild (Juliani *et al.,* 2013, or the idea of wild-harvested plants in relation to sustainability is being poorly understood in rural areas (Khadehyea *et al.,* 2015).

It is apparent to note the importance of sustainable collection of NTFPs and the preservation of forest biodiversity with longer-term benefits of productivity and continuous income generation (Peters, 1994; Cunningham, 2001; Ticktin, 2004). This was expressed in results realized from the alternative and improved method of harvesting that yielded similar collections during the two harvesting seasons for both plant species (Fig. 4.1 and 4.3), with very little impact observed during the second season for both plants (Fig. 4.2 and 4.4). Discussion with all collectors after the field study about results and best method for adoption was conducted; local collectors all approved the improved method as their best choice, with all expressing interest and ease of adoption.

4.4 Conclusion

Traditional methods due to lack of knowledge of a better harvesting practice yields less and often leads to destruction and/or wastefulness of plant populations, which may cause population decline and loss overtime. Trained community members in the use of materials and tools that minimize damage to plant during harvesting were able to preserve the resource, at the same time obtain maximum yield. Changes in behavior pattern of local collectors towards sustainable harvesting techniques result in increased yields linked to biodiversity conservation. The study suggests that the training of people has huge impact on sustainable harvesting that leads to conservation and continuous yield production. Hence, sustainable collection of NTFP can ensure the preservation of forest biological diversity, with a longer-term benefit of productivity and continuous income. Results from both methods of collection were discussed with the collectors after the field study; collectors were asked as to preferred method of choice. They all approvedw the improved method as their best choice; with all expressing interest and ease of adoption, with need for training and awareness of more people to the sustainable harvesting practices of NTFP.

5 Chapter 5: Assessing the domestic value chain for three leading NTFP in Liberia: Griffonia (*Griffonia simplicifolia*), West African Black Pepper (*Piper guineense*) and Country Spice (*Xylopia aethiopica*)

5.1 Introduction

It has been argued that while much is known about the characteristics of individual NTFP, there is limited knowledge about their commercial performance and developmental relationships (Arnold, 2004). The knowledge in the role of NTFP in rural community development is limited (Angelsen and Wunder, 2003). Priority areas for NTFP contributions have been identified, such as rural community livelihood, and trade and market issues (Angelsen and Wunder, 2003), as well as supporting economic development processes (Byron and Arnold, 1999).

Commercialization of NTFP is an important aspect involving different processes such as production, collection, processing, storage, transport, marketing and sale (Marshall *et al,* 2003). Marshall *et al.* (2003) found that product marketing and sale were the most important of all factors that constrain the overall success of NTFP commercialization. However, Ghate *et al.* (2009) established a clear relationship between the degree of proximity to market and NTFP dependence; with low market access to remote places having high NTFP dependency. The demand for NTFP is increasing not only in local markets, but also in international markets. Therefore, identifying potential species with trade value and conducting research on their ecology and sustainable harvest levels; in depth value chain analyses and use patterns; and trends assessment and challenges in marketing and management (Shackleton and Pandey, 2014) are among important steps to facilitate integration of NTFP into the development agenda with beneficial consequences for local communities.

A value chain approach is a process which describes the full range of activities required to bring a product or service from the producer or point of conception, through the intermediary phases of production, delivery to the consumer and final disposal after use, emphasizing the value that is realized and how it is communicated (Kaplinsky, 2000; Wong, 2006). Value chain analysis is considered a methodological tool for describing markets for NTFP (Kaplinsky and Morris, 2001) and is now an accepted practice for agricultural development. In most cases, this involves drawing a map of the different production stages and their relations; or computing profit margins or levels of success at each stage in the value chain (te Velde *et al.,* 2006). The design of appropriate policies and development of interventions is also ensured by the understanding of issues all across the entire value chain (te Velde *et al.,* 2006). Value chain involves a variety of key players at each step, its organization and function that impact the efficiency and strength of the commercialization efforts (Juliani *et al.,* 2013). Strengthening all aspects of the value chain and ensuring all are properly functioning facilitates successful trade linking adequate and acceptable supply to market demands and needs.

Deshmukh *et al.* (2009) reported that programs targeting commercializing products often end up unintentionally targeting males because of their tendency to dominate production of higher value products. They further argued that assuring a high level of women's involvement in higher value products is critical, owing that women are more susceptible to poverty and in greater need of revenues, and that their revenue flows are more family-orientated than men's revenues, which are more egoistic. This can be challenged because many studies are showing that in many countries in sub-Sahara Africa, it is the women that is the lead and more effective entrepreneur for high value specialty crops while the male dominates the agronomic crops, livestock and prime food and income driving activities. The use of income is another story. Thus, it is important to recognize the leadership of women in NTFP. Shea butter is an excellent example of a highly successful NTFP dominated by women and their children relative to the collection and local processing. When it moves into the value chain toward collection centers, processing and exports, men begin to dominate and take over. The increased involvement of women in high value products to increase their revenues when promoting increased levels of equity (Deshmukh *et al.,* 2009). Equally, youths are often neglected in the process of a commercialized product, because commercialization is frequently dominated by non-youths, more so by men. The level of youth involvement is an important consideration in NTFP commercialization initiatives, partly because rural communities have considerable levels of youths, and partly to provide an incentive for the youth to stay in rural areas, which is an important way of promoting equity (Deshmukh *et al.,* 2009).

The economic value and value chains of NTFP have been underestimated due to the lack of an established industry responsible for the check and balances of the sector, limited local government regulation of collection, sales and trade, and the lack of tracking of trade (Adelaja *et al.,* 2003). NTFP trade is usually informal with less statistics gathered to show the real economic value and volume of trade involved. Hence, the establishment of program for NTFP can encourage and change the successful development of NTFP by involving intermediaries (traders, wholesalers, retailers etc.), to assist in the development of new industries (Juliani *et al.,* 2013). The lack of appreciation for economic potential, ignorance of NTFP importance to rural communities and the general lack of knowledge have impeded the establishment of policy programs directed to the management of NTFP in Liberia (FDA, 2006). Addressing these limitations ensure the potential of natural resources to contribute to local, regional, and international markets (Juliani *et al.,* 2013). Though, other West African countries have strong economic trade establishment in domestic natural products, the weak purchasing power coupled with low population in Liberia necessitates the acceptance of regional trade as a major driver for economic growth and development (Govindasamy *et al.,* 2007).

The goal of this study was to gain a better understanding of the underlying conditions and income generated across the domestic NTFP value chain; and to extend current knowledge of the value chains for the selected NTFP for their commercialization efforts. The objectives of this study were therefore to: 1) to identify the main actors (stakeholders) in the commercialization chain from the collector through to the final consumer, with their specific activities identified; and 2) to identify routes to commercialize the three selected NTFP, complexities and opportunities in their value chains.

5.2 Materials and methods

5.2.1 Survey study area

The study was conducted in 25 communities from six counties in Liberia including Bong, Nimba, Grand Bassa, Lofa, Margibi, and Montserrado Counties. Team of trained interviewers visited five communities in Bong County (Palala, Gbarnga, Totota, Salala, and Ferlelah), six communities in Nimba County (Sanniquellie, Zorgowee, Karnplay, Ganta, Saclapea, and Tappita), four communities in Grand Bassa County (Buchanan city, Barcoline, District 4, and Boye town), four communities in Lofa County (Zorzor, Salayea, Gbatatuah, and Gollu), three communities in Margibi County (Kakata, Weala, and Marshall) and three communities in Montserrado County, mainly in Monrovia city (Redlight, Duala, and Vai town) from May 2016 to August 2016.

5.2.2 Methods

Prior to the beginning of the survey study, the Committee for the Protection of Human Subjects, the Institutional Review Board (IRB), at of Rutgers, The State University of New Jersey, reviewed and approved the study protocol, Protocol #: E16-235. Approval to conduct interviews was also obtained from local authorities at each survey site/community. Oral informed consent and approval from the town chiefs and/or local community leaders often in the presence of community members was obtained for studies in the community. With a welcoming approval, questionnaire was read out to community leader/chief mostly in the presence of community members with the objectives and intents clearly explained. The written consent form approved by Rutgers IRB Committee was also read to inform participants of their rights and confidentiality thereof. Upon acceptance, each participant was given a copy of the consent form and endorsed before interview began. Participation was purely on a voluntary basis; neither monetary nor material incentives were offered for participation.

Ethnobotanical survey on the value chain analysis of NTFP was collected by interviewing 140 informants, mainly agents and subagents (traders, wholesalers and exporters involved in purchasing and/or processing as well as exporting of NTFP), using a standardized structured questionnaire with both close-ended (90%) and open-ended (10%) questions. A copy of the entire survey instrument is provided in Appendix …The survey questionnaire was prepared and pretested weeks prior to the actual field study to rectify any bias and to authenticate the questionnaire. The questionnaire comprised two sections, including the demographics of the participants and the ethnobotanical survey on the value chain analysis of three promising Liberian NTFP, including Griffonia (*Griffonia simplicifolia* M. Vahl ex DC. Baill.), Bush pepper or West African black pepper (*Piper guineense,* Schumach.), and Country spice (*Xylopia aethiopica,* A. Rich.).

Informants were chosen through simple randomized sampling in each community. Interviews were conducted using door-to-door and face-to-face in person approach. One or two team members fluent in the local language served as interpreters during the interview process when it was necessary, as the informants were mostly interviewed in Liberian English (Deshmukh *et al.,* 2009). The ethnobotanical survey questionnaire (Appendix C) was used to collect data on value chain of the selected NTFP including product purchase location, processing method, storage, means of transport, quantity, export, moisture quality, major trading partners, purchase price, income from further sale/export, purchasing experience, as well as individual position as a purchaser and/or processor. Data were analyzed both qualitatively and quantitatively; computerized in excel worksheet and inputted into Statistical Package for the Social Sciences (SPSS v. 21) for analysis using the descriptive statistical methods. A copy of the ethnobotanical survey questionnaire is found in Appendix C.

5.2.3 NTFP value chain description and analysis

The NTFP industry in Liberia is informal with very limited data to determine its impact on the economy, coupled with uncertain number of particular NTFP from communities and government forests in the Country (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013). The NTFP value chain analysis was therefore done based on community survey that was drafted and pretested in the field, along with the principal investigator and team's experience and knowledge of the industry. Data gathered and analyzed were based on information from twenty-five communities within six counties in Liberia.

5.2.4 Selected NTFP

Three of four NTFP of this study were selected for value chain analysis based on feedback gathered from collection survey on the four NTFP. The three selected were Griffonia (*Griffonia simplicifolia* DC. Baill.), Bush pepper or West African black pepper (*Piper guineense* Schum. and Thonn.), and Country spice (*Xylopia aethiopica* Dunal A. Rich.). Grains of Paradise – GOP (*Aframomum melegueta,* K. Schum.), the fourth NTFP, was reported to have low collection power and low market capacity, while the other three were reported to be abundant and/or have great market capacity. A market capacity is determined by the quantity of product collected from the wild and the constant demand for such product for purchase. Among the three selected, Country spice was reported the most abundant as reported throughout all communities visited, followed by Bush pepper, and Griffonia; though Griffonia was not found in some communities, the market potential for the product to that of GOP validated its selection.

Based on the criteria used for the selected NTFP which includes market demand, as well as the experience and knowledge of the principal investigator and the team in the industry, Griffonia, Bush pepper and Country spice were selected for value chain analysis. Each of the selected NTFP show potential for income generation and can be successfully procured in an environmentally sustainable manner and at levels sufficient for sustainability to meet market demands. They each can be produced to supply commercial volumes for domestic, regional and international markets.

5.3 Results and Discussion

The collectors often considered the producers of NTFP in value chains (Chapter 3) of this study, while this chapter deals with the agents and subagents (traders, wholesalers and exporters involved in purchasing and/or processing as well as exporting) of NTFP as actors in the value chains. A total of 140 informants, 26 female (18.3%) and 114 male (81.7%), were interviewed from 25 communities within 6 counties in Liberia on the value chain of three selected NTFP (Table 5.1).

The large number of males (81.7%) is evident that males are mainly the dominating gender group in production of higher value products (Deshmukh *et al.,* 2009). However, in Chapter 3 of this paper, the number of females involved in the collection of NTFP were fairly similar to the number of males (Figure 3.1), indicating the equal involvement of both group in NTFP collection. The large number of males may stem from points reported by Deshmukh et al. (2009), that programs targeting commercializing products do end up targeting males owing to the their tendency to dominate production of higher value products. Therefore, encouraging women in higher value products can promote increased levels of equity, given that they are more vulnerable to poverty and in greater needs of revenues and the fact that they have a family-oriented flow of revenue (Deshmukh *et al.,* 2009).

Table 5.1: Male and female informants from the various communities within the six Liberian counties participating in the value chain study

County	Number of Communities	Male	Percentage (male)	Female	Percentage (Female)
Bassa	4	18	12.9	3	2.1
Bong	5	24	17.1	4	2.9
Lofa	4	17	12.1	4	2.9
Margibi	3	13	9.3	3	2.1
Montserrado	3	9	6.4	7	5.0
Nimba	6	33	23.6	5	3.6
Total	**25**	**114**	**81.4**	**26**	**18.6**

5.3.1 Socio- economic characteristics

The age category of the socioeconomic characteristics of respondents in the value chain survey was between 21 years and above 65 years, with majority of respondents (51.3%) in the age range of 51 – 65 years, followed by 36 – 50 years (32.2%), over 65 years (12.2%), and 21 – 35 years (4.3%). For their marital status, more than half of the respondents were married (50.4%), while 19.1% were engaged, 16.5% were widow/widower, 7.8% were single, and only 6.1% were divorced. Respondents had varied educational levels, with only 4.3% who did not have any form of education. Majority had up to high school level (65.2%), followed by primary-elementary level (16.5%), 2-year college degree (13%), and 0.9% with 4 year college degree. Equally so, majority of respondents were self-employed (77.6%), followed by 13% being employed by others, and 9.6% of respondents who were retired. It worthy to note that 60% of respondents reported annual income ranging from $1,000 - $3,999, followed by annual income of ranging from $4,000 - $7,999 (21.7%), <$1,000 (15.7%), while only 2.6% reported to have annual income ranging from $6,000 - $7,999 (Table 5.2). The older age group (51 – 65 years) were known to dominate the value chain, suggesting that the trade, processing as well as exporting of value NTFP are mainly done by adults. This observation is supported by the fact that majority of the respondents were married (50.4%).

The absence of youth involvement in value chain of NTFP suggests the non-participation of youth and young people in the process and trade of NTFP, either due to their neglect in the process of a commercialized product, as is frequently dominated by non-youths (Deshmukh *et al.,* 2009). It is therefore important to encourage and include youths in NTFP commercialization initiatives; as Deshmukh *et al.* (2009) reported that rural communities have considerable levels of youths, and that providing some form of incentives for youths to stay in rural areas is an important way of promoting equity. Unlike the socioeconomic characteristics of NTFP collectors (Table 3.2), report on the educational levels of value chain respondents showed that there were at many with some form of educational background, especially 65.2% achieving up to high school level, while others reported having 2 year college degree (13%) and 4 year college degree (0.9%). This indicates that education has a great impact on the value chain of NTFP commercialization. This is even more evident with majority (77.6%) being self-employed, either being involved in NTFP commercial activities. Therefore, incorporating education such as trainings and knowledge based NTFP programs for rural communities to the collectors and producers would strengthen their economic capacity, thereby promoting poverty alleviation in the lives of rural communities. This is in line with the fact none of the respondents were farmers, while majority of the collectors (59.6%, Table 3.2) were farmers. Farmers could therefore benefit through knowledge of NTFP commercialization initiatives and processes. The results also showed that NTFP are also an activity for retirees (9.6%).

Table 5.2: Socio-economic characteristics of informants interviewed from the six counties

Demographics	Percentage
Age category	
Under 20yrs	0
21-35yrs	4.3
36-50yrs	32.2
51-65yrs	51.3
Over 65yrs	12.2
Marital status	
Single	7.8
Engaged	19.1
Married	50.4
Widow/widower	16.5
Divorced	6.1
Educational level	
No formal education	4.3
Primary-elementary	16.5
Up to high school	65.2
2yrs college deg.	13
4yrs college deg.	0.9
Graduate deg.	0
Current occupation	
Retired	9.6
Self-employed	77.6
Employed by others	13
Homemaker	0
Farmer	0

Demographics	**Percentage**
Annual income (USD)	
< $1,000	15.7
$1,000 - $3,999	60
$4,000 - $5,999	21.7
$6,000 - $7,999	2.6
$8,000 - $9,999	0
$10,000 - $30,000	0

Though the result of the annual income may not reflect reality, owing to the fact that many informants would find it more difficult to disclose their financial status but would still provide some answers to the study, it was recorded that some gathered an annual income of more than $5,000 (Table 5.2), which when divided over a 12-month employment year can be equivalent to a 4-yr-degree annual wage or more in Liberia. Moreover, considering the quantity collected per season and the price of 50 kg sale, it is certain that the amount would double even for any one of the three products (Tables 5.8 and 5.9). The annual income status indicates a need to strengthen and promote more potential NTFP for commercialization, while involving all stakeholders in the process for benefits distribution across the value chain.

5.3.2 Ethnobotanical survey of the selected NTFP

The growth habit of different NTFP showed that Griffonia is considered as a shrub when growing in places with fewer trees, but can grow into a vine when there is a tree to climb on; the results showed that 84.3% of the respondents considered Griffonia a vine (Table 5.3), with its seeds (100%) as the most important economic part. While Bush pepper was considered as a vine by all respondents (100%), with the seeds as the most essential economic part (100%), it has to be noted that the leaves of Bush pepper can be eaten, thus showing a potential to develop new products (Chapter 3, Table 3.6). Country spice was considered by all participants as typically a small tree (Table 5.3) with its seeds reported as the main used product commercialized by all of participants.

Though the main use of the three NTFP was for medicinal purpose (Bush pepper – 32.2%, Country spice – 28.7%, and Griffonia – 100%), Bush pepper and Country spice were also known to be used as spices. This provides an opportunity for the development of these spices into product into a wider commercial product, owing to their multiple uses, and the fact that they are spice with aromatic flavors even double their value. It was noticed no one reported the use of the stems of Country spice, especially as a building material, since the pole of Country spice is often used as a building material in rural communities (Chapter 3, Table 3.6). This is so because the targeted value chain respondents were mainly involved in seeds purchase for commercialization and not the stems (0%) (Table 5.3).

Table 5.3: Percentage distribution of growth habit, plant parts and main uses of Bush pepper (*Piper guineense*), Country spice (*Xylopia aethiopica*), and Griffonia (*Griffonia simplicifolia*) as recorded by participants of value chain survey

	Parts Used	Bush pepper (*Piper guineense*)	Country spice (*Xylopia aethiopica*)	Griffonia (*Griffonia simplicifolia*)
Growth habit	Tree	0%	100%	0%
	Shrub	0%	0%	15.7%
	Vine	100%	0%	84.3%
Part of plant	Leaves	0%	0%	0%
	Seeds	100%	100%	100%
	Stems	0%	0%	0%
	Bark	0%	0%	0%
	Roots	0%	0%	0%
	Entire plant	0%	0%	0%
Main use	Food[1]	0%	0%	0%
	Medicine	32.2%	28.7%	100%
	Spice	67.8%	71.3%	0%
	Building material	0%	0%	0%

[1]Based on the response of participants (sub/agents) regarding the use that each final user for a given product

There are many processes involved in the processing of NTFP; among these are drying, moisture content level, and storing among others. All participants reported drying (100%) as one of the processes for the three NTFP. Storing is very critical to the quality of any valued NTFP. Various storage methods are employed. Majority of respondents attested to using bag to store the NTFP seeds, while the use of barrel was reported as storage for Bush pepper (28.7%), Country spice (13.9%), and Griffonia (15.7%) (Table 5.4). Yet 9.6% respondents reported storing Country spice on floor, which may affect the quality of the product. NTFP are collected in various forms either from local collectors or from subagents for further processing and marketing. The collection of plant parts, in this case the seeds, can either be mature, intermediate, and young/green. More than half the total number of respondents reported obtaining mature plant products. However, there were some intermediate (Bush pepper – 29.8%, Country spice – 37.4%, and Griffonia 36.5%) and young or green (Bush pepper – 7.5% and Country spice – 11%) seeds reported. Respondents also reported collecting products that were fully dry, half dry, or fresh/raw for the three NTFP. 11.3% respondents reported fully dry for Country spice, followed by 10% for Bush pepper, and 8.7% for Griffonia; while 48.75 reported half dry for Griffonia, followed by 38.3% for Bush pepper, and 30.4% for Country spice. The moisture content levels for the various NTFP were provided by the respondents. 52.2% respondents reported moisture level of 6-9% for Griffonia, followed by 46.1% for Bush pepper, and 41.7% for Country spice. Also 58.3% respondents reported moisture level for Country spice, followed by 53.9% for Bush pepper, and 47.8% for Griffonia.

Drying in sun is one way to easily reduce moisture content for a product; however drying on bare floor may affect the quality. Hence, having a raised platform to dry product is the preferred way that minimizes soil dirt, foreign matters and encroachment of rodent on product during the process, all of which reduce the value of product especially to international markets. It is not certain if the use of barrel may have any effect on the quality of the products. There is a need for further study to assess the quality impact from the use of barrel as storage material. The storing of NTFP on floor raises concerns of quality issues, largely due to dirt, soil and non-plant species entering into the product, coupled with microbiological and food safety issues. There was limited knowledge of storage method, as this method often results in the introduction of foreign matters on product, thereby rendering the product reduced quality. An informative program in the sustainable processing practices of potential NTFP for their commercialization is necessary across all levels of the value chain. The collection of young/green product only suggests unsustainable harvesting practices that tend to fully destroy the individual plant as well as the population. Seeds collection with some seeds being uncollected would support future regeneration; however, collection of entire seeds may have future impact on plant population (Hall and Bawa, 1993; Ticktin, 2004). The moisture level is a major processing component for any internationally traded NTFP. At least all these NTFP product should be no more than 10% moisture level. All respondents met the accepted levels for the moisture percent of the three NTFP, 10% and below (Table 5.3).

The collection type includes mature, intermediate, and young/green for the three plant products. Processors and traders purchase products that fell, but with few informants mentioning collecting young or green seeds for processing (Table 5.4). This may just suggest that producers play their part in harvesting often mature to intermediate seeds from plants. Storing of products after processing was often in bags or in barrel, with only few informants reporting storing Country spice on the floor (Table 5.4).

As a product requires certain moisture quality upon export, each informant was asked about the moisture content of a particular product being handled before export. For all three plant products, moisture content recorded was 10% or below (Table 5.4).

Table 5.4: Percentage distribution of processing and storage methods, collection type, product kind, and moisture level of Bush pepper (*Piper guineense*), Country spice (*Xylopia aethiopica*), and Griffonia (*Griffonia simplicifolia*) as recorded by participants of value chain survey

Questions	Parameters	Bush pepper (*Piper guineense*)	Country spice (*Xylopia aethiopica*)	Griffonia (*Griffonia simplicifolia*)
Processing method	Dry in sun	100%	100%	100%
	Remain fresh and store	0%	0%	0%
	Dry with fire	0%	0%	0%
	Sell directly as fresh	0%	0%	0%
Storage method	Store in bag	71.3%	76.5%	84.3%
	Store in barrel	28.7%	13.9%	15.7%
	On floor	0%	9.6%	0%
	On zinc	0%	0%	0%
	On mat	0%	0%	0%
Collection type	Mature	62.7%	51.6%	63.5%
	Intermediate/half dry	29.8%	37.4%	36.5%
	Green/young	7.5%	11.0%	0%
Product kind	Fully dry	10.0%	11.3%	8.7%
	Half dry	38.3%	30.4%	48.7%
	Fresh/raw	51.3%	58.3%	42.6%
Moisture level	6-9% moisture	46.1%	41.7%	52.2%
	10% moisture	53.9%	58.3%	47.8%
	>10% moisture	0%	0%	0%

Table 5.5: Percentage distribution of quantity purchased per year, quantity exported per year and export locations of Bush pepper (*Piper guineense*), Country spice (*Xylopia aethiopica*), and Griffonia (*Griffonia simplicifolia*) as recorded by participants of value chain survey

Questions	Parameters	Bush pepper (*Piper guineense*)	Country spice (*Xylopia aethiopica*)	Griffonia (*Griffonia simplicifolia*)
Quantity handled/purchased per year (tons)	1-10 tons	100%	22.6%	100%
	11 - 20 tons	0%	28.7%	0%
	21 - 30 tons	0%	32.2%	0%
	31 - 50 tons	0%	13.9%	0%
	51 - 100 tons	0%	2.6%	0%
	> 100 tons	0%	0.0%	0%
Export	Guinea	23.5%	29.6%	0%
	Ivory Coast	16.5%	10.4%	37.4%
	Ghana	18.3%	12.2%	62.6%
	Senegal	30.4%	31.3%	0%
	Mali	11.3%	16.5%	0%
Quantity per export per year	2 containers (20ft)	0%	0%	0%
	1 container (20ft)	0%	0%	0%
	0.5 container (20ft)	0%	40.0%	0%
	1-2 trucks	0%	53.9%	0%
	< 1 truck	100%	6.1%	100%

The percent number of informants providing information on the quantity handled/purchased per season/year, per export, and the country of export for the three plant products is presented in Table 5.5. Survey results indicated that the quantity handled or purchased per season/year for Country spice can be up to 100 tons per year; while informants reported up to 10 tons of Griffonia and Bush pepper in quantity can be handled/purchased per year. It was reported with enough collection, a single trader or processor can export up to 0.5 container (20ft); with two to three persons making the container a complete filled for export. The country of export for these products include Guinea, Ivory Coast, Ghana, Senegal, and Mali. In short, the NTFP industry is significantly larger than most anticipated and most recognize.

In order to understand the purchasing power of an individual for a given product, the quantity often relates to the strength of purchase of a product. Among the three NTFP, respondents confirmed that Country spice was mostly purchased by agents and subagents. There were 32.2% of respondents that reported the purchase of 21-30 tons per year, followed by 28.7% who reported purchase of 11-20 tons per year; while 22.6% reported 1-10 tons purchase per year, 13.9% reported 31-50 tons purchase per year, and 2.6% reported 51-100 tons purchase per year. In contrast, for both Bush pepper and Griffonia, respondents reported that they handled and traded between 1-10 tons per year (Table 5.5).

The collection of these products are mainly for commercial trading especially out of country. Certain quantity is exported by an individual. For Country spice, 53.9% respondents confirmed the export of 1-2 trucks per year, 40% reported half container load (20ft size) per year, and 6.1% reported less than one truck per year. For both Bush pepper and Griffonia, respondents reported less than one truck of export per year (Table 5.5). Exporting countries for these products either for consumption or for further export internationally include Guinea, Côte d'Ivoire, Ghana, Senegal, and Mali. Bush pepper and Country spice are both exported to all these five countries;

while Griffonia is only exported to two countries, Ivory Coast and Ghana (Table 5.5) for further export to international markets. Exportation of NTFP can occur overland by roads and through the forests into Sierra Leone, Guinea, and Côte d'Ivoire where it can continue to move into other countries including but not limited to Ghana, Senegal and Mali. Alternatively, Liberia has the potential for exporting by sea, but as it is still in the rebuilding of ports in the post-civil-war torn environment, that has not developed to the extent market demand would permit.

Most of the participants reported strong purchasing power especially for Country spice, with some being able to purchase between 51 – 100 tons of this spice. In comparison, the low quantity of Bush pepper and Griffonia may not mean low purchasing power for an individual; rather, it may suggest that collectors involvement in the harvesting may be limited probably due to lack of information about quantity needed for purchase, since it is a tedious process to harvest more quantity only to sell for very low price for fear of spoiling if not bought. For this very reason, the process of drying and storing is very important for the collectors, where they can begin the drying process to a very acceptable moisture level that will be able to store for a longer time without losing its quality. For Griffonia, collection is only done when there is a buyer who requests for a certain quantity that he or she can purchase. The subagents will then inform local collectors about the quantity needed. However, the development of this sector can ensure international companies to directly purchase from Liberia, based on an agreement of certain quantity being met at all time. In this case, the need for cultivation in order increase population is a necessity, especially the introduction to other natural habitats in Liberia. This situation likely has to do with final use of each NTFP. Country spice is used in culinary cuisine locally and regionally, yet Griffonia is not used extensively in Liberia and most of the collection in Liberia is for sale to eventually reach Ghana. The Ghana Griffonia market is almost exclusively geared for sales to China where it is processed and then sold/traded to the EU and the USA.

Quantity exported per year may be at the discretion of the individual, wherein quantity purchased may be enough for export or not, as exporting may have its own financial attachment. However, team work in this area may be suggested, especially when there are more than two or three agents who can afford up to a truck or half a truck load per season. Their aggregate may be sufficient for a joint exporting effort. This can be accomplished with an active and strong association or organization established for such group of people. Respondents only confirmed the establishment of one association in Nimba County, the Botanical Products Association of Liberia (BOTPAL) (Table 5.9). This association is to supervise the purchases of NTFP as well as ensure its collector groups adhere to sustainable harvesting practices. However, majority of the respondents (87.8%) (Table 5.9) did not know about the existence of such group nor do they have any association that is involved in the major activities of NTFP to do a check and balance for all stakeholders involved. The need for expansion, or establishment of organization in other counties with similar vision is essential.

The purchase and collection of various NTFP can be either at various local markets, or from local collectors from the community, while in some cases, the subagent or community agents may be involved in personal or self-harvest of NTFP to minimize cost of purchase, thereby increasing profit. Collecting NTFP from local markets, 54.8% of respondents reported collecting Bush pepper from local markets, followed by 37.4% for Country spice, and 18.3% for Griffonia. Collecting from local collectors, 68.7% respondents reported collection of Griffonia from local collectors, followed by 60.9% for Country spice, and 42.6% for Bush pepper. Further, 13% respondents reported self-harvest of Griffonia; 2.6% reported self-harvest of Bush pepper; while 1.7% reported self-harvest for Country spice (Table 5.6).

Table 5.6: Percentage distribution of collection location, transport means, and collection experience of Bush pepper (*Piper guineense*), Country spice (*Xylopia aethiopica*), and Griffonia (*Griffonia simplicifolia*) as recorded by participants of value chain survey

Questions	Parameters	Bush pepper (*Piper guineense*)	Country spice (*Xylopia aethiopica*)	Griffonia (*Griffonia simplicifolia*)
Collection location	Market	54.8%	37.4%	18.3%
	From local collectors	42.6%	60.9%	68.7%
	Self-harvest	2.6%	1.7%	13.0%
Means of transport	In pickup	4.3%	22.6%	11.3%
	In truck	3.5%	40.9%	4.3%
	On bike	81.7%	18.3%	79.1%
	In Taxi/jeep	10.4%	18.3%	5.2%
	On head	0%	0%	0%
Collection experience	Easy/ 0-1hr	0%	7.0%	0%
	Difficult/2-3hrs	31.3%	33.9%	55.7%
	Very difficult/ >3 hrs	68.7%	59.1%	44.3%

The transportation system in Liberia is a major issue, coupled with poor road network within the Country. 81.7% of respondents reported using motorcycles as means of transport of Bush pepper, while 79.1% also used motorcycle for Griffonia transport, and 18.3% used motorcycle for Country spice transport. Transportation is often done from area of purchase to area of aggregate, or to main agents for further processing and aggregation for export. A pickup truck is used for transport of NTFP (22.6% for Country spice, 11.3% for Griffonia, and 4.3% for Bush pepper). Larger trucks are also used for transport, often when NTFP have been aggregated for export purpose (40.9% for Country spice, 4.3% for Griffonia, and 3.5% for Bush pepper). Mini transports such as taxi or Jeep (4-wheel vehicles) are also used for NTFP transport (18.3% for Country spice, 10.4% for Bush pepper, and 5.2% for Griffonia) (Table 5.6).

There are many difficulties and challenges across the NTFP value chain in the collection of the individual NTFP. While only 7% reported easy/0-1 hour distance for collection, the rest of respondent stated difficult/2-3 hours distance (55.7% for Griffonia, 33.9% for Country spice, and 31.3% for Bush pepper). Respondents often stated that they have difficulty in obtaining NTFP, with distance being the major constrains, in most cases, more than 3 hours to collect/purchase products; 68.7% respondents reported very difficult for Bush pepper; 59.1% informants reported very difficult for Country spice; while 44.3% informants reported very difficult for Griffonia (Table 5.6). The collection location of NTFP coupled with the road network both help to increase the difficulties in obtaining any one of the NTFP.

Prices for the various NTFP are often unstable and often decided by the buyers- not the collectors thus also causing some concern and risk to the collectors and local communities. Respondents stated the price (US$) per 50 kg for Bush pepper ($10 - $30, 6.1%; $35 - $50, 41.7%; $55 - $70, 49.6%; $75 - $100, 2.6%), Country spice ($10 - $30, 51.3%; $35 - $50, 48.7%), and Griffonia ($35 - $50, 21.7%; $55 - $70, 25.2%; $75 - $100, 53%). Respondents reported very high demands (80 –

100%) for the three NTFP (25.2% for Bush pepper, 15.7% for Country spice, and 3.5% for Griffonia). While it was also reported that there was high demand (50 – 79%) for Bush pepper (60%), Country spice (49.6%), and Griffonia (6.1%). However, there was also low demand reported (30% and below) for Griffonia (44.3% low and 46.1% very low demands), Country spice (27.8% low and 7% very low), and Bush pepper (14.8% low). For annual income generation from the NTFP, 7.8% of informants reported income of $5,001 – $7,500 for Country spice; while 7% of informants reported annual income in range of $2,001 – $5,000 for Griffonia. For annual income in range of $2,001 - $5,000, only Country spice (33.9%) and Griffonia (7%) were reported; for $1,000 - $2,000, annual income for NTFP was reported for Bush pepper (22.6%), Country spice (39.1%), and Griffonia (30.4%). Yet majority reported income less than $1,000 for all three NTFP (Bush pepper – 77.4%, Griffonia – 62.6%, and Country spice – 19.1%).

As stated earlier, financial status is normally considered private issue and disclosure is often limited on the part of the informants. As earlier noted, the demand for a product relates the quantity purchased or obtained; the higher the demand, the more the subagents and traders collect/purchase from local collectors or from market in order to meet the demand for the product. We observed how price for Country spice per 50 kg is very low, despite the demand. The development of a product for this NTFP may add more value, thereby increasing the purchasing price per kg. This can in turn increase yearly income from the NTFP.

Table 5.7: Percentage distribution of purchased price, demand and income of Bush pepper (*Piper guineense*), Country spice (*Xylopia aethiopica*), and Griffonia (*Griffonia simplicifolia*) as recorded by participants of value chain survey

Questions	Parameters	Bush pepper (*Piper guineense*)	Country spice (*Xylopia aethiopica*)	Griffonia (*Griffonia simplicifolia*)
Purchase price per 50kg (US$)	$10 - 30	6.1%	51.3%	0.0%
	$35 - 50	41.7%	48.7%	21.7%
	$55 - 70	49.6%	0%	25.2%
	$75 - 100	2.6%	0%	53.0%
	> $100	0%	0%	0%
Demand for product	80 - 100% / very high	25.2%	15.7%	3.5%
	50 - 79% / high	60.0%	49.6%	6.1%
	30 - 49% / low	14.8%	27.8%	44.3%
	< 30% / very low	0%	7.0%	46.1%
Income from product per year (USD)	< $1,000	77.4%	19.1%	62.6%
	$1,000 - $2,000	22.6%	39.1%	30.4%
	$2,001 - $5,000	0%	33.9%	7.0%
	$5,001 - $7,500	0%	7.8%	0%
	$7,501 - $10,000	0%	0%	0%

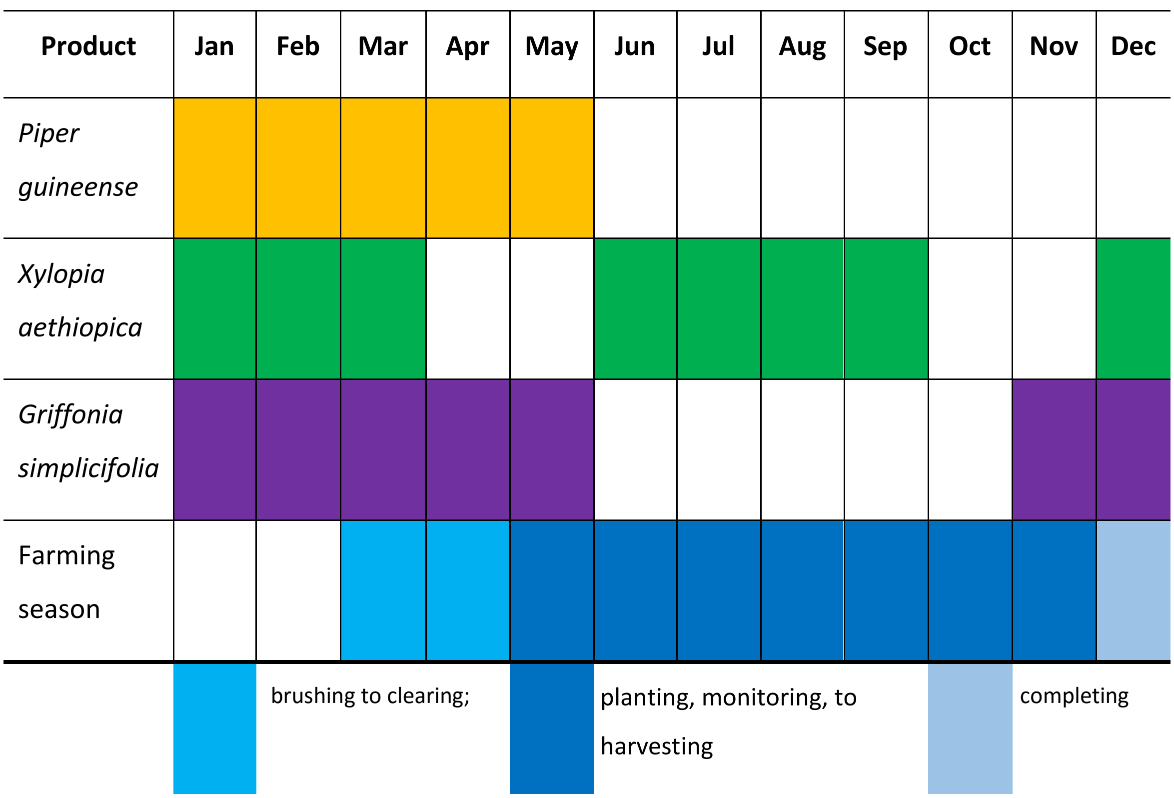
Table 5.8: Percentage distribution of respondent's position, year of experience with product and trading partners of Bush pepper (*Piper guineense*), Country spice (*Xylopia aethiopica*), and Griffonia (*Griffonia simplicifolia*) as recorded by participants of value chain survey

Questions	Parameters	Bush pepper (*Piper guineense*)	Country spice (*Xylopia aethiopica*)	Griffonia (*Griffonia simplicifolia*)
Your position in chain process	Main agent	11.3%	9.6%	7.8%
	Sub-agent	64.3%	60.0%	56.5%
	Community collector	24.3%	30.4%	35.7%
	Local collector	0%	0%	0%
	Retailer	0%	0%	0%
Year of experience with product	1 - 4yrs.	10.4%	15.7%	82.0%
	5 - 10yrs.	61.7%	51.3%	18.0%
	11 - 15yrs.	24%	19.1%	0%
	16 - 20yrs.	4%	11.3%	0%
	21+yrs.	0%	2.6%	0%
Major trading partners	Direct to consumers	0%	0%	0%
	Retailers/wholesalers	31.3%	27.0%	0%
	Intermediators/ commission agents	68.7%	73.0%	100%
	Processing company	0%	0%	0%

Table 5.9: Information on established organization or association for any or all the plant products

Questions	Parameters	Bush pepper (Piper guineense)	Country spice (Xylopia aethiopica)	Griffonia (Griffonia simplicifolia)
Association	YES	0%	0%	12.2%
	NO	0%	0%	87.8%
If YES, name		-	-	BOTPAL

Table 5.10: Annual production season of the three plant products



The roles of respondents in the value chain were provided. There were more sub-agents (64.3% for Bush pepper, 60% for Country spice, and 56.5% for Griffonia) than community collectors (24.3% for Bush pepper, 30.4% for Country spice, and 35.7% for Griffonia) and main agents (11.3% for Bush pepper, 9.6% for Country spice, and 7.8% for Griffonia). The respondents also had years of experience with the various NTFP. The majority had 5 – 10 year experience for the three NTFP (61.7% for Bush pepper, 51.3% for Country spice, and 18% for Griffonia). For 1 – 4 years of experience, 82% reported for Griffonia, 15.7% for Country spice, and 10.4% for Bush pepper; for 11 – 15 years of experience, 24% reported for Bush pepper and 19.1% for Country spice; for 16 – 20 years of experience, 11.3% reported for Country spice, and 4% for Bush pepper; while 2.6% reported 21+years of experience with Country spice. In most cases, subagents represent main agents in the value chain. The majority of trading partners were commission agents/intermediators (100% for Griffonia, 73% for Country spice, and 68.7% for Bush pepper); while retailers/wholesalers accounted for 31.3% for Bush pepper and 27% for Country spice. The subagents purchase NTFP from local collectors and then take the NTFP to the main agents where it is finally processed before being exported. Years of experience with NTFP showed that Griffonia among the three is a newly growing commercial NTFP that needs more awareness about its economic potential and market value.

Only 12.2% of informants confirmed that there was an association for Griffonia NTFP sector in Nimba County, known as the Botanical Products Association of Liberia (BOTPAL), indicating that there is at least one organization established to spearhead all activities of NTFP in Liberia. The role of BOTPAL is to supervise the purchases of NTFP as well as ensure its collector groups adhere to sustainable harvesting practices (Table 5.9) (Juliani *et al.,* 2013).

Informants provided clear responses on seasonal production/harvesting periods for the three plant products. It was reported that while Griffonia and Bush pepper are known to have only one annual season period, Country spice was reported to have two harvesting seasons in a year, December – March, and June – September (Table 5.10).

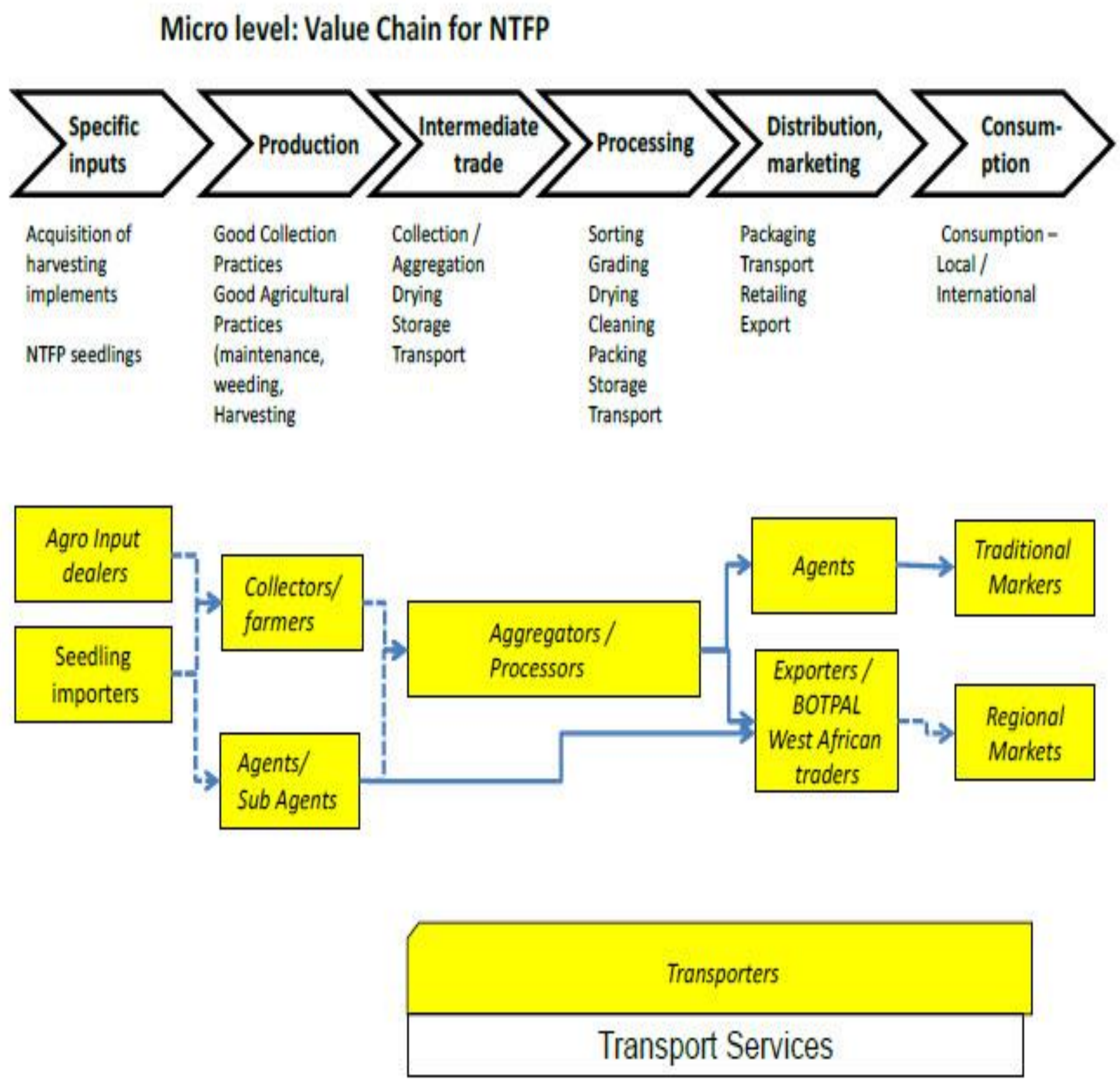


Figure 5.1: Overview of value chain of NTFP in Liberia as *adopted from Juliani et al. (2013)*

5.4 Value chain description and analysis

The value chain defines the full range of events required to bring a product or service from point of origin or conception, through the different stages of production involving the conversion and the input of various producer services, to the delivery to final consumers and final disposal after use, all of which involves many different actors at each step (Figure 5.1). The organization and functionality of a value chain affects the efficiency and strength of the commercialization efforts.

Based on the selection criteria used for the NTFP value chain, three recommended NTFP were selected to conduct a value chain analysis in this chapter; these include Griffonia (*Griffonia simplicifolia* DC. Baill.), Bush pepper or West African black pepper (*Piper guineense* Schum. and Thonn.), and Country spice (*Xylopia aethiopica* Dunal A. Rich.). Though limited data were available in the communities for each NTFP, the value chain has been organized according to the ethnobotanical report provided for these NTFP.

5.5 Griffonia: Value chain description

Griffonia is one of the most established commercially traded medicinal plants, especially in Ghana (the leading global supplier of this botanical) (Juliani *et al.,* 2013), Griffonia seeds contain high levels of the bio-chemical compound 5-hydroxytryptophan (5-HTP), which is a precursor of serotonin known as the natural and commercial source of this compound (Kim *et al.,* 2009). Griffonia is used in western medicine or healthcare market to treat depression, migraine and headaches, insomnia, fibromyalgia, appetite suppressant, and attention-deficit/hyperactivity disorder.

The value chain of Griffonia begins with identifying the collectors and acquiring specific tools for harvesting implements and bags. Collectors, agents and subagents collect and organize Griffonia seeds that are then sold to processors who cumulative in volumes. The processors and larger agents are tasked with activities such as cleaning, drying sorting, grading, and packaging of Griffonia seeds. Seeds are then taken to regional and international markets through agents and exporters.

5.5.1 Specific input supply

Input supply is a function of the availability from the agro-forestry dealer's side and the demand from the users, collectors or farmers. The agro-dealers perform this function around the community by developing networks. They are then motivated by profits through margins and sale volumes. Currently, Griffonia is collected from the wild either from the forest floor or by using traditional harvesting methods, often unsustainable methods, due to unavailability of appropriate harvesting practices and tools such as sickles for harvesting hanging pods on tall trees. Collection sacks and other equipment such scales are often not available; in most cases, stores where such equipment may be found are distant away from local communities requiring hours of drive, incurring cost on extra transport, to get these tools. In facilitating the logistics of acquiring input supplies such as the tools needed for sustainable harvesting and collection for collectors, the role of organizations such as BOTPAL is major in providing such supplies/tools that provide easier access to local collectors at affordable and reasonable prices.

5.5.2 Harvesting season and methods

As with many fruit-bearing NTFP, Griffonia seeds are available for harvest during the dry season (December – May, Table 5.10). Collection of Griffonia assist in food purchase especially during this season for local communities. The development of the NTFP industry including Griffonia could provide additional alternative income generating activity for rural communities, especially farmers during their off-season farming activities, thereby enhancing food security and poverty alleviation.

Griffonia seeds is harvested by collection from forest floor, by cutting down vines/trees, and/or by pulling down of vine to pluck fruits. In most cases as was noted, local communities use unsustainable harvesting practices for the collection of Griffonia such as cutting down vines/trees to obtain pods. None of the participant reported knowledge and use of any known sustainable harvesting practice for Griffonia seeds collection. The establishment of a sustainable harvesting practice that minimize damage to plant population while still obtaining maximum collection is necessary under the NTFP industry. Local communities could be trained in such methods across the country for other NTFP collection that may suffer similar situation.

5.5.3 Actors

Local collectors are the main harvesters of Griffonia from the forest. They hand-pick seeds from forest floor, while in some cases cut or pull down the vines to collect pods. Collectors process Griffonia by traditional means, such as manually extracting seeds from pods, one pod at a time, and drying the seeds to some extent (about 15-20% moisture content level) before selling to subagents/agents within the communities. Seeds extraction is mostly done by women and children. A completely dried product requires more seeds to reach a kilo; half dried enables easy kilo obtaining, but less price. Product is then sold to agents or subagents for aggregate to volume and/or further processing. The tools used for the harvesting include collection bags and cutlasses; no specific wearing is required for the harvesting. At this level, the trade is mainly small scale, products are sold in either buckets, cups (equivalent to 1 kg). Sale per kg is about $2.00 to $3.00 depending on the trader.

Collection of Griffonia is observed to be inconsistent because though many communities may have knowledge of whereabouts of Griffonia, they hardly ever collect. Collection in most cases is done based on quantities demanded by foreign traders to agents who then mobilize local collectors, since the product is not locally used, besides the traditional importance. Communities involved in regular trade of Griffonia are often those bordering nearby countries involved in major trade of the product such as Ivory Coast and Guinea.

Subagents and agents are the players who are at the front of the purchasing and the aggregating of the product from the local collectors. They include traders, processors, wholesalers, and agents. Upon purchasing product from local collectors, these groups are involved in activities such as aggregating, sorting, grading, drying, cleaning, packing/packaging, storage, and transporting of product either to larger agents, or to other out-of-country traders who often come to purchase products. In some instances, the community agents can become involved in collection of product from the wild to save on funds and increase margins of profits from further sales. Griffonia harvested from the communities are sold by collectors to the subagents who represent the agents/larger agents. Subagents mobilize local collectors for products on behalf of foreign traders and buyers from neighboring countries, Guinea, Ivory Coast, and Ghana. Products are brought to actual moisture content (<10%) by drying before sold to foreign traders. Drying can be anywhere from 4 – 10 days, or more, depending on the weather. These traders in turn serve regional and international markets. They package the dried seeds in large bags for transport out of the country. There are few women involved in this aspect of collection and processing of product. There is need for the encouragement of more women through all levels of the value chain to support equity by providing opportunities for women to earn income and develop entrepreneurial skills.

Larger agents are the main aggregators and exporters of the product. The larger agents are involved in further processes including making sure product is clean, and sorted out of other foreign matters; drying product to actual moisture level (<10%) that is a required standard, packaging, transporting, storing, and exporting. The storage of Griffonia is often done on bare floor where they are mixed with other products or encounter house rodents that easily contaminate the products. These practices shows the general lack of knowledge involved on appropriate storage required for Griffonia. Poor storage is known to have significant impact on the quality of product that relates to the price and market demands for those products. Failure to adhere to good storage practices leads to deterioration of Griffonia product and a decline in purchase. An intervention such as storing in polypropylene sacks also known as 'rice bags' and keeping in warehouse before exporting can minimize deterioration and maintain quality of product; hence, the better value of the product. Foreign traders who come to Liberia in search of Griffonia are likely to meet with larger agents who will then send out information through subagents for collection. There are very limited women involved at this level of the chain for the exporting of products. There is need for the encouragement and involvement of more women through all levels of the value chain to support equity by providing opportunities for women to earn income and develop entrepreneurial skills.

Foreign traders often come from neighboring Guinea and Ivory Coast, while other sporadically from Ghana in search of Griffonia. The foreign traders meet the intermediators (agents and subagents) who then inform local collectors to collect seeds. Knowledge that large volumes could be collected in Liberia can facilitate regional and international trade and the development of this sector that could encourage international companies to invest in the purchase of the products and other NTFP in Liberia. Currently only three counties are noted to home this potential plant species (Nimba, Bassa, and Lofa Counties). Cultivation to other counties would also provide increased volume during its season, which could provide some income to local communities within the cultivated areas.

5.5.4 Transport

Transport of Griffonia is a major problem in the country. Liberia has a very poor road infrastructure, which has resulted in the domination of motorcycles in the transport sector costing more than twice the amount required to transport a particular over the same distance by truck or other transport cars. Griffonia is transported from one point to another using motorcycles in Liberia; while trucks are used to transport/export large volumes of aggregated seeds out to neighboring countries. Coupled with the poor road network, transport fares are high due to frequent breakdown of transport vehicles. The establishment of aggregation points in major communities with known high collection volumes of supply can be used so that trucks can haul large volumes from the aggregation point to reduce costs.

5.5.5 Distribution, marketing and consumption

Griffonia is harvested mainly there is an existing market demand, when and if local collectors are informed of upcoming purchase. Market price and volume demand is the main driver in the mobilization of collectors and the industry engagement. In most cases, during market demand, a driving force is the amount of product that can be harvested at one given site at a time. Therefore the mobilization of collectors and movement of products out of a community or area is ensured by effective and strategic campaigns.

5.5.6 Quality requirements

Quality assurance of Griffonia seeds is very important for providing information on the processing of the seeds and ensuring that the product meets buyer's expectation (Kim et al., 2009). Properly processed seeds are dark brown and the endosperm (visible when seeds are split) is bright yellow-green; seeds are whole and intact; contain low amount of foreign materials, if any (0.5% by wt.); and moisture content should not exceed 10%. Improperly dried seeds can become moldy which lowers the value of the final product. Before exporting of seeds, they should be checked for moisture level, as seeds can decay during transportation to industrial consumer. Seed moisture needs to be tested both during drying in order to identify when seeds have reached the appropriate moisture content level for bagging, and periodically during longer-term storage to ensure seeds have not absorbed moisture that could lead to mold and seed deterioration, hence, devaluing the product. Tools to measure seed moisture are available and easy to use.

5.5.7 Market outlook

Griffonia is largely traded on the international market, being exported to Asia (China) for the extraction of 5-HTP and later exported to the USA and Europe for final processing and refining of 5-HTP into dietary supplements. Ghana currently exports over 2,000 MT of Griffonia annually to Europe and Asian markets. An estimated 30 – 40% of this quantity is gathered from neighboring countries of Ivory Coast and Liberia for re-exporting. The estimated price for Griffonia range from $3 – 8 per kg for the past decade. A company that has registered interest in purchase of Liberian Griffonia is the Chinese company, BannerBio Nutraceuticals, Inc. The company processes 200 tons of seeds annually; international prices for Griffonia ranges from $5 - $5.50. Yet even if the prices/kg of NTFP received were lower and not higher, the NTFP comes as additional income with little to no input costs, suggesting an even high profitability at community and collector level.

5.6 Bush pepper: Value chain description

Bush pepper (*Piper guineense*) commonly known as West African Black pepper, Ashanti pepper, Guinea pepper, Bush pepper, or Guinea cubebs (Adjaye-Gbewonyo *et al.,* 2010) is a climbing perennial plant found throughout West Africa reaching up to 12 m high in forest areas and has protruding nodes and tight roots. Its flowers are white and small, producing fruits on short hanging spikes, with green berry-like fruits when unripe and red to dark red at maturity. Bush pepper, known as a spice, is used as a seasoning in food preparation to enhance food acceptability. This spice plant has great potential for commercialization as a unique and new spice for local, regional and international markets, being a mild and highly aromatic spice (Simon *et al.,* 2012).

5.6.1 Specific input supply

Many of the agro-forestry inputs that are needed for harvesting products such as Bush pepper from the wild can be purchased locally. These inputs include cutlasses, scales, sack/bags, sickles or curved serrated blades, and poles that are needed to ensure sustainable collection practices. No specific wearing is required for the harvesting.

5.6.2 Harvesting season and methods

The harvesting season of Bush pepper is from January-May (Table 5.10), often during the dry season and during off-farm season, as with many fruit-bearing NTFP, thereby ensuring food security and reducing poverty by providing cash flow to farmers as an alternative income generating activity (Juliani *et al.,* 2013); hence, the need for development of this product. The berries are easily seen when hanging from vines but sometimes far from reach, which can tempt collectors to either cut down the vines or cut down the tree that it is attached on to gain access to the fruits. This unsustainable and destructive harvesting practices can be mitigated by using poles with curved serrated blades to cut the pods hanging from the vines and then placed into a collecting bag or fall to the ground from where they are easily collected.

5.6.3 Actors

Local collectors are the main harvesters of the berries of Bush pepper, sometimes using unsustainable and destructive technique by cutting down tree that contain the vines just to reach the hanging berries. Processing include collecting, cleaning, grading, sorting, drying, and packaging. As drying is often done on floor and takes about 10 days to fully dry depending on weather, a preferred means is to dry on raised platform to prevent against sand and household animals from contaminating the fresh products. Packaging requires the practice of good hygiene especially during the process of sorting and bagging to prevent microbial contamination and ensure safe handling techniques.

Bush pepper is dried directly after harvesting and sold. The drying of Bush pepper is often done on bare floor without protection from rodents and mixture of unwanted particles that may contaminate the product. Drying takes 4 – 10 days depending on weather. To ensure physical quality standard, drying should be done on raised platforms and never on bare ground; while moisture content level not exceed 10%. At this level, the trade is mainly small scale, products are sold in either buckets, cups (equivalent to 1 kg). Sale per kg is about $3.00 to $5.00 depending on the traders and the level of moisture content. Hence, drying should be done by local collectors, as they are the first to receive the fresh product; fresh product has low price, while dry product has high price. Seeds can be sorted from the seed stem after drying to reduce contamination on fresh fruits.

All players in the value chain be trained in GACP including hygienic handling practices of products. There is need for improvement in the areas of harvesting and post-harvesting of the product and other products as well.

Subagents and agents are the players who are at the front of the purchasing and the aggregating of the product from the local collectors. They include traders, processors, wholesalers, and agents. Upon purchasing product from local collectors, these groups are involved in activities such as aggregating, sorting, grading, drying, cleaning, packing/packaging, storage, and transporting of product either to larger agents, or to other out-of-country traders who often come to purchase products. Bush pepper harvested from the communities are sold by collectors to the subagents who represent the agents/larger agents. Subagents mobilize local collectors for products on behalf of foreign traders and buyers from neighboring countries, such as Guinea, Ivory Coast, Mali, Senegal, and Ghana. Many subagents and agents indicated neighboring Ivory Coast as the main source of supply for the Liberian market, while the other countries were involved in small quantities, based on limited demand from those countries.

Products are brought to actual moisture content (<10%) by drying before sold to foreign traders. Drying takes between 4 and 10 days, or more, depending on the weather. The traders who in turn serve regional and international markets are also involved in packaging the dried products in large bags for export. There are few women involved in this aspect of collection and processing of product. There is need to encourage more women through all levels of the value chain to support equity by providing opportunities for women to earn income and develop entrepreneurial skills.

The processing of bush pepper and other spices presents some challenges during collection, drying, sorting, and bagging. Therefore it is important to follow good hygienic practices to prevent microbial contamination and to ensure safe handling techniques as a requirement is fully met. Collectors should wash hands when handling fresh fruits and to make sure fresh fruit not in contact with soil, earth or debris; packaging bags need to be clean and free of contaminants.

Larger agents are the main aggregators and exporters of the product. The larger agents are involved in further processes including making sure product is clean, and sorted out of other foreign matters; drying product to actual moisture level (<10%) that is a required standard, packaging, transporting, storing, and exporting.

The storage of Bush pepper is often done on bare floor where they are mixed with other products or where they may encounter house rodents that easily contaminate the products. Poor storage conditions are known to have significant impact on the quality of product. It is imperative to establish standards of quality control to ensure compliance with market requirements. An intervention such as storing in polypropylene sacks also known as ‘rice bags’ and keeping in warehouse before exporting can minimize deterioration and maintain quality of product; hence, the better value of the product.

There are very limited women involved at this level of the chain for the exporting of products. There is need for the encouragement of more women through all levels of the value chain to support equity by providing opportunities for women to earn income and develop entrepreneurial skills.

Foreign traders often come from neighboring Guinea and Ivory Coast, while other sporadically from Ghana, Mali, and Senegal in search of Bush pepper. The foreign traders meet the intermediators (agents and subagents) who then inform local collectors to collect seeds.

5.6.4 Transport

The challenges relating to the transport of Bush pepper are similar to that of Griffonia value chain. In addition, this product is often collected and transported from distances on motorcycles, incurring more cost on the transporter who does not have rights to include transport cost in price during sale. Transport to neighboring countries is very expensive and requires good planning.

5.6.5 Distribution, marketing and consumption

The market for Bush pepper is an all year process, as the product is popular and used in cuisine locally and in sub-regions. It is traded in small volumes, about 25 kg in polybags in various Liberian markets and also in much larger quantities by agents in neighboring countries, up to 1–2 tons, which suggests that both local and international markets can be expanded. Further, this spice can be introduced into cultivation and would be adaptable ecologically to fit well into the traditional polyculture crop enterprises, though no established cost of crop production from nursery onward known. However, as the spice with great commercial potential, additional quantities to meet market demands could be provided by wild indigenous growing populations and materials begun in local nursery and transplanted into community fields. Currently there exist no cultivation nor is there a history in the production of this high value crop in Liberia, while other West African countries are involved in the cultivation. There is a potential opportunity together with appropriate training and capacity building with a step to develop this plant species into cultivation and introduce seedling into natural habitat to grow and market harvested seeds.

5.6.6 Quality requirements

Sensory evaluation is one of the easiest methods to determine spice quality. Seeds should be whole and color of berries be black, or blackish brown; while whitish, greyish tints are often associated with poor drying conditions leading to mold. Harvesting seeds that have stayed long on the ground can also lead to discoloration and improper drying problems. Moldy and improperly dried seed products can accumulate high levels of aflatoxins, a condition that is not acceptable to international buyers. Fruits showing some levels of decay will have moldy aromas. The spices should contain low levels of foreign materials (<0.5%) including stems, stones, soil/dirt, non-plant debris, extraneous materials and botanical dust. The cleanliness of each NTFP is a prime initial quality factor. Therefore, the harvesting of fruits from above ground along with rapid and proper drying, improved cleanliness and dry conditions during storage can all mitigate against aflatoxins.

5.6.7 Market outlook

Bush pepper has a market both in the sub-region and internationally. Liberian Bush pepper already has a niche market in some foreign and West African markets. It is purchased locally by Fulani for the sub-regional market. Different spice companies have declared interest in volumes of Liberian Bush pepper for its unique aroma characteristics that distinguish it from other sources of Bush pepper. Total quantity demanded by these buyers average around 6 MT per year at $10 per kg in price. Currently neighboring Guinea and other West African countries purchase at similar price; though large volumes tend to have price drop to almost half, yet appreciable. A company in Nigeria registered interest to purchase large quantities from ASNAPP at competitive price.

5.7 Country spice: Value chain description

The value chain for Country spice is similar to that of Bush pepper, however with very few differences discussed below.

The product of Country spice is the dried seed of *Xylopia aethiopica* (Deshmukh *et al.,* 2009); known to flower twice annually (March–July and October–December), while fruiting occurs in December–March and June–September (Orwa *et al.,* 2009). The demand for Country spice has been known to be high in neighboring West African countries including Guinea, Mali, Côte d'Ivoire, and Senegal where it is used as spice for cooking (Deshmukh *et al.,* 2009). It is a tree that extends up to 20 m high or more, with a clear straight pole, to 75 cm circumference, often with short prop roots, smooth grey bark, scented when fresh; found in lowland rainforest, coastal brackish swamps and littoral formations, and deciduous and fringing forests of the Guinean savanna zones; often cultivated near villages (Burkhills, 1985) and often in protected forest (Burkhills, 1985; Deshmukh *et al.,* 2009).

Collectors are the main harvesters of the pod of Country spice, sometimes using unsustainable and destructive technique by cutting down the tree just to reach the pods. A sustainable harvesting in a nondestructive manner can be done by using poles with curved serrated blades attached to harvest the pods from the branches that would easily fall to the ground for collection.

The markets for Country spice are a year round process and traded in small volumes, about 25 kg in polybags in various Liberian markets and also in much larger quantities by agents in neighboring countries of Guinea, Ivory Coast, Senegal, and Mali, about 1-2 containers load (20ft), which suggests that both local and international markets can be expanded. Further, the plant can be introduced into cultivation and be adaptable ecologically in agroforestry. As this spice can be commercially produced, additional quantities needed by the market could be provided both by wild indigenous growing populations and cultivated population that can be transplanted in local community fields.

Price of a sack of 30kg of dried Country spice is in the range of $9-$11, or a total of $0.333 per kg. A trader in Gbarnga, however, noted in general that dried Country spice is purchased at $0.5 per kg, which would suggest there is possibly some room for price negotiation at the producer level.

There are no needed inputs for Country, other than machetes and boots, and a good management of sustainable harvesting practice required. With difficulty in harvesting the fruits due to the tallness of trees, producers tend to exhibit unsustainable harvesting practice by cutting down the tree in order to harvest fruits. Further, producers lack business skill and have low market information necessary to increase their profitability.

5.8 Conclusion

The study gathered information on the value chain analysis of Liberian NTFP from 25 communities in six Counties within Liberia, from both males (81.4%) and females (18.6%). Among these, the age group of 50 years and above were the majority of participants; while majority of the participants had at least up to high school level of education. Education plays a key role in value chain component of any commodity, especially NTFP commercialization.

The value chain of NTFP is important in providing the knowledge in the underlying factors and income generation across the domestic NTFP value chain. The value chain analysis has allowed the selection of three potential NTFP including Griffonia, Xylopia, and Piper with great commercial value. The selected NTFP have socio-economic and commercial potential for local, regional, and international markets; their development can contribute to rural household annual income, thereby contributing to poverty alleviation and the promotion of forest biodiversity conservation in Liberia. This study adds to previous knowledge of the value chain for selected NTFP commercialization achievements, with actors, routes and prospects of NTFP commercialization identified. We conclude that these value chains can be strengthened and that NTFP can present unique high value income generating opportunities to those Liberians residing in the forest for which they have few other alternative opportunities except to focus on palm oil and other commodity crops which generate income. Yet for collectors and rural communities that collection and trade of NTFP need not compete with or inhibit the development of additional income generating activities.

6 Chapter VI: Resource Inventory of *Griffonia simplicifolia* in Liberia: A Case Study in the Lepula Community Forest in Nimba County

6.1 Introduction

Medicinal plants are among the most essential and recognized NTFPs, with about 80% of the populations in most developing countries dependent on traditional medicines derived from plants for treating human diseases (de Silva, 1997). Whether this actual relative percentage is accurate or not, certainly it reflects a significant and important contribution to the health and well-being in sub-Sahara Africa and is aligned with the cultural belief systems. In Liberia, Juliani *et al.* (2013) listed 48% of the 51 commonly reported NTFP as serving at least in part for their medicinal applications plants. Kpadehyea *et al.* (2015) also reported the importance of medicinal plant use in the lives of the local people at Wonegizi, Ziama Clan, and listed 101 plants of medicinal potential. In Ghana, the medicinal export earnings in 2000 was US $5 million and rose to more than US$15 million in 2008, 80% of which was derived from Griffonia and Voacanga exports (Arthur, 2010).

Many studies have concentrated on the local, regional and international economic significance, and over-exploitation of medicinal plants (Schippmann, 1997; Soehartono and Newton, 2001; Shahabuddin and Prasad, 2004). However, only limited focus has been directed on the natural conservation and management requirements of medicinal plant collections, especially within the broader regional, ecological, cultural and economic perspectives. A significant issue, therefore, is the extent to which ecological surveys (resource inventory) can reliably inform decisions concerning the potential for sustainable harvest and management of target species, including identifying needs for further targeted autecological population studies (Russell-Smith, 2006).

Ecological survey is essential to the conservation status assessment of wild populations, and as the fundamentals for addressing harvesting sustainability of major or target species (Hall and Bawa, 1993). Again, the availability of case studies is lacking, despite useful guides for the broad inventories of medicinals and other NTFP undertakings and broad general recommendations (e.g. Hall and Bawa, 1993; Peters, 1996; Cunningham, 2001).

Griffonia simplicifolia (M. Vahl ex DC.) Baill. is a firm woody vine, or climbing shrub that grows approximately three meters in length as a shrub (Brendler *et al.,* 2010), or up to 10 20 m as a climber/liana as it attaches to trees reaching varying heights (Kim *et al.,* 2009). The shrub thrives the Guinean forest in the countries of Ivory Coast, Ghana and Liberia (Kim *et al.,* 2009), mainly abundant in Ghana and Liberia (Juliani *et al.,* 2013). Being a very hardy and adaptive plant with the ability to withstand a variety of climatic conditions, has been found growing in coastal areas with high moisture, sunlight and wind, or in forest areas with high moisture and shade (Acquaye, 1997).

Griffonia is noted for its traditional medicinal uses, including treatments of kidney disorders, skin injuries and ulcerations, syphilitic sores, cough, constipation, vomiting, sickle cell disease, and eye inflammation, as well as an aphrodisiac (den Boer and Westenberg, 1990; Larmie and Poston, 1991; Neuwinger, 2000; Brendler *et al.,* 2010; Kumar *et al.,* 2010).

In recent decades Griffonia has attracted international commercial interests, with its seeds containing an unusually high amount of an uncommon amino acid known as 5-hydroxytryptophan (5-HTP) (Lemaire and Adosraku, 2002). This biochemical compound is widely sought after as a natural treatment for conditions involving an imbalance of serotonin such as depression (Loftis and Turner, 2010), insomnia (Kim *et al.,* 2009; Attele *et al.,* 2000), insatiable appetite (Del Corral and Pacak, 2005; Halford *et al.,* 2007; Carnevale *et al.,* 2011), fibromyalgia (Birdsall, 1998), as well as migraine and headache (Bono *et al.,* 1984; Birdsall, 1998). Other alkaloids such as trigonelline (a non-toxic metabolite of vitamin B3), 5-hydroxy-3-(2- hydroxyethyl) indole, 5-hydroxyindole-3-carboxaldehyde, hyrtiosulawesine, hyrtioerectine B, 3- carboxy-6-hydroxy-β-carboline, griffonine (Wang *et al.,* 2013), indole-3-acetyl aspartic acid, and 5'-hydroxyindole-3-acetic acid (Fellow and Bell, 1970) have been found in the seeds in much lower amounts (Giurleo, 2017 –*unpublished*). Trigonelline compound may be used to treat type-2 diabetes (Lang *et al.,* 2013) and nervous system diseases (Zhou *et al.,* 2012).

In Liberia, Griffonia seeds are harvested from the wild in forest areas for commercialization (Juliani *et al.,* 2013). The commercial trade of this medicinal plant gained momentum when the Land Rights and Community Forestry Project (LRCFP) of Liberia in collaboration with its partners, ASNAPP-Ghana and Rutgers University, established a pilot study with awareness and sensitization campaigns on the economic importance of Griffonia. This awareness led to the mobilization of seeds that generated over US$80,000 in revenues for beneficiary communities between 2010 and 2012 (Juliani *et al.,* 2013), ensuring an economic potential commodity. While this is a positive intervention for the promotion of forest resources to contribute to local economy, harvesting of fruits and seeds, though not immediately harmful, can affect the future regeneration of a species (Hall and Bawa 1993; Sunderland *et al.,* 2011; Ticktin, 2004). Apart from unsustainable harvesting practices such as cutting and pulling of vines for the collection of pods of Griffonia that have been noted (Juliani *et al.,* 2013), there is no report on the collection patterns and habits of local collectors in regards to seeds collection from forest floor. There are no studies that provide any evidence that the current collecting techniques have led to population loss, loss of biodiversity, damage and loss to non-Griffonia species, or an increase to the ecological systems. However, it can be hypothesized that (1) should the demand for collection significantly increase, there would be an increased pressure on the indigenous population and surrounding plant species; and that

(2) the awareness of sustainable production practices that do not decrease the collectors' income should be easily adopted particularly when linked to future and sustained income opportunities. The awareness that led to the massive mobilization of Griffonia seeds collection (Juliani *et al.,* 2013) did not consider threat to future regeneration of plant species from fruit harvests. Sunderland *et al.* (2011) have reported that harvesting can be considered sustainable at the species level if there is no long-term deleterious effect on the reproduction and regeneration of the plant populations being harvested. Griffonia seeds harvesting for local, regional and international trade is still an ongoing process in Liberia, with local traders, as well as traders from neighboring countries such as Ivory Coast and Guinea who purchase to aggregate for export to international markets (Juliani *et al.,* 2013).

However, coupled with the unsustainable harvesting of Griffonia and other NTFP (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013) due to market demands and extended use (Manvell, 2011; Kpadehyea *et al.,* 2015) many community forests are threatened by the continual rise of illegal logging and trade, both on large-scale and on small-scale (pit-sawing, distorted timber markets) (Bickel and Cerutti, 2017). Forest cover area has declined from deforestation and conversion to agricultural farmland and plantation (Lomax, 2008; Bickel and Cerutti, 2017). Equally so is the rapidly growing Liberian population over the years, from 3 million in 2000 to 4.3 million at 2.44% population growth rate in 2016 (CIA, 2016). Furthermore, there has been no single record selected NTFP population in Liberia, making it more difficult for policy decision makers to address some of the issues relating to sustainability and biodiversity conservation.

The best management approach with regards to the promotion of trade in medicinal plants for sustainable management and biodiversity conservation requires the necessary information not only on the existing trade, and uses, but also on the ecology, population structure, and harvesting techniques of the species involved (van Andel *et al.,* 2012). Hall and Bawa (1993) noted the undertaking of ecological surveys that concentrate on the distribution, abundance and population structures of medicinal plants is fundamental to the assessment of the conservation status of wild populations, and prerequisite for addressing harvesting sustainability of key or target species; hence, the main objective of this study is to provide comprehensive information about the state and dynamics of Griffonia for strategic and management planning. The specific objectives of this study were, 1) to investigate the population density of new seedling growths of Griffonia using quadrat, 2) to examine the distribution of seedlings using transect, to compare population density and distribution of seedlings in forest area to that of plantation area, 3) to examine number of mature plants per tree, to measure the number of seeds per pod of Griffonia, and 4) to estimate average number of seedlings per hectare.

6.2 Materials and methods

6.2.1 Study site

The Zor Lepula Community forest was used to conduct forest inventory studies on Griffonia from November 2016 to February 2017. Zor Lepula Community is found within the Zor Clan in Nimba County, Liberia, with the forest area coordinates of N 07°19.863' and W 008°30.504'. The community forest was selected based on the richness and abundance of Griffonia found in the forest, and also the willingness and acceptance of the community leaders and members to allow a portion of their forest to be used for the research project. Though few community forests were earmarked for selection, only the people of Zor Lepula Community accepted the request to use portion of their forest for research project. This was after a group discussion and agreement with the community leaders including youth leader, men's leader, women's leader, and as well as the elders and town chief, together with majority of the community members to allow the use of their forest for research project. Upon agreement, the forest, which is mainly owned and managed by the town chief, was demarcated and selected portion for the research work was barbwire fenced to restrict access into project area for unwanted activities by community and non-community members. Community members also expressed willingness to assist during any intervention and activities that would require extra manpower. This was a way to also show them the process of forest inventory for specific plant species; eight to ten community members who volunteered and actively participated in the process that lasted for the two months. Along with a RTI EHELD contract faculty from Ethiopia at the College of Agriculture and Sustainable Development (CASD) in Cuttington University who supervised the field inventory are Dr. Getachew Eshete (Professor), Brother Nathaniel, Steve Toungar, Martha Sarmie, Darius Dahn, Mercy Miagbah, Emmanuel Dahn, Mitchell Kpakata, Martin Gaye, Darcious Tomah, and Hawa Vivian Viagoly. The discussion for the selection and approval of the forest area as research was done in 2015 and required more than 12 months of sensitization and discussions. Forest area had been set aside for research purpose since the approval from community leaders and members. Monitoring of research forest area had been sporadic for any sign of changes whatsoever; no sign of any change has been noted, or not to the observance of the investigator.

Plantation site, a cocoa plantation that is grown just adjacent the research forest area, was used to compare number of Griffonia seedlings found growing within the plantation site to that found growing in the forest area.

Figure 6.1: (A) Dr. Getachew Eshete accompanies one of volunteered community members along transect line in the forest; (B) Principal Investigator awaits number of counted vines near a tree from community volunteers; (C) Lepula community members who volunteered to help in the forest inventory on Griffonia; (D) One local community member is throwing the quadrat along the transect

6.2.2 Methods

The following procedures were followed for field seedling population sampling within the Zor Lepula Community forest:

A GPSMAP 64s GARMIN system instrument was used to delineate the boundaries of the study site, providing the actual forest area (4197.3 m^3, or 0.42 ha) and the coordinates (N 07°19916' and W 008°30.480') along with the distance (286 m).

Transect lines were laid out first by measuring one side of the forest from foot path entrance (the total length of the side from entrance was 83.27m. This distance was divided by four to layout the transect lines. Hence, five transect lines were fixed (three in the middle and two along the boundaries). Each transect was demarcated with Lufkin FE300/1709 Fiberglass Long Measuring Tape, 300ft x 1/2".The farmers helped to cut the lines with cutlass to connect the boundaries from the entrance side to the other side of the forest (boundary of selected forest coordinates: N 07°19.863' and W 008°30.504', distance: 72.1m).

Five (5) quadrats (quadrat measurement: 1 m x 1 m) were placed along each of the transect lines starting at random point. The random point was selected using random number generator and multiplying the random number with the quotient of the length of the transect line and the number of plots; in this case five plots. The quadrats along the line were then placed by adding the distance that was determined by dividing the transect line length with the number of pre-determined plots, the quotient, to the random point, and then adding quotient to subsequent random point up to five random points for five quadrats. The quadrats were then placed by just throwing from the random point to the right side of the transect line from the initial foot path entrance except on the first transect which was on the left side. In each quadrat seedlings of

Griffonia spp. of any size were counted and recorded. Each sample mean was multiplied by 10000 to change to per hectare.

For the estimation of the seedling population, the following formula was used:

To determine the mean use this formula: $\bar{x} = \sum_{i=1}^{n} \frac{x_i}{n}$

To determine the standard deviation you use: $s^2 = \frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{n-1}$

To determine the standard error: $SE = \sqrt{\frac{s^2}{n}}$

Reporting the result is given by: $\bar{x} \pm SE$

Where $\bar{x}$ is the population mean; n is the number of elements in the sample; x_i is the ith element from the sample; S^2 is the standard deviation; SE is the standard error.

To assess the number of Griffonia vines growing near a tree (forest tree) as a supporter to climb upon, transect lines already layout by community members (farmers) during field seedling population sampling were used. Transect lines within the forest were used; a total of four transect lines out of five were selected for use; the 5th line on edge of the forest, had no tree; rather, was a demarcation between the forest and the plantation area. Five trees were randomly selected along each transect and number of plants were counted per tree. A total of 20 trees were selected for the four plot areas (transect lines).

Two transect lines were measured in plantation area just adjacent research forest site to compare seedling population with forest population. The plantation area is that part of the land area that is used by the community for the cultivation of cocoa; hence, the cocoa plantation site, or plantation area/site.

Same procedure for transect line layout in step 2 was used for plantation transect. The total length from the edge of the forest area into the plantation site was 24 m. This distance was divided by two to layout the transect lines. Hence, 3 transect lines were fixed (one in the middle and two along the boundaries). The transect line along the forest demarcating the forest from the plantation was not used; only the two lines that fell within the plantation were used.

Five (5) quadrats were placed along each of the two transect lines starting at random point, and subsequent random point by adding quotient, up to five random points for five quadrats. The quadrats were placed by just throwing from the random point to the right side of the transect line from the demarcating line, the forest edge. Seedlings of *Griffonia spp.* of any size were counted and recorded in each quadrat.

Ten (10) pods of Griffonia in duplicate were collected from five plots in the research forest area for seeds count analysis. Seeds were counted per pod and average value from the replicate recorded. The total mean were also recorded.

The study used simple random sampling for the sampling method. All data was subjected to Excel worksheet for data analysis using Descriptive Analysis.

6.3 Results and discussion

Five transect measurements were used to determine the seedlings distributed in the forest area; while the quadrat determined the population density of within a plot. A total of 25 quadrats were randomly selected as plots and used to determine the population density of Griffonia in the entire forest area, with 5 plots within each block, or transect. The average number of seedlings per plot within each block or transect was 14.72 (Table 6.1). This indicates that in every 1 m^2 area, there was at least 14.72 seedlings of Griffonia found.

The number of seedlings estimated per hectare showed Griffonia seedlings ranging from about 90,000 up to about 200,000 per transect, with a total mean of more than 140,000 seedlings (Table 6.2). This entails the abundance of Griffonia seedlings found in a hectare of forest area. Moreover, providing a 95% confidence level gives us the following mean of 147200 ± 31583.3. Thus, we are 95% confident that the average number of seedlings per hectare of forest area is between 115,616.7 and 178,783.3 (Table 6.2).

Table 6.1: Numbers of Griffonia seedlings (*Griffonia simplicifolia*) in transect areas in the Zor Lepula Community forest

Transect	Mean
Transect -1	15.4 ± 2.4
Transect -2	9.2 ± 2.8
Transect-3	22.6 ± 4.1
Transect-4	10 ± 2.3
Transect-5	16.4 ± 2.3
Total Mean	**14.7 ± 1.5**

(Mean ± standard error)

Seedlings were also counted in plantation area to compare number of seedlings with that of the number found in forest area. Total mean recorded slight higher seedlings number (22.2±4.9) per meter square in plantation site (Table 6.4) than total mean recorded in forest area (14.7±1.5) (Table 6.1). Also estimated number of seedlings per hectare in plantation site was slightly higher (222,000 ± 49075.9) (Table 6.3) than the estimated number of seedlings per hectare in forest area (147200 ± 15302.7) (Table 6.2). Given the degree of confidence, we are 95% confident that the average number of seedlings found per hectare in the plantation site is between 110982.6 and 333017.4 (Table 6.3). Though the bottom range may be slightly lower for the plantation than the bottom for the forest area, the top range for the plantation site shows more than 60 percent estimated number of seedlings compared to only about 35 percent, when the two are totaled.

Collection practices whereby collectors tend to collect nearly all seeds from forest floor normally renders a decrease in future regeneration of a plant species (Hall and Bawa, 1993; Ticktin, 2004), while the opposite is true. Collectors have been mainly engaged in collection of seeds from main forest areas, with less attention in plantation area, though the dehiscing or ‘popping’ of pods often causes distant dispersal of seeds. We are confident that the little to no collection pattern at plantation site caused the recorded number of seedlings found within that site compared to that of the forest area. Also, harvesting of Griffonia especially within the research selected forest area has been reduced during the past two years of approval of forest area for research purpose. This may account for the recorded number of seedlings found within the forest area as well. Hence, supporting future regeneration process through collection requires the maximum collection of seeds but letting some to remain and sprout for future supplying generation. This initiative support Sunderland *et al.* (2011), in their report stating that harvesting can be considered sustainable at the species level if there is no long-term deleterious effect on the reproduction and regeneration of the plant populations being harvested.

Table 6.2: Estimated mean of Griffonia seedling (*Griffonia simplicifolia*) numbers per hectare in transect

Transect	Mean
Transect -1	154000 ± 24413.1
Transect -2	92000 ± 27820.9
Transect-3	226000 ± 40816.7
Transect-4	100000 ± 22583.2
Transect-5	164000 ± 22934.7
Total Mean	**147200 ± 15302.7**
Confidence Level (95%)	**31583.2**

(Mean ± standard error)

The denseness and closed/thick overhead canopies that were seen within the forest trees provide a means to collect majority of the sunlight allowing only sparing amount to reach the forest floor especially during shifting of trees due to wind. However, given the adaptable capabilities of Griffonia to various environmental conditions have enabled even the young seedlings to survive with little amount of sunlight. This confirms studies by Acquare (1997) that Griffonia being an adaptive plant has the ability to withstand a variety of climatic conditions including sunlight and wind, or high moisture and shade in forest areas. We however did not have light meters and thus could not take quantitative light penetration readings under all environments and treatments which would have allowed us to do.

Griffonia is noted for possessing a characteristics of a liana plant that climbs up to about 20 m depending on the canopy of tree it attaches on to compete for sunlight (Kim *et al.,* 2009). Matured vines of Griffonia were assessed and counted on a total of 20 trees within the research forest area. Mean number of Griffonia vines growing near trees was recorded (15.3 ± 2.5); with the degree of confidence, we can be 95% sure that the number of Griffonia plants growing near various trees within the forest area is between 10.1 and 20.4 (Table 6.4). This also shows how the forest is densely populated with Griffonia, both seedlings (Table 6.1) and mature vines (Table 6.5).

Table 6.3: Number of Griffonia (*Griffonia simplicifolia*) seedlings per square meter and per hectare in two transects within a plantation area and the confidence level (95%) per hectare

Transect	Mean (sq. m)	Mean (ha)
Transect-1	26 ± 9.6	260000 ± 95864.5
Transect-2	18.4 ± 3.0	184000 ± 30430.3
Total Mean	**22.2 ± 5.0**	**222,000 ± 49075.9**
St. Dev.	15.5	155191.6
Confidence Level (95.0%)		111017.4

(Mean ± standard error)

Table 6.4: Number of Griffonia (*Griffonia simplicifolia*) plants growing near twenty trees in forest area, showing the mean of Griffonia vines per tree and the confidence level (95%)

Mean	Confidence Level (95%)
15.3 ± 2.5	5.2

(Mean ± standard error)

Seeds of Griffonia were counted from 10 pods collected from five plot areas within the research forest, plot in duplicate, to determine the number of seeds generally found in a pod. Result showed all five plot areas having similar average seed counts (3.0) from pods collected (Table 6.5), which indicates that pods of Griffonia would normally contain on average 3 seeds per pod.

Table 6.5: Number of seeds per pod of Griffonia (*Griffonia simplicifolia*) from five plots (P 1-5) from research forest

	P-1	P-2	P-3	P-4	P-5	Mean
Seeds	3.0	3.0	3.0	3.1	3.0	3.0 ± 0.03

(Mean ± standard error)

6.4 Conclusion

The study has shown that seedlings are abundant and highly distributed throughout the forest area per hectare, with high population density.

This study showed that Griffonia seedling were abundant in a hectare of forest area, with an estimated mean of 140,000 seedlings in a range of 90,000 to 200,000 per transect. We are 95% confident that the average number of seedlings per hectare of forest area is between 115,616.7 and 178,783.3. Also seedlings of Griffonia found in plantation area was abundant, with estimated number per hectare in forest area of 147,200±15302.7. A 95% degree of confidence showed estimated number of seedlings in a hectare of forest area between 110982.6 and 333017.4. The high estimated number of seedlings found within the plantation area suggests harvesting pattern whereby some seeds are left for future regeneration of the resource population. Also their growth in the plantation area show how Griffonia behaves as a shrub when there is no tree to climb on, but exhibits the characteristics as a climber when growing near support tree.

Given the high number of Griffonia seedlings found in the forest and plantation areas, and the number or vines growing on various trees within the forest, there is a need for management and strategic planning such that collectors would leave some fruits and seeds uncollected for natural regeneration of the plant species as the potential future supplying generation. Regeneration of plant species is ensured by a behavior pattern of collection whereby some seeds are left uncollected for sprouting for regeneration process. Possessing the characteristics of a liana, Griffonia is often seen growing near trees and climbing to heights depending on height of tree in competition for sunlight. The study recorded mean of 15.3±2.5 Griffonia vines growing near a tree within the forest area. Mean seeds count in pods of Griffonia was 3 per pod.

The study has provided reliable information to help decision makers concerning the potential for sustainable development and management of medicinal plants especially *Griffonia simplicifolia*. This can also be used as a case study for addressing harvesting sustainability of major potential NTFPs.

7 Chapter VII: Enhancing Germination for Forest Enrichment Planting of *Griffonia simplicifolia*

7.1 Introduction

Griffonia simplicifolia M. Vahl ex DC. Baill. (Bosch, 2008) is a medicinal plant that has gained worldwide recognition for its high levels of the bioactive compound 5-hydroxytryptophan (5-HTP), a natural serotonin precursor found abundant in its seeds (Birdsall, 1998; Bagdy *et al.,* 2000; Kumar *et al.,* 2010; Carnevale *et al.,* 2011). Griffonia, found in the Guinean rainforest in West and part of Central Africa, is abundant in Ghana, Liberia, and part of the Ivory Coast (Deshmukh *et al.,* 2009). Being a very hardy and adaptive plant with the ability to withstand a variety of climatic conditions, it is found growing in coastal areas with high moisture, sunlight and wind, or in forest areas with high moisture and shade (Acquaye, 1997). In the coastal plains, Griffonia grows as a shrub to height of about two to three meters (Brendler *et al.,* 2010), while in the forest areas it takes the form of liana/climber vine to about 5 – 20 meters depending on the canopy and surrounding forest trees (Irvine, 1961; PORSPI, 1992; Kim *et al.,* 2009).

The bioactive compound 5-HTP which is the precursor of the neurotransmitter serotonin that naturally occurs at 5–20% in the seeds of Griffonia (Lemaire and Adosraku, 2002; Eriksson *et al.,* 2006; Giurleo, 2017) is scientifically known to be used in the treatments of various conditions. These include anxiety and depression (Byerley et al., 1987; Van Praag. 1996; Cauffield and Forbes, 1999; Loftis and Turner, 2010), insomnia (Attele *et al.,* 2000), migraine and headache (Bono *et al.,* 1984; Birdsall, 1998), fibromyalgia (Nicolodi and Sicuteri 1996; Caruso *et al.,* 1990; Birdsall, 1998), aphrodisiac effects (Wolf *et al.,* 1998; Frohlich and Meston, 2000; Uphouse, 2000), as well as an appetite suppressant or weight loss agent (Cangiano *et al.,* 1992; Halford *et al.,* 2007; Carnevale *et al.,* 2011; Rondanelli *et al.,* 2012).

Traditionally, Griffonia simplicifolia is known to treat a variety of illnesses (den Boer *et al.,* 1990; Maissen and Ludin, 1991; Kim *et al.,* 2010). The leaves have been known to treat kidney disorders, skin injuries, cough (Brendler *et al.,* 2010), and used in chicken pens to eliminate bird lice (Pathak et al., 2010); the bark is used to treat skin ulcerations and syphilitic sores (Brendler *et al.,* 2010); the leaves and twigs extracts used to treat constipation, vomiting, as well as an aphrodisiac to increase stamina and sexual desire and as an antiseptic wash for wounds (Neuwinger, 2000; Brendler *et al.,* 2010). The roots and leaves also used in the treatment of sickle cell disease (Larmie and Poston, 1991). The leaf sap used as eye drops for treatment of eye inflammation (Kumar *et al.,* 2010); paste of leaves applied to burns (den Boer *et al.,* 1990).

The potential of Griffonia and other medicinal plants for the economic growth and development of local communities as well as economic support to national governments cannot be overstated. In Liberia, the Land Rights and Community Forestry Project (LRCFP) of Liberia in collaboration with its partners including ASNAPP and Rutgers University established a pilot study with Griffonia. This that led to the mobilization of more than 8,000 kg of Griffonia seeds from the wild in Nimba County that generated over US$80,000 in revenues for beneficiary communities between 2010 and 2012 (Juliani *et al.,* 2013). While in Ghana the medicinal plant export earnings rose from US$5 million in 2000 to more than US$15 million in 2008, with 80% derived from Griffonia and Voacanga exports (Arthur, 2010).

Knowledge about the economic and medicinal importance of Griffonia to enhancing rural livelihood sustenance as well as health needs of users make this medical plant a promising NTFP with regional and international commercial potential. However, considering the outstanding threats and the complications involved in the collection of medicinal plants from the forest and the challenges therein (Hamilton, 1992; Singh *et al.,* 2003; Ahenkan and Boon, 2008) necessitate their cultivation.

Outstanding threats with medicinal plants include population decline, endangerment or extinction of species (Koroch *et al.,* 1997; Prasad, 2009) from over-exploitation due to increasing demands (FAO, 1997; Bodeker, 1997; Singh *et al.,* 2003; Ahenkan and Boon, 2008) for pharmaceuticals, phytochemicals, nutraceuticals, dietary supplements, cosmetics and other products. Others include habitat modification due to urbanization (Joshi and Joshi, 2000; Tabuti *et al.,* 2003), deforestation from timber logging and agriculture (Ahenkan and Boon, 2008; Juliani *et al.,* 2011a), changes in traditional patterns of harvests resulting to unsustainable rates of exploitation, and overgrazing (Bodeker, 1997; Schippmann *et al.,* 2003; Wiersum *et al.,* 2006). Also the rapidly growing human population leading to increase in human activities such as commercial agriculture and human disturbance (Ahenkan and Boon, 2008; Prasad, 2009), and, as in the case of *Griffonia simplicifolia* in Liberia, the limitation of some group of medicinal plants in a particular region (Leakey and Izac, 1996) may lead to these plant species facing threat of population decline and eventually extinction (Koroch *et al.,* 1997; Prasad, 2009). This paper identified only three out of fifteen counties in Liberia (Nimba, Bassa, and Lofa Counties) (*Chapter 2,* Table 2.4) as home of Griffonia. Cultivation ensures increased productivity to meet growing demands and the mitigation of rising threats of the plant, in addition to sustainable harvest and changes in collection patterns of harvesters (Franz, 1993; Amujoyegbe *et al.,* 2012).

Reports have shown that though protection of medicinal plants could be achieved through regulation and introduction of sustainable methods of wild harvesting, cultivation is seen as an option that could both reduce pressure on wild populations and solve some of the basic problems in the production of herbal medicines (Canter *et al.,* 2005). These basic problems include uniform and high quality raw material compared to the wildly collected (Juliani *et al.,* 2011a; Amujoyegbe *et al.,* 2012); yield optimization and control of plant in every stage of the production process (Amujoyegbe *et al.,* 2012); the adjustment of biological concentrations of important compounds through the manipulation of growing environments, traditional selective breeding methods, and through the application of modern biotechnology (Amujoyegbe *et al.,* 2012), and means for genetic preservation and conservation of plant species (Franz, 1993).

Very limited if not lack of information about cultivation of Griffonia is known, with no known record of cultivation for the effective replacement of old and cut vines especially from practices of unsustainable harvesting in Liberia (Juliani *et al.,* 2013). This may be due to a number of factors, including non-existing effective propagation technique, limited research consideration devoted to the plant, the general lack of knowledge on the economic value of the product. Other includes the lack of knowledge of adverse consequences on self-propagated plants in the wild from unsustainable harvesting, which among other things have led to effortless cultivation of many NTFPs including medicinal plants.

No studies have been conducted on germination of *Griffonia simplicifolia* (Fabaceae) either vegetative or through seed propagation. However, studies have been conducted on various legume plants (Fabaceae), investigating various germination processes involving seed dormancy and germination (Baskin and Baskin, 1998; Dickie and Pritchard, 2002; Hartmann *et al.,* 2002; Ehiagbonare and Onyibe, 2008; Tsobeng *et al.,* 2013), though none on Griffonia.

Information on seed dormancy and the control of germination timing is an important part of understanding how a species is adapted to its habitat. In other words, seed dormancy-break and timing of germination are important components of plant life history strategies, as they may help to control the distribution and abundance of a plant species (Rees, 1997; Handley and Davy, 2005).

Tsobeng *et al.* (2013) had noted that seeds of many plants in the Family Fabaceae are characterized by seed coat dormancy, and that they need pretreatment to allow and initiate germination. Effect of temperature on seed germination and seedling radicle length, and on the effects of soaking seeds in tap water had been studied for Fabaceae plants (Anegbeh *et al.,* 2006; Ehiagbonare and Onyibe, 2008; Tsobeng *et al.,* 2013). No information on seed dormancy and germination is available for Griffonia. This study draws upon others for suitable seed germination of *Griffonia simplicifolia* for a baseline local community application without sophistication of instrument and materials for germination process.

The primary goal of this study was to investigate the germination biology using simple tools for the germination of Griffonia seeds. The specific objectives were (i) to accelerate the rate of seeds germination through seed dormancy-break; (ii) to assess the time course for seeds potency; (iii) to investigate optimum conditions for seed germination to improve the percentage of total germination; (iv) to introduce seedlings into natural habitat using an enrichment planting scheme; and (v) to monitor survival and assess the growth rates of introduced plant seedlings in natural habitat.

7.2 Materials and methods

7.2.1 Seeds germination trials

All seeds of Griffonia were collected from Nimba County in Liberia for germination trials. Seeds were obtained one to two days upon collection from forest floor, indicating matured and potential for germination.

Triplicates of 50 seeds were soaked in water at three temperature levels for 8 hours each, 10°C (Treatment-A, Trt-A), 25°C (Treatment-B, Trt-B), and 40°C (Treatment-C, Trt-C). Seeds in Treatment-A were placed in refrigerator to maintain constant temperature; Treatment-B seeds were placed in oven, oven#1 preset to 25°C, to maintain constant temperature; Treatment-C seeds were placed in oven, oven#2 preset to 40°C, to maintain constant temperature. Temperatures 25°C and 40°C were used to determine effect of heat on seed germination, since the seed is from a tropical plant. After 8 hours of soaking, seeds were planted in polybags for germination testing.

Triplicates of 50 seeds were planted at various time courses (TC) to determine the viability of seeds for germination. Upon receiving seeds, TC-1 seeds were planted in 2 days; TC-2 seeds were planted in 13 days (2 weeks); TC-3 seeds were planted in 17 days; TC-4 seeds were planted in 20 days (3 weeks); TC-5 seeds were planted in 30 days (1 month); TC-6 seeds were planted in 60 days (2 months); and TC-7 seeds were planted 1 year after obtaining seeds. All TC seeds were planted in polybags for germination trials.

Two substrates and different soaking time frequencies of Griffonia seeds were used to assess optimum conditions for seed germination in order to improve percentage of total germination. The substrates included the sandy loamy soil (media 1) and the fine sandy soil (media 2). Both substrates were analyzed at the CASD Plant and Soil Science (PSS) laboratory for their distinctive characteristics. Substrate with approximately 60 percent sand, 10 percent clay and 30 percent silt particles was considered sandy loamy soil and used as media 1. Soil type with less than 20 percent silt and clay and containing large particles of 0.1 – 2.5mm size was considered fine sandy soil and used as media 2. Triplicates of 150 seeds were soaked at different time frequencies and planted in polybags containing the soil media types. Seeds were soaked for 24 hours (Trt-24hrs), 48 hours (Trt-48hrs), and non-soaked seeds (Control). Seeds were then planted in soil media for germination trials. The control seeds experiment was repeated using the two substrates to improve percentage of total germination.

7.2.2 Transplanting and growth rate trials

Griffonia seedlings were transferred to three localities for introduction into natural habitat as part of an enrichment planting scheme. Survival percentage of seedlings were recorded from each locality. The three localities included the Gokai community forest, the Raymond Town community forest, and the Cuttington University (CU) Ecological forest. At the two communities, distribution of seedlings was based on number of households involved in NTFP activities, with each household receiving 50 polybags of Griffonia seedlings. 700 polybags of Griffonia seedlings were distributed to the Gokai community to 14 households; 850 polybags of seedlings were distributed to the Balamah community to 17 household. 450 polybag seedlings of Griffonia were distributed in 10 plots, at 45 seedlings per plot, at the CU Ecological forest. Plot sizes were 20m x 10m, with seedlings planting spaced at 2 m each. Survival percentage was determined by count of survived seedlings in the three localities; result expressed as percentage.

Growth rates of transplanted seedlings were then assessed by physical measurement of seedling heights and observational counts of leaves at 4 different time intervals from day one after transplant into natural habitats to day 100. Days included Day-1, Day-30, Day-70, and Day-100. 100 Griffonia seedlings were randomly selected at each of the three sites for growth rate analyses. Results recorded as mean from measurement of 100 plant seedling heights (units in centimeter – cm), and mean number of new leaves counted from 100 plant seedlings.

The experimental design was fully randomized. Data were recorded in excel worksheet and analyzed statistically by analysis of variance (ANOVA), with the level of significance set at $p = 0.05$.

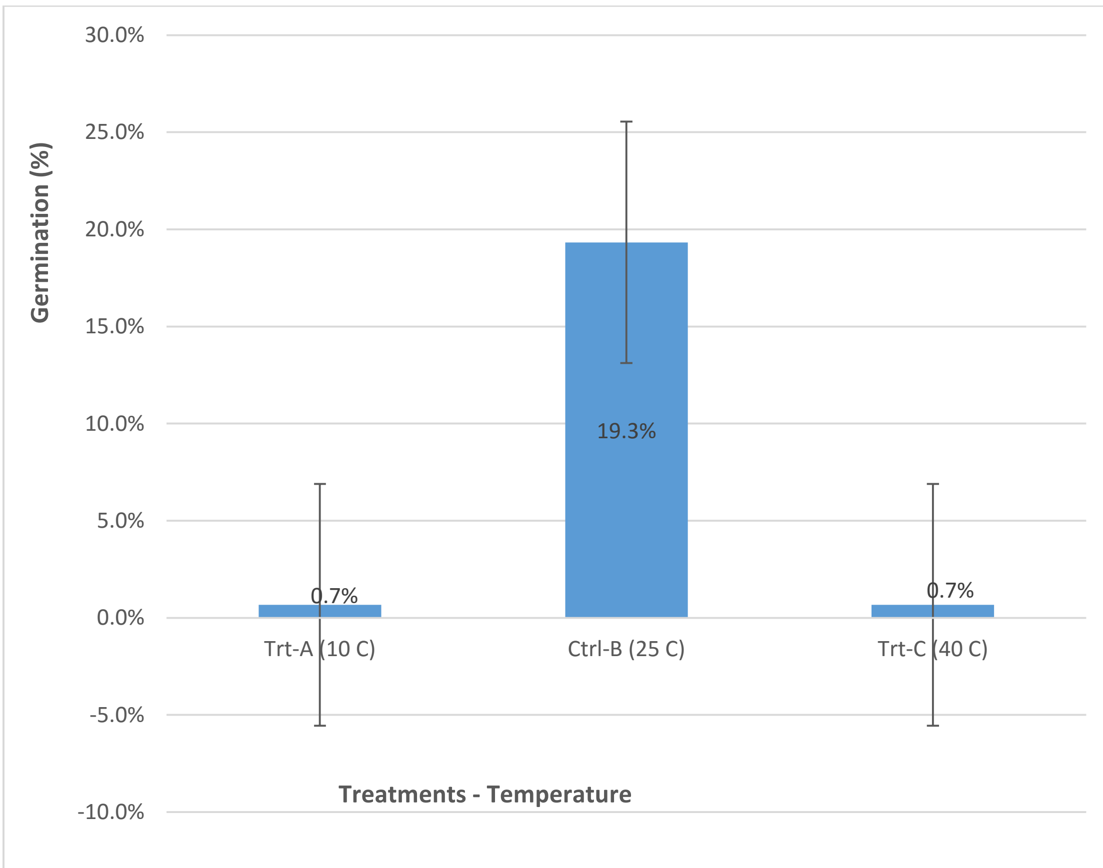
7.3 Results and Discussion

Griffonia seeds soaked at different temperature levels showed very limited or no germination at 10^{o}C (0.7%), and 40^{o}C (0.7%) (Figure 7.1), suggesting temperatures above or below normal (21 – 25^{o}C, normal room temperature) often kill the seeds, causing little to no germination. However, though at 25^{o}C, germination was noted (19.3%) (Figure 7.1), this does not suggest a preferred choice for germination of Griffonia seeds, as 19% germination of planted seeds is more than three quarters (81%) of wasted seeds.

Time course analysis for germination percentage of Griffonia seeds showed increased germinations (> 80%) from day 2 up to three weeks (Figure 7.2). Though germination was recorded at least one and two months after collection from forest (14.7% and 0.7% respectively), it can be suggested deterioration of seeds for germination begins after three weeks from collection (Figure 7.2). The result henceforth indicates that viability of seeds for a better germination rate can be up to three weeks from collection of mature seeds to planting.

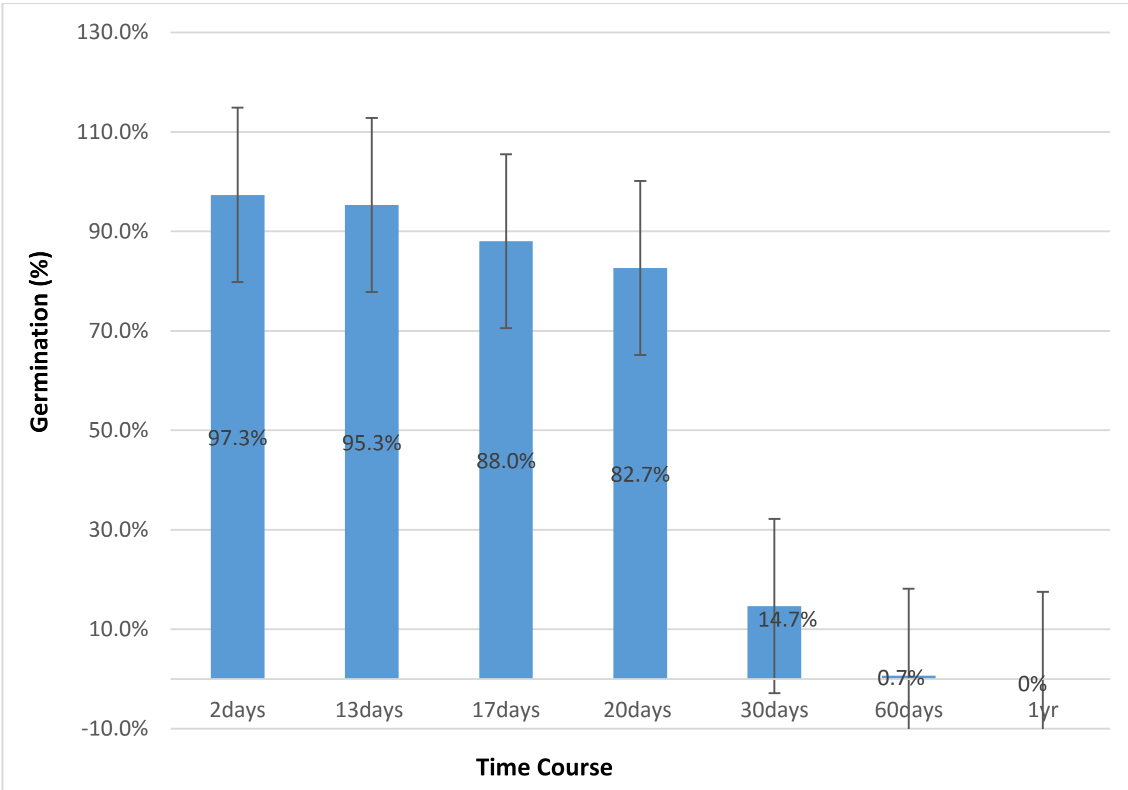
Germination rate of Griffonia seeds significantly improved with the use of sandy loamy soil with control seeds (80.4% from trial 1 and 89.6% from trial 2, Figure 7.3) compared to treated and control seeds in fine sandy soil. However, it was noted that Griffonia seeds grow in both media with control seeds, but at different growth rates; 89.6% and 57.6% for sandy loamy soil and fine sandy soil, respectively (Figure 7.3). This confirms the report by Irvine (1961) and Brendler *et al.* (2010) the plant easily grows in coastal plains, as well as secondary forest areas. The sandy loamy soil is no different from soils found in forest and farmland areas, while the fine sandy soil is mostly seen in coastal areas, almost similar if not considered as beach sand. Due to the hardy and adaptable nature of the plant, no growth enhancers were used including fertilizers and mulch.

Watering during the germination trials were closely spaced and monitored to ascertain its ability to withstand varied climatic and environmental conditions (PORSPI, 1992; Brendler *et al.,* 2010). Germination results from the second experiment using the two soil types and only control seeds (73.6% average percentage) confirmed the plant's ability to adapt to diverse environmental conditions beginning at an early stage of its life.



(P-value = 1.72E-06)

Figure 7.1: Percentage of germination of Griffonia seeds soaked for 8 hours at three different temperature levels

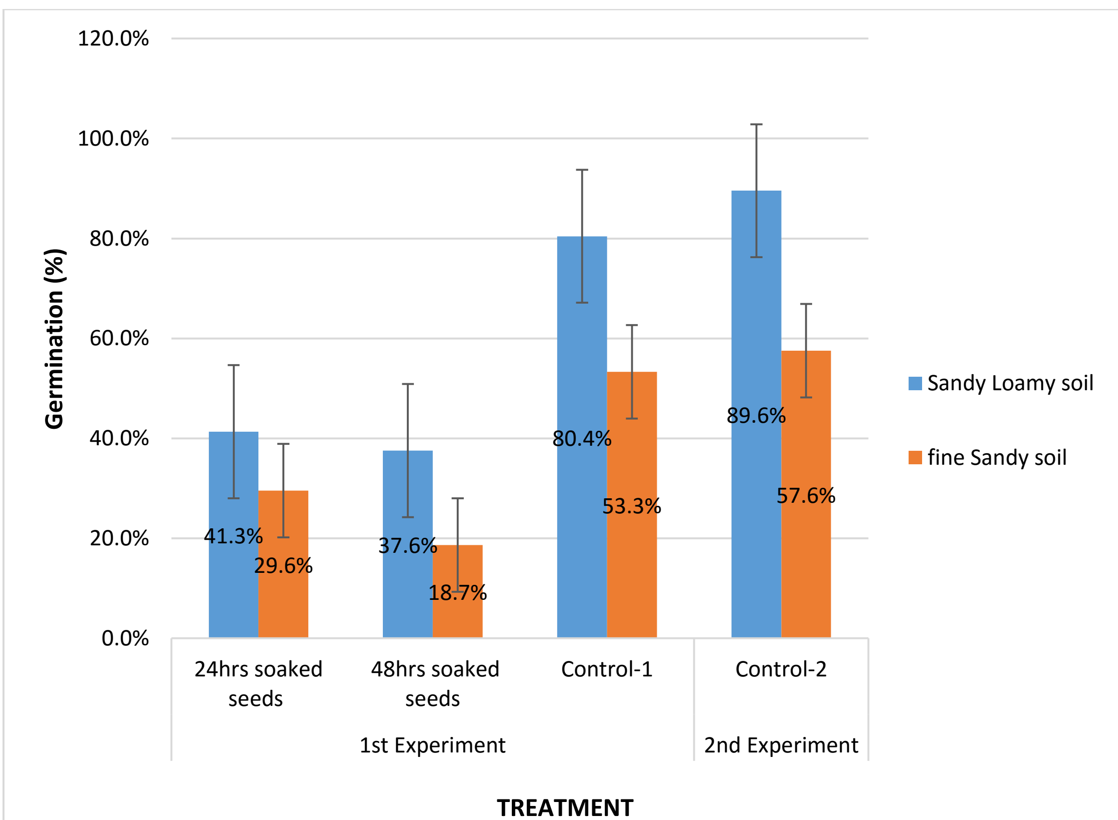


(P-value = 2.04E-16)

Figure 7.2: Percent of germination of time course for Griffonia seeds from 2 days to 1 year

With a threatening genetic diversity loss through exploitation of the plant by locals (Juliani *et al.,* 2013) attributed to increased knowledge of its commercial value (Deshmukh *et al.,* 2009) and low production power (Juliani et al., 2013), reintroduction of germinated seedlings into selected forests was used to test growth and survival rates of plant introduced in new natural habitat. Leakey and Izac (1996) had reported threats due to limited population of medicinal plant in a region. Previous report identified Nimba, Bassa and Lofa Counties as the only home of Griffonia in Liberia (Chapter 2, Table 2.4), suggesting an imminent threat and need for domestication to other counties. Three localities in Bong County, a county that borders Nimba, Lofa and Bassa

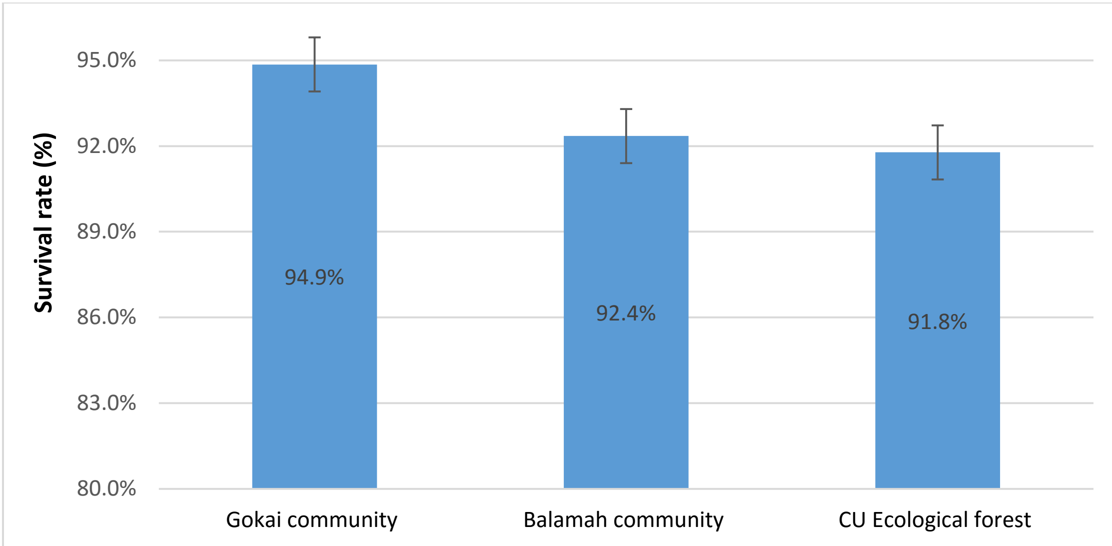
Counties were selected, considered as new habitat for their growth and development. All localities showed significant survival of transferred seedlings, with about 92% - 95% survival percentage recorded in Gokai community (Figure 7.4), affirming the adaptability of the plant to different climates and environments (Irvine, 1961; Acquaye, 1997; Brendler *et al.,* 2010). It can therefore be asserted that Griffonia can be grown in many parts of Liberia if not all, as supported by the survival rate of reintroduced seedlings (Figure 7.4). Further research is needed to ascertain the opportunity of yield optimization and uniform high-quality product from the cultivated plant in these new habitats.



(P-value = 0.0499)

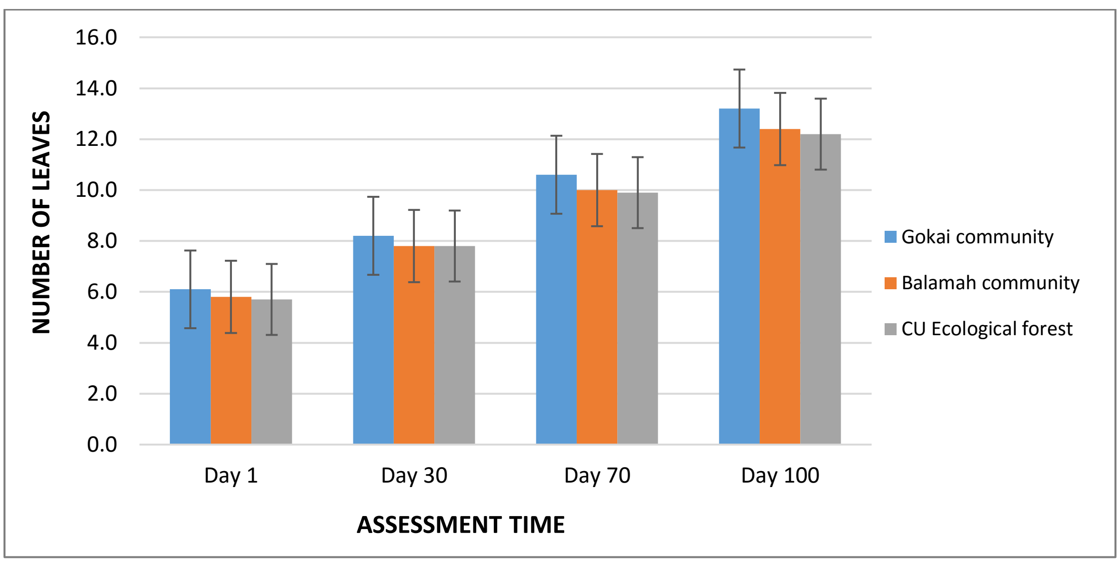
Figure 7.3: Germination percent of Griffonia seeds soaked at 24 hours, 48 hours, and control (not soaked) in Sandy loamy soil and fine sandy soil, with repeat of control in the two soil types

Further growth assessment on transplanted seedlings showed about 50 percent growth elongation in height from Day 1 to Day 100 after transferred into natural habitat at all three localities (Figures 7.5). Leaves development had also doubled within just 100 days from day one of transplant at all localities (Figures 7.6). This further affirmed Brendler *et al.* (2010) and Irvine (1961) reports of Griffonia adaptability to different climatic and environmental conditions. Though a further study on yield production is necessary, the germination production of Griffonia for introduction into other parts of the Country may seem fruitful, as this could increase the species population and hopefully increases in yield production to meet market demands at various local, national, regional, and international levels. This could solve many of the major problems that are associated with threats of important NTFP like Griffonia, such as the increasing activities from the rapidly growing human population (Ahenkan and Boon, 2008), threats of population decline and possible extinction from unsustainable exploitation due to increasing demands (Bodeker, 1997; Schippmann *et al.,* 2003), as well as threat due to limitation of some group of medicinal plants within a particular region (Leakey and Izac, 1996). Chapter 2 of this study reported Griffonia population found in three of the fifteen counties in Liberia, which may suggest low population for this potential commercial medicinal plant (Chapter 2). Coupled with the limited distribution of the species within the Country, Juliani *et al.* (2013) reported mobilization Griffonia seeds that took two years for a one 20ft container load for export, which further provides more evidence of limited population to meet the challenge of increasing demands for international commercialization.



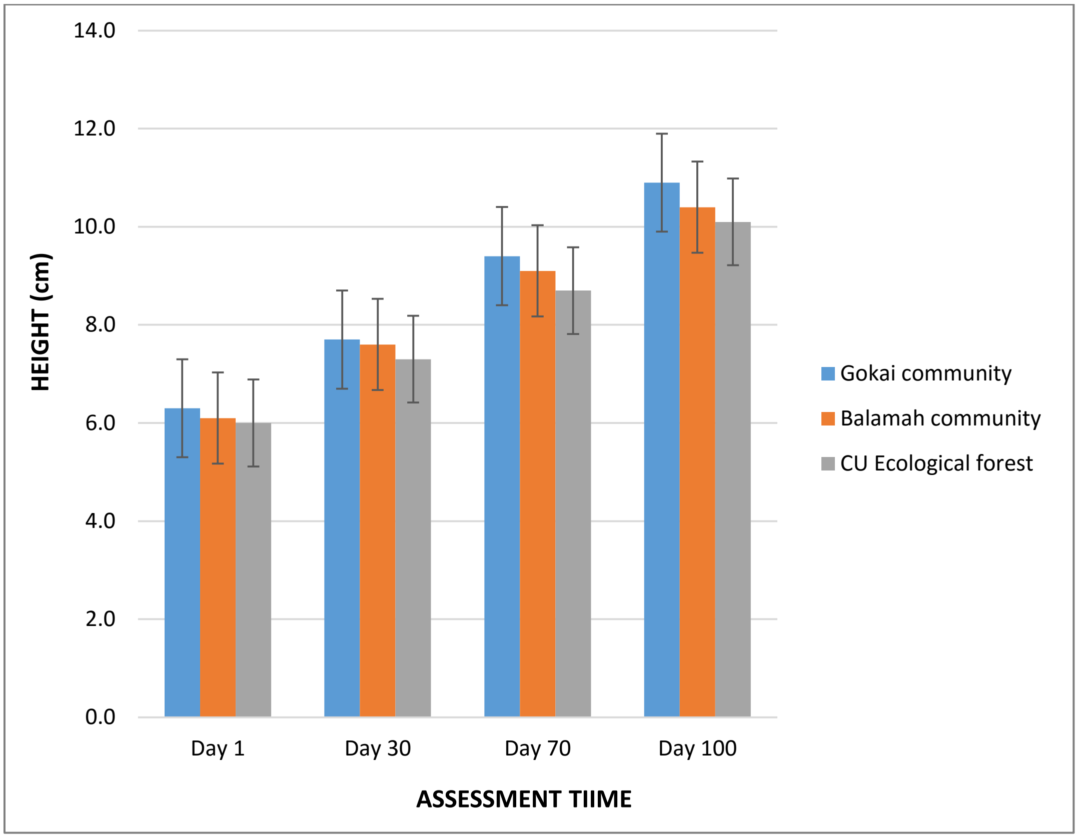
(P-value = 0.0033)

Figure 7.4: Survival percent of transplanted seedlings in three communities (Gokai, Balamah, and the CU Ecological forest)



(P-value = 0.98)

Figure 7.5: Number of leaves of 100 Griffonia vines (Griffonia simplicifolia) per location in the three testing sites (Gokai community, Balamah community, and CU Ecological forest) from Day 1 to Day 100



(P-value = 0.992617)

Figure 7.6: Height measurement (cm) of 100 Griffonia vines (Griffonia simplicifolia) per location in the three testing sites (Gokai community, Balamah community, and CU Ecological forest) from Day 1 to Day 100

7.4 Conclusion

There have been various studies conducted on Griffonia, highlighting its economic importance and traditional uses. None, however, have concentrated on the possible cultivation of the medicinal plant species, though well informed of imminent threats of rapid decline and possible extinction from unsustainable and over exploitation. Cultivation of Griffonia has the potential to alleviate the growing threats on the natural populations, while meeting increasing demands from national and international markets.

Cultivation is seen as an option that could both reduce pressure on wild populations and solve most of the basic problems that may lead to threatening of the population. This study suggests cultivation ensures yield optimization and production of uniform high-quality product, while also serving as a means for genetic preservation and conservation of the plant species.

The study has demonstrated that seed potency can be up to three weeks (21 days) from time of collection of *Griffonia simplicifolia* seeds from forest to planting. Total germination percentage was improved using optimum conditions for seeds germination. Transferred seedlings had high survival percentage at all three locations with growth observed from leaf count and height measurement.

The study showed that Griffonia can be cultivated in other parts of Liberia, which could boost productivity to meeting national and international demands, while mitigating the unsustainable harvesting practices due to increasing demands. With an easy-to-follow method of germination, Griffonia can be cultivated by many local communities and serve as one of many if not an important income generating tree crop for smallholder farmers.

The process of reintroduction via transplant seedlings with informed knowledge of agronomic practices on collection can ensure continuous and increased growth, production and survival of the species, while providing other ecosystem benefits such as biodiversity conservation on forest and farmlands.

The successful cultivation of Griffonia can support the potential for other unsustainable harvested NTFPs for possible germination and cultivation as they continue to meet collectors and market demands, while benefiting biodiversity conservation and providing more income for local communities.

8 Chapter VIII: Developing Quality Standards and New Products for Liberian Spices

8.1 Introduction

In Liberia, indigenous spices have been long used by local communities for culinary and medicinal purposes (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013). Following a review of the most commonly used spices in Liberia (See Chapter II), we selected three of these spices that are also popular as condiments flavorings, or medicinals and commonly enter into local, regional and export commerce in other West African countries such as Ghana (Abbiw, 1990; Ekanem and Obiekezie, 2000; Ekanem *et al.,* 2004; N'dri *et al.,* 2009; Nwinyi *et al.,* 2009; Ezekwesili *et al.,* 2010; Acquaye *et al.,* 2011) to ask if and how the same Liberian spices differ from those found in commerce outside Liberia. This was done to characterize the quality including the natural products chemistry of these spices and to explore whether the quality found in such indigenous Liberian spices met the quality as observed from other West African countries such as Ghana which provides these same materials to the regional and international marketplace. The three spices selected include Grains of Paradise (*Aframomum melegueta,* K. Schum.), the Ashanti pepper (also called bush pepper, or West African black pepper, *Piper guineense,* Schumach.), and Country spice or Guinea pepper (*Xylopia aethiopica,* A. Rich.). This approach is needed to assess the commercial potential of such indigenous plants and complements the other supportive studies presented earlier in this dissertation (population density and supply, value chain and sustainable collection and cultivation).

Grains of Paradise (*Aframomum melegueta, K. Schum.*), which only grows up to 2 m, is well known for its flavor and scent, containing pungent, aromatic ketones such as 6-paradol, 6-gingerol and 6-shogaol, in addition to sesquiterpenes and non-terpenoids (Sugita *et al.,* 2013). This species is also known for its healing abilities against influenza, nausea, and inflammatory disorders (Ilic *et al.,* 2014). In West Africa, the seeds are commonly used as a spice and as a general medicinal product (Abbiw, 1990; Burkill, 2000). The entire plant is known to contain many chemical components, with different components being more in various parts of the plant including the leaves, stems, roots, or seeds (Owokotomo *et al.,* 2014). The most prominent compounds, specifically in the seeds are α-caryophyllene (48.78%) and β-caryophyllene (32.5%), which are commonly used in anti-inflammatory treatments (Owokotomo *et al.,* 2014). More exciting to those that enjoy beer is that GOP from Ghana is used to flavor a number of commercial beers including Samuel Adams Boston Pale Ale (brewed by Boston Beer Company – Samuel Adams, Massachusetts, United States) and Akvavit (a clear Scandinavian liquor flavored with caraway seeds and GOP to flavor); while also having applications in cosmetics (Dalziel, 1955), foods, spices and beverages (Dada *et al.,* 2013).

Similarly, the Ashanti pepper, bush pepper, or West African black pepper (*Piper guineense,* Schumach.), which reaches to heights of 10 m or more as a climber, is commonly used as either a culinary spice or as an anti-bacterial and anti-inflammatory agent (Besong *et al.,* 2016). In addition to the various vitamins found in *Piper guineense*, the most common chemical compounds are linalool, benzoic acid, and (Z)-b-Ocimeme (Juliani *et al.,* 2013b). West African black pepper is also sold as a dried seed spice, often substituting for the more traditional black pepper (*Piper nigrum*) and even as an aromatic essential oil (Deans and Ritchie, 1987; Sultana *et al.,* 2010).

The third spice selected for these case studies on quality is the Liberian Country spice or Guinea pepper (*Xylopia aethiopica,* A. Rich.), which is an evergreen plant that grows to heights of 15 – 20 m (Orwa *et al.,* 2009; Obiri and Osafo, 2013), is known for its culinary use as spice (Katzer, 2003); while its fruits have been widely used in industry as a constituent in products like soaps, or creams due to its aromatic characteristics (Ayedoun *et al.,* 1996). The chemical constituents found in the fruits are terpenes, mono- and sesquiterpenoids; the essential oil containing phenols such as flavonoids, tannins, and saponins; and sterols such as sitosterol, stigmasterol and campesterol (Ezekwesili *et al.,* 2010), all of which are important for the maintenance of the normal functioning of the human body (Ekpo *et al.,* 2012). The essential oil of Xylopia is reported to contain more than 100 different volatiles. The major essential oil constituents in the oil include β-pinene (18%), terpinen-4-ol (8.9%), sabinene (7.2%), α-terpineol (4.1%), 1, 8-cineole (2.5%), mytenol (2.4%), and kaurane derivatives (4.2%) (EL-Kamali and Adam, 2009).

The fruits of Xylopia have been investigated for their potential use as a preservative, mainly using the aqueous and diethyl ether extracts of the dried fruits as a fungicide (Amadioha and Obi, 1998); with the fruit extract exhibiting fungitoxic activity against *Fusarium oxysporum*, *Aspergillus niger* and *Aspergillus flavus* that are among the frequently occurring spoilage fungi (Okigbo and Nmeka, 2005); while some extracts shown to inhibit growth of *Escherichia coli* and *Bacillus cereus* that are among the commonly microbes involved in food contamination (Adegoke *et al.,* 2003). These findings that point out Xylopia extracts as potential food preservative create an advantage for Xylopia fruit extracts, because unlike chemical preservatives, the extracts are generally of low toxicity and environmentally safe (Fetse *et al.,* 2016). Further, Xylopia has been studied for its potential as an antioxidant in food (Adegoke *et al.,* 2003). Okafor and Apebende (2014) had shown the inhibitory ability of the ethanol extracts of the essential oil from fruits of Xylopia to the corrosion of mild steel in sulphuric acid solutions. Thus, the potential for application in paint and other related industries, through the identification of the specific compounds for inhibition of corrosion could be explored (Fetse *et al.,* 2016).

In Liberia, seeds/fruits of Grains of Paradise, bush pepper, and country spice are used as spices for flavoring food, while also having medicinal properties (Deshmukh *et al.,* 2009; Juliani *et al.,* 2013). Same has been reported in Ghana for these plants (Abbiw, 1990; Agbonon *et al.,* 2010; Adetutu *et al.,* 2011; Asase *et al.,* 2012).

The chemical constituents in the seeds of *A. melegueta* have been reported, with the presence of alkaloid and saponins determined, while tannins, cyanogenetic glycosides, cardiac glycosides and anthraquinones appear not to be present (Sonibare *et al.,* 2011). Other bioactive compounds of the seeds include hydrophenolalkanones such as paradol, shogaol, zingerone and gingerol (Galal, 1996; Umukoro and Ashorobi, 2007), which provide for the pungent and peppery taste within A. melegueta seeds (Iwami *et al.,* 2011; Sugita *et al.,* 2013; Vriens *et al.,* 2008).

Chemical constituents of *P. guineense* have been conducted in several studies. The fruits contain alkaloids including piperine, the major alkaloid responsible for the pungent smell (Adosraku *et al.,* 2013). The roots contain the alkaloids wisanine and wisanidine (Addae-Mensah *et al.,* 1977), though are not found in the fruits or seeds, the product of commerce as a spice. Essential oils content in different parts of the plant have also been studied. Tankam and Ito (2013); with monoterpene limonene identified in the fruit-leaf and liana/stem essential oils (Oyedeji *et al.,* 2005; Francois *et al.,* 2009); phenypropanoid muristicin identified in fruit and leaf essential oils (Zollo *et al.,* 1998; Oyedeji *et al.,* 2005); phenolic derivative 3,5-dimethoxytoluene (Tankam and Ito, 2013), monoterpenes linalool (Oyedeji *et al.,* 2005; Francois *et al.,* 2009; Tankam and Ito, 2013), β-pinene (Zollo *et al.,* 1998), α-pinene (Zollo *et al.,* 1998; Francois *et al.,* 2009), and cis-β-ocimene (Oyedeji *et al.,* 2005), the sesquiterpenes β-caryophyllene (Oyedeji *et al.,* 2005; Francois *et al.,* 2009), ishwarane, β-elemene, bicyclogermacrene and sesquiterpenes germacrene (Fracois *et al.,* 2009), and E-β farnesene (Zollo *et al.,* 1998) in the fruit essential oils. The liana/stem essential oil contained the sesquiterpene (Z, E)-α-Farsenene (Francois *et al.,* 2009).

Studies on the fruits essential oil of *X. aethiopica* have shown a variety of mono-and sesquiterpenes, with the main compounds varying depending on the geographical location and time of harvest (Karioti *et al.,* 2004). The differences in genetics in contrast to environment impacts on the essential oils is unknown. The essential oil from seeds of *X. aethiopica* can be used to formulate shampoos due to its high saponification value (207.2±8.0) (Ajiwe *et al.,* 1998). Conversely, Ogbonna *et al.* (2015) also determined the saponification value of the oil to be 130.18 in a preliminary evaluation studies of *X. aethiopica* seeds essential oils. Fetse *et al.* (2016) concluded that the difference in value obtained in the two studies suggests impact of geographical location and time of harvest that could all affect the nature and composition of essential oils in the plant product. Studies confirmed that dried fruits collected from Egypt, Benin and Mali and essential oil analyzed showed all contained high contents of the monoterpenes β-pinene and 1,8-cineole (Karioti *et al.,* 2004). Dried fruits collected from Benin have been shown to contain the monoterpene sabinene, while the fruits from Egypt were shown to be rich in the monoterpene 4-terpineol (Karioti *et al.,* 2004). Other studies have also reported contents of diterpenes such as 13-epimanoyl oxide, kaur-16-ene (Elhassan *et al.,* 2010) and xylopic acid (Woode *et al.,* 2012).

Many of these studies that reported on the composition of the essential oils of fruits, seeds, stem bark, root bark and leaves are from countries other than Liberia; while only few studies have focused on areas leading to characterization of quality standards (e.g. Juliani *et al.,* 2008; Freiesleben *et al.,* 2015). However, there is a gap in information about the characteristic physicochemical compositions of the dried fruits of the Liberian indigenous spices have been provided, for the development of the quality of the consumed products. Tairu *et al.* (1999) has stressed that one of the main disadvantages of traditional medicinal plants is due to lack of standardization and quality control. We agree and can extend that statement to spice and botanicals- not only medicinals. Asase *et al.* (2005) also reported that products with defined quality standards may have better entrance to more markets and capture the interest in the market when introduced in a reliable manner.

This chapter aims to provide information on the composition of essential oils, antioxidant activity, and the quality control standards to develop quality standards for Liberian indigenous spices. The objectives were 1) to analyze the macroscopic and chemo-biological qualities of *A. melegueta, P. guineense*, and *X. aethiopica* from Liberia; 2) to compare the quality of the Liberian indigenous spices to the Ghanaian spices; 3) and to assess the chemical composition and develop quality control standards of the Liberian spice *X. aethiopica* for the development of new products. Given the chemical composition relates directly to the aroma, taste, and activity of a spice such an approach allows us to better understand whether Liberian spices could meet the norms and industry expectations as well as simply being enjoyed as a local spice and in foods locally.

8.2 Materials and methods

8.2.1 Sample collection locations

Dried fruits/seeds of *Piper guineense, Xylopia aethiopica* and *Aframomum melegueta* spices were each collected from two markets in the Ashanti Region from Ghana in October 2014 and two markets in Bong County (Jenepleta market and the Gbarnga City market) from Liberia in July 2016 for macroscopic analysis. Seeds of the three NTFP were furthered obtained from the Monrovia market to analyze their volatile aroma composition. All spices were botanically authenticated as to the genus and species in two ways. First, by the research team whom have been working with these three spices for many years. Secondly, fruits obtained from the Liberian markets were also identified and authenticated at the Ministry of Agriculture in Liberia, with a phytosanitary certificate provided (Appendix E), with Certificate #: MOA/RL/NQES/180716, to certify plant product fit for research out of origin of country. A United States Permit document to ship agricultural products accompanied the phytosanitary certificate during shipment of products; with Plant Import PERMIT #: PCIP-16-00107.

8.2.2 Materials

Materials used for the various analyses include; Protein Analysis: Bradford reagent, bovine serum albumin (source of protein for comparison), coffee grinder, 48-well plate, and 1000 microliter pipette; Total Ash analysis: crucibles, specific plant tested, and coffee grinder; Moisture Analysis: specific part of plant tested for moisture content, aluminum foil, and oven; SH/GC/MS (Shimadzu Headspace Gas Chromatography/Mass Spectrometry GC-2010 plus): plant material, chromatograph, Pestle and mortar, and GCMS Analysis computer program.

8.2.3 Methods

8.2.3.1 Quality Control Analysis

The dry seeds of *P. guineense* and *X. aethiopica* from Ghana and Liberia were submitted to color and aroma analysis, foreign matter analysis and moisture content analysis. **Seed color** was determined by visual observation. **Aroma** was also determined by physical smell perception of the seeds. **Particulate matters (foreign particles and botanical dust)** were determined by separation of seeds from any foreign material through physical means (spreading of seeds on a flat surface preferably a plate); while botanical dust was measured by using a 0.25mm sift. **Moisture Analysis:** The mass of the seeds of each plant was recorded. The aluminum foil, which was used to hold the seeds was also weighed separately. The seeds were then placed into the aluminum foil and the mass of both the seeds and aluminum foil were recorded. After placing the seeds into the aluminum foil, the aluminum foil was then precisely folded in order to keep the seeds stable. The aluminum foil packets were then placed into the oven (model and company) at 150^{o}C for24 hours. After this time period, the aluminum foil packets were then weighed, recorded, and the differences in mass were compared with the mass of the seeds and aluminum foil before the heating step took place.

Ashes were measured using an oven (Fisher Isotemp oven, 100 Series, model 106G), crucibles and powdered plant materials. The crucibles were dried one day before use, in the oven preset at 150^{o}C. The mass of the crucibles was measured. The pods and seeds were powdered and measure of 1-5 grams of each was added in each crucible. The crucibles with the plant material were placed in 600^{o}C for muffle furnace oven (what type details needed) and stayed for 8 hours. The final weight was measured to calculate the difference.

Protein content was determined using the Bradford reagent with modifications (Ramalakshmi *et al.,* 2007). A total of 50 mg of the grounded leaves were placed in a tube along with 10 ml of 0.1N NaOH. This was mixed until all the material had dissolved and then transferred to a centrifuge tube for centrifugation for 2 minutes. Following, the supernatant was transferred to another cuvette where 1.5 ml of the Bradford reagent was added to each. After 20 minutes the absorption was measured at 595 nm. The results were expressed as g of protein (Albumin) on a dry weight basis (g Albumin/100 g DW).

Total phenol analysis: A total of 100 mg of the grounded seeds of Xylopia were placed in a 25 ml volumetric flask and extracted with 70% methanol in water. Different concentrations of methanol/water were tested to determine the highest recovery of total phenols. The Xylopia extracts (100 mg dry powder/25 ml) were sonicated for 25 minutes. The total phenols were measured using the Folin Ciocalteu's reagent and absorbance was measured at 752 nm. The results were expressed as grams of Gallic acid equivalents on a dry basis (g gallic acid/100 g DW) (Gao *et al.,* 2000).

Soxhlet extraction: Plant material was first ground, then placed in a filter paper envelope. Seeds of *P. guineense* and *X. aethiopica* from Liberia and Ghana were used for this experiment. The envelope was put in the Soxhlet apparatus. Hexane was added as the extractor in the round flask. The process of extraction lasted 8 hours. The hexane with the fatty acids was transferred in a clean balloon and its weight measured. The balloon was put in the rotary evaporator until all solvent was evaporated, at 50^0C. The weight of the balloon was recorded and subtracted to calculate the fatty acids content (g of crude fats/100g of dry weight).

Different parts of the fruit (pod) of Country spice (*X. aethiopica*) were used for headspace analysis: whole fruits, whole intact seeds, grounded capsules and grounded seeds. Approximately 40 mg of each part was transferred to 20 mL headspace vials, 2000 mL of headspace was injected with an autosampler (AOC 6000) into a Shimadzu GC/TQMS (GC2010 Plus/TQ8040) the Inlet temperature was 220°C, in a SH-Rxi-5Sil MS (30m long, 0.25 mm ID, 0.25 mm Film) column, temperature program, 35°C 4 min, rate 20°C/min, 250°C 10 min. Helium constant flow was set at 1 ml/min. Individual identifications were made by matching their spectra with those from mass spectral libraries and the identity of each component was confirmed by comparison of its Kovat's index with those from literature (Adams, 2007). Each component was listed in order of elution from the SH-Rxi-5Sil MS (DB5 equivalent) column.

8.2.4 Data analysis

All data was expressed in Excel 2013 worksheet and was subjected to quantitative descriptive statistical data analysis. Data was quantitatively analyzed using data tabulation (frequency distributions & percent distributions), descriptive data (mean), and ANOVA.

8.3 Results and discussion

Seeds color and aroma of *P. guineense, X. aethiopica* and *A. melegueta* from Ghana and Liberia were assessed. Seed color of *P. guineense* from Liberia was found to be dark brown, whereas there were some whitish brown spots on *P. guineense* seeds from Ghana, indicating moldy condition. Mold tends to reduce the quality of plant products especially on seeds; the quality of the seeds of *P. guineense* from Ghana were observably seen to be less. The seeds of *X. aethiopica* from Ghana and Liberia both seemed to maintain their quality with color, dark brown to black brown; while the seeds of *A. melegueta* from Liberia were all brown, and those from Ghana were either dark brown or light brown. The aroma was another sensory quality examined from the seeds of *P. guineense*, *X. aethiopica*, and *A. melegueta*. Both Liberian and Ghanaian seeds for the two plant products were found to have moldy notes, indicating some form of contamination on the seed coat that might deteriorate the seed, or reduce its quality level; while the seeds of A. melegueta from Liberia had strong or regular spicy scent and those from Ghana had light to moldy spicy scent. Xylopia seeds from both countries had spicy with moldy scent. Xylopia seeds collected from market 1 from Ghana has spicy with very light moldy scent. The *P. guineense* also collected from market 1 from Ghana had black pepper scent, with high mold sent. These were the seeds that had whitish brown spots on seed coat visible. The *P. guineense* seeds collected from market 1 from Liberia was found to have regular black pepper scent, pepper scent, but also high mold scent (Table 8.1).

Foreign particles and botanical dust were assessed from the seeds of *P. guineense, X. aethiopica* and *A. melegueta* from Ghana and Liberia (Table 8.2). *P. guineense* seeds from Liberia showed higher amount of foreign particles (small twigs, rocks, and other unwanted materials) particularly sample 2 (Table 8.2). This sample also had very high percentage of botanical dust (1.29%) (fine particles that easily passed through a 0.25mm pores of sift) compared with seeds from Ghana. Only the *A. melegueta* seeds from Liberia showed lower levels of foreign particles as well as botanical dust compared with those from Ghana. This implies that the seeds from Liberia may have been dried on the bare floor where foreign particles easily get mixed with products (Table 8.2) and that quality control procedures are needed. A clean product entails high quality and great potential for acceptable commercialization.

Moisture content levels in *P. guineense* seeds from Ghana were slightly higher (sample 1 - 11.86% and sample 2 - 14.89%) than *P. guineense* from Liberia (1 - 9.17% and 2 - 9.36%) (Table 8.3); while the moisture content levels in A. melegueta fluctuated between the two samples for each location. However, moisture levels in *X. aethiopica* seeds from Liberia showed slightly high percentage (1 – 11.21% and 2 – 11.41%) than seeds from Ghana (1 - 9.61% and 2 – 9.54%). This may account for the moldy scent of the seeds from the two countries. High moisture level (higher than 10%) implies seeds not dry enough and so can easily encourage the growth of mold on its surface, evidence of whitish spot on *P. guineense* seeds from Ghana which have high moisture level (Table 8.3). A preferred and acceptable moisture content level for seed product should often be below 10% to maintain quality, or problems of deterioration may be soon visual.

Table 8.1 Seeds Color and aroma analysis of *Piper guineense, Xylopia aethiopica* and *Aframomum melegueta* from Ghana and Liberia

Sample	Color		Aroma	
	Liberia	**Ghana**	**Liberia**	**Ghana**
P. guineense - 1	Dark brown	Whitish brown with spots	Regular black pepper scent, but slightly moldy	Black pepper scent, with mold highest
P. guineense - 2	Slight dark brown with minute whitish spots	Light brown with spots	Black pepper scent, but mold high	Black pepper scent, but moldy scent
X. aethiopica -1	Dark brown	Dark brown	Spicy with moldy scent	Spicy with very slight moldy scent
X. aethiopica -2	Black brown	Dark brown	Spicy with moldy scent	Spicy with moldy scent
A. melegueta -1	Brown	Dirt brown	Strong spicy scent	Light spicy scent
A. melegueta -2	Brown	Brown-black	Regular spicy scent	Moldy spicy scent

Table 8.2: Percent particulate matter in seeds of *Piper guineense, Xylopia aethiopica* and *Aframomum melegueta* from Ghana and Liberia

Sample	Liberia		Ghana	
	Foreign particle	Botanical dust	Foreign particle	Botanical dust
P. guineense - 1	1.091 ± 0.43	0.014 ± 0.90	0.847 ± 0.22	0.04 ± 0.001
P. guineense - 2	1.705 ± 0.31	1.285 ± 0.64	0.541 ± 0.15	0.042 ± 0.001
X. aethiopica -1	0 ± 0.001	0.007 ± 0.001	2.094 ± 0.86	0.03 ± 0.002
X. aethiopica -2	1.054 ± 0.75	0.009 ± 0.001	0.876 ± 0.61	0.026 ± 0.003
A. melegueta -1	0.714 ± 0.34	0.0011 ± 0.001	1.1765 ± 0.43	0.0254 ± 0.001
A. melegueta -2	0.013 ± 0.17	0.0041 ± 0.001	0.262 ± 0.17	0.0113 ± 0.001

(Mean ± Standard deviation)

Table 8.3 Percent moisture levels of *Piper guineense, Xylopia aethiopica* and *Aframomum melegueta* from Ghana and Liberia

Sample	Liberia	Ghana
P. guineense - 1	9.170 ± 0.13	11.860 ± 1.52
P. guineense - 2	9.360 ± 0.13	14.890 ± 2.14
X. aethiopica -1	11.21 ± 0.14	9.61 ± 0.05
X. aethiopica -2	11.41 ± 0.14	9.54 ± 0.04
A. melegueta -1	10.02 ± 0.15	9.03 ± 0.03
A. melegueta -2	9.14 ± 0.13	9.49 ± 0.05

(Mean ± Standard deviation)

Table 8.4: Mass distribution of *Xylopia aethiopica* seeds in pods from Liberia and Ghana

Mass Distribution of Seeds in Pods (g)	**Ghana**	**Liberia**
Total initial mass of whole fruit	1.73 ± 0.113	1.36 ± 0.062
Total amount of whole fruit	7.50 ± 3.534	7.00 ± 2.828
Total amount of seeds	19.50 ± 2.121	18.50 ± 6.364
Total mass of seeds	0.60 ± 0.070	0.34 ± 0.019
Total amount of black seeds	13.50 ± 0.707	9.00 ± 2.828
Total amount of brown seeds	6.00 ± 2.828	9.50 ± 3.536
Total mass of black seeds	0.46 ± 0.036	0.23 ± 0.009
Total mass of brown seeds	0.14 ± 0.032	0.11 ± 0.027
Mass percentage (%)		
Mass percentage of total amount of seeds	34.7 ± 0.018	24.8 ± 0.025
Mass percentage of black seeds (compared to whole fruit)	26.6 ± 0.004	16.9 ± 0.001
Mass percentage of brown seeds (compared to whole fruit)	8.1 ± 0.013	7.9 ± 0.024
Mass percentage of black seeds (compared to total amount of seeds)	76.8 ± 0.026	68.6 ± 0.064
Mass percentage of brown seeds (compared to total amount of seeds)	23.3 ± 0.025	31.4 ± 0.064

(Mean ± Standard deviation)

Traditionally, the whole pods of Xylopia are ground and the added to foods as a spice. In order to find new uses and applications of this Liberian spice, we explored the possibility of using the seeds also as a spice. It was observed that the seeds made up to 34.7% in the pods from Ghana, while 24.7% in the pods from Liberia (Table 8.4). The seeds are normally black (76.8%, 68.6%) with 23.3% and 31.4% of the seeds being brown, respectively for Ghana and Liberia. This study suggests that Xylopia seeds can be used as a new product that will add variety and color to combination of spices available in the retail markets, such as the MCCORMICK® PEPPERCORN MEDLEY GRINDER, a registered product containing a combination of whole black, white, green, and pink peppercorns, whole allspice, and whole coriander (McCormick.com).

Additional studies were conducted to the seeds to describe their chemical and nutritional profile. Protein analysis for *X. aethiopica* from Ghana showed slightly high percentage (3.84%) compared to seeds from Liberia (3.14%) (Table 8.5). However, the whole fruit showed high protein percentage for the Liberian seeds than the Ghanaian whole fruit (0.82%). Overall, the protein levels in the seeds are low, 3.84% and 3.14% for the seeds from Ghana and Liberia, respectively, the amount of total proteins in the whole pod are even lower (0.82% for Ghanaian and 2.88% for Liberian Xylopia). Xylopia seeds contained a significant amounts of total fats, 13.9% in the Ghana and 14.5% in the samples from Liberia (Table 8.5).

The percentage of total phenol in the whole pods from Liberia were slightly higher (6.04%) than the one from Ghana (4.0%). Percentage of total phenol in capsule was relatively high for Ghana (5.46%) than capsule percentage (5.39%) from Liberia (Table 8.6). Though there were differences noted in total phenol levels within the parts of the fruit, it is however pleasing to point out that these parts had some levels of total phenols, with whole pods containing the highest of the three organ parts examined. Thus for total phenol levels, the content in the whole pod is presented in Table 8.6.

Table 8.5 Protein and Fat analysis in seeds and whole fruits of *Xylopia aethiopica* from Ghana and Liberia

Analysis (%)	**Ghana**	**Liberia**
Protein analysis of seeds	3.84 ± 0.021	3.14 ± 0.002
Protein analysis of whole Fruit	0.82 ± 0.015	2.88 ± 0.001
Total fats analysis of seeds	1.39 ± 0.164	1.45 ± 0.115
Total ash analysis of whole fruit	3.07 ± 0.095	3.38 ± 0.101
Bulk density of seeds (g/cm^3)	0.328 ± 0.009	0.369 ± 0.011

(Mean ± Standard deviation)

Table 8.6 Absorbance and total phenol in *Xylopia aethiopica* fruit (seeds, whole pods, and capsule from Liberia and Ghana

	Part of organ	**Absorbance**	**Total phenol (mg/ml**	**Total phenol (%)**
Liberia	Seeds	0.08 ± 0.011	0.12 ± 0.016	1.54 ± 0.199
	Whole pods	0.04 ± 0.009	0.49 ± 0.071	6.04 ± 0.883
	Capsule	0.04 ± 0.007	0.43 ± 0.053	5.39 ± 0.657
Ghana	Seeds	0.05 ± 0.008	0.07 ± 0.011	0.93 ± 0.141
	Whole pods	0.02 ± 0.010	0.32 ± 0.073	4.00 ± 0.899
	Capsule	0.04 ± 0.011	0.44 ± 0.086	5.46 ± 1.055

(Mean ± Standard deviation)

Table 8.7. Essential oil chemical composition of different parts of *Xylopia aethiopica* pods from Liberia

	Retention		Whole black seeds	Ground black seeds	Whole brown seeds	Ground brown seeds	Capsules	Whole intact fruits
Aromatic Constituents in Essential Oil (EO)	**Ret. Index**	**Ret. Time**	**Rel. Concentration (as % of total EO)**					
α-Thujene	931	7.67	0.4	0.4	-	-	-	0.3
α-Pinene	940	7.77	13.6	21.6	18.1	27.1	35.9	26.3
Camphene	961	8.02	0.1	-	0.8	1.1	0.6	0.7
Sabinene	978	8.22	-	-	-	0.9	3.5	0.4
β-Pinene	984	8.28	30.6	40.6	32.5	43.5	40.2	42.2
α-Phellandrene	1009	8.56	1.1	0.6	0.4	0.2	0.3	0.1
para-Cymene	1029	8.75	6.2	11.3	7.3	3.4	3.2	5.9
1,8 Cineole	1039	8.84	35.8	22.8	21.6	14.1	13.7	11.8
Ocimene (allo-)	1098	9.41	1.4	0.3	2.5	0.4	0.1	0.2
(Z) - Verbenol	1153	9.86	1.6	0.5	0.7	1.3	0.5	3.5
Pinocarvone	1173	10.03	0.8	0.2	5.1	0.6	0.3	1.3
α- Terpineol	1201	10.27	-	-	1.9	-	-	-
Myrtenol	1206	10.31	2.5	0.5	3.3	1.3	0.5	2.9
(E)-carveol	1218	10.4	0.1	0	1.3	0.2	0.1	0.4
δ-Elemene	1348	11.35	1.1	0.1	0.4	0.6	0.2	0.1
α-Cubebene	1393	11.67	1.7	0.5	2.4	1.4	0.5	1.6
(E) - Caryophyllene	1429	11.91	0.8	0.2	0.9	1.1	0.3	0.9

With the results obtained using the Shimadzu Headspace Gas Chromatograph for Mass Spectrometer (GC/MS) 2010 plus, differences in the chemical volatile compositions were observed in the different parts of the pods of *X. aethiopica*. The whole intact fruits (pods) emitted volatiles characterized by high levels of α- pinene (26.3%) and β - pinene (42.2%) and low levels of 1,8 cineole (11.8%) (Table 8.7). The pods breakdown in capsules and seeds revealed that ground capsules had a similar composition to that of the whole pods dominated by α- pinene (35.9%) and β- pinene (40.2%) and lower levels of 1,8 cineole (13.7%). Capsules and the whole fruits were characterized by the presence of camphene and sabinene, not detected in the seeds (Table 8.7).

The whole and ground black seeds were characterized by lower levels of β-pinene (13.6 - 21.6%, respectively) and higher levels of 1,8 cineole (35.8 – 22.8%). The monoterpene 1,8 cineole, also known as eucalyptol, is important as it provides fresh notes to the aroma of spices. The ground black seeds were also characterized by the highest percentages of para – cymene (11.3%) (Table 8.7).

The volatile components were also analyzed in the immature brown seeds. The whole seeds showed lower levels of 1,8 cineole, while the ground brown seeds exhibited even lower percentages (14.1%). The brown seeds showed a characteristic composition, α-terpineol, found only in the whole brown seeds (2%). They also seem to have higher levels of sesquiterpenes particularly β– cubebene and caryophyllene <E->, 2.4% and 0.9% for the whole and 1.4% and 1.1% for the ground seeds, respectively (Table 8.7).

The results demonstrated that from a sensory perspective the capsules would have more spicy and less fresh notes as the levels of pinenes were higher and 1,8 cineole lower. The black seeds containing higher levels of 1,8 cineole, characterized by fresh and minty notes, can provide condiments with enhance sensory profiles (Table 8.7).

Volatile components of essential oil were characterized from *Xylopia aethiopica* seeds obtained from Ghana and Liberia. A total of 38 and 43 volatile aromatic constituents based on their retention index were identified from the fruit of *Xylopia aethiopica* that was obtained from Liberia and Ghana, respectively, using static headspace Shimadzu GCMS analysis (Tables 8.8 and 8.9). Among the three different organ parts, the seeds exhibited more volatile constituents than those of the capsule and the whole fruit from the two countries. Also, among the volatile compositions obtained, α-pinene, β-pinene, and 1,8-cineole showed high concentrations in all three parts of the fruit, with β-pinene emitting higher levels of volatiles concentration in all three fruit parts of Xylopia from Liberia (41.24% - capsule; 42.42% - seeds; and 42.36% - whole fruit) (Table 8.8). Similar results were also recorded from the volatile characterization of the fruit parts of Xylopia from Ghana; with β-pinene also emitting higher levels of volatile concentration than the other two parts- the capsule and whole fruit (Table 8.9). Quantitatively, the sample from Ghana showed higher levels of β-pinene in all fruit parts (44.04% - capsule; 42% - seeds; and 47.2% - whole fruit) (Table 8.9) than that of the sample from Liberia (Table 8.8). However, the Xylopia sample from Liberia emitted volatiles characterized by higher levels of 1,8-cineole (18.63% - capsule; 17.58% - seeds; and 18.65% - whole fruit) (Table 8.8) than that of the fruit parts from the sample obtained from Ghana. Overall, individual oils displayed their unique chemical profiles in quantity and quality characterized by the amount of relative percentage of each volatile constituent for the various organ parts. The pods containing levels of 1,8 cineole, characterized by fresh and minty notes, are the basis for their use as condiments with enhanced sensory profiles.

Table 8.8: Chemical composition and relative percent concentrations of essential oils of *Xylopia aethiopica* fruit (seeds, whole pods, and capsule) from Liberia

Name	Retention Time	Retention Index	Capsule rel. %	Seeds rel. %	W/fruit rel. %
Hexanal	5.655	787	-	2.85	0.67
Santene	6.945	875	0.13	-	0.33
Thujene <α->	7.553	920	0.98	0.74	0.46
Pinene <α->	7.649	929	27.91	28.01	26.5
Fenchene <α->	7.854	947	0.46	0.31	0.44
Thuja-2,4(10)-diene	7.896	951	0.23	0.36	0.73
Sabinene	8.115	969	2.55	1.56	0.97
Pinene <β->	8.174	975	41.24	42.42	42.37
Pentyl furan <2->	8.274	984	-	0.13	-
Octen-5-yne <(2-methyl-(3E)->	8.303	987	-	-	0.09
4(10)-Thujen-3-ol	8.453	1000	-	-	0.09
Phellandrene <α->	8.461	1001	0.2	0.11	-
Carene <δ-3->	8.503	1005	0.05	-	-
Terpinene <α->	8.577	1013	0.05	-	-
Cymene <p->	8.651	1021	4.29	2.88	3.13
Cineole <1,8->	8.745	1031	18.63	17.58	18.65
Tolualdehyde <meta->	8.979	1056	0.1	-	0.1
Sabinene hydrate <cis->	9.098	1069	0.17	-	0.16
Vertocitral C <cis->	9.254	1086	0.12	-	0.19
Camphenone <6->	9.326	1093	0.21	0.22	0.23

Name	Retention Time	Retention Index	Capsule rel. %	Seeds rel. %	W/fruit rel. %
Linalool	9.37	1098	-	0.1	0.12
Campholenal <α->	9.612	1127	0.08	0.1	0.23
Camphor	9.744	1143	-	0.17	0.52
Menthatriene <1,3,8-p->	9.769	1146	0.61	-	-
Pinocarvone	9.941	1166	0.34	0.41	0.95
Myrtenol	10.134	1190	-	-	0.17
Myrtenal	10.216	1199	0.49	0.69	1.41
D-Verbenone	10.31	1212	0.06	0.08	0.21
Elemene <δ->	11.258	1340	0.18	0.14	0.17
α-Cubebene	11.349	1353	-	-	0.06
Nepetalactone [Z,Z]	11.473	1371	-	0.11	0.08
Ylangene <α->	11.578	1386	0.41	-	-
Copaene <α->	11.578	1386	-	0.6	-
Cubebene <β->	11.578	1386	-	-	0.65
Elemene <β->	11.645	1395	-	-	0.06
Gurjunene <α->	11.815	1421	0.22	-	0.25
Duprezianene <β->	11.815	1421	-	0.19	-
Muurola-4(14),5-diene <trans->	12.303	1494	0.28	0.13	-

Table 8.9: Chemical composition and relative percent concentrations of essential oils of *Xylopia aethiopica* fruit (seeds, whole pods, and capsule) from Ghana

Name	Retention Time	Retention Index	Capsule	Seeds	W/fruit
Hexanal	5.653	787	-	5.73	-
Santene	6.943	875	0.18	0.16	0.21
Heptanal	7.228	894	-	0.08	-
α-Thujene	7.549	920	2.32	1.21	2.38
α-Pinene	7.649	929	23.6	19.93	25.2
Fenchene <α->	7.851	947	0.57	0.47	0.65
Thuja-2,4(10)-diene	7.893	951	0.27	0.66	0.32
Sabinene	8.109	969	6.76	2.49	5.82
Pinene <β->	8.177	975	44.04	42	47.2
Carene <δ-2->	8.301	986	3	1.2	1.73
Mentha-2,8-diene <cis-meta->	8.344	990	1.3	0.36	0.65
Octanal <n->	8.404	995	-	0.13	-
Phellandrene <α->	8.462	1001	-	0.12	-
Carene <δ-3->	8.576	1013	0.12	0.12	0.11
Cymene <p->	8.65	1021	2.7	3.46	2.68
D-Limonene	8.703	1026	1.86	1.44	1.64
Cineole <1,8->	8.74	1030	9.33	9.67	7.99
Terpinene <γ->	8.977	1056	0.29	0.34	0.23
Sabinene hydrate <cis->	9.096	1069	0.39	0.12	0.33
Mentha-3,8-diene <p->	9.21	1081	0.17	0.08	0.15
Tolualdehyde <p->	9.263	1087	0.14	-	0.15
Camphenone <6->	9.327	1093	-	0.29	-

Name	**Retention Time**	**Retention Index**	**Capsule**	**Seeds**	**W/fruit**
Nonanal	9.365	1097	-	0.81	-
α-Campholenal	9.61	1127	0.06	0.17	0.07
Nopinone	9.742	1143	-	0.37	-
Menthatriene <1,3,8-p->	9.768	1146	0.73	-	0.68
Pinocarvone	9.94	1166	0.49	0.71	0.54
Terpinen-4-ol	10.078	1183	0.09	0.24	0.07
Myrtenal	10.216	1199	0.6	1.27	0.57
D-Verbenone	10.309	1212	0.07	0.15	0.07
δ-Elemene	11.257	1340	0.28	0.75	0.12
Longipinene <α->	11.348	1353	-	0.14	-
Nepatalactone (Z,E)	11.471	1371	-	0.25	-
Copaene <α->	11.577	1386	0.54	2.55	0.45
Cubebene <β->	11.644	1395	0.2	-	-
Bergamotene <α-trans->	11.909	1435	-	0.77	-
Farnesene <(Z)-β->	11.986	1446	-	0.3	-
Curcumene <γ->	12.23	1483	-	0.32	-
Germacrene D	12.302	1494	0.1	0.31	
Bisabolene <(z)-α->	12.39	1508	-	0.25	-
Macrocarpene <αr->	12.496	1524	-	0.2	-
Calamenene <cis->	12.533	1530	-	0.08	-

There is need for grades and standards to be established on these and other spices as that could facilitate increased access to new markets and provide confidence to buyers that the Non-Timber Forest Products will be consistent and defined. As there is a lack of standardization and quality controls, we propose the following initial standards for *X. aethiopica* to provide the users, buyers and the international community with consistent and defined products (Table 8.8). These standards however reflect a conservative approach to the *X. aethiopica* product and should allow many producers to more than meet the proposed levels.

Table 8.10. Proposed quality standards dried fruits of *Xylopia aethiopica*; adopted from Juliani *et al.* (2008)

Characteristic	Requirement
Color	Brown, brown/reddish
Aroma	Spicy, woody, free from foreign odors
Taste	Slightly spicy
Excreta (mammalian and others)	Practically free
Extraneous foreign matter (%, m/m) maximum	1
Fine particles (%, m/m) maximum	1
Moisture (%, m/m) maximum	10
Total ashes (%, m/m) maximum	4
Acid Insoluble ashes (%, m/m) maximum	1
Essential oil content (%, m/m) minimum	3
Total phenols (%, m/m) minimum	0.8
Antioxidant activity (%, g Trolox/100 g) minimum	3

Table 8.11. Essential oil chemical composition of *Piper guineense* seeds from Liberia

Aroma Constituents	Retention Index	Retention Time	Concentration (Rel % of Total EO)
α-pinene	939	7.764	11.2
β-pinene	978	8.207	0.1
Myrcene	984	8.279	14.9
d-3-Carene	1012	8.564	0.3
p-cymene	1031	8.743	0.1
Ocimene <(Z)-β->	1038	8.814	1.9
(E)-β-Ocimene	1050	8.925	0.5
cis-Sabinene hydrate	1073	9.136	1
Linalool	1103	9.41	2.9
Ocimene <allo->	1133	9.662	0.7
Methyl cinnamate <(Z)->	1304	11.005	1.7
Piperitol acetate <trans->	1352	11.342	0.1
Cubebene <α->	1365	11.435	0.8
Cyperene	1398	11.666	10.3
α-Gurjenene	1408	11.733	4.1
Bergamotene <α-cis->	1431	11.881	0.3
Caryophyllene <(E)->	1449	12	30
Farnesene <(E)-β->	1458	12.066	1
Muurola-4(14),5-diene <cis->	1471	12.147	0.2

Aroma Constituents	Retention Index	Retention Time	Concentration (Rel % of Total EO)
Muurola-3,5-diene <trans->	1475	12.177	0.2
Humulene <α->	1484	12.237	4
Amorphene <γ->	1495	12.311	0.6
Germacrene D	1508	12.391	6.1
Bicyclogermacrene	1518	12.458	5.4
Cadinene <δ->	1524	12.492	3.8
Cadina-1,4-diene <trans->	1539	12.587	1.6
Elemol	1550	12.656	0.1
Nerolidol <trans->	1555	12.692	0.2

Results that were obtained using the Shimadzu GC/MS indicated differences in the chemical volatile compositions in the seeds of *Piper guineense*; with the seeds of *P. guineense* emitting volatiles characterized by high levels of Caryophyllene <(E)-> (30%), Myrcene (14.91%), α-Pinene (11.21%), and Cyperene (10.3%). Others include Germacrene D (6.1%), Bicyclogermacrene (5.4%), α-Gurjenene (4.1%), Humulene <α-> (4%), Cadienene <δ-> (3.8%), Linalool (2.9%), Ocimene <(Z)-β-> (1.9%), Methyl cinnamate <(Z)-> (1.7%), Cadina-1,4-diene <trans-> (1.6%), cis-Sabinene hydrate (1%), and Farnesene <(E)-β-> (1%). Thirteen other aroma constituents were found in lower levels (<1%) as a relative % concentration of total essential oil (Tables 8.10).

The aromatic volatile constituents and the relative percentage concentrations of the seeds of *Aframomum melegueta* from Ghana and Liberia were characterized using SH Shimadzu GC/MS. The *A. melegueta* sample obtained from Ghana showed less amount of total volatile constituents compared to those of the samples obtained from Liberia, with more than two times more the numbers of total volatile constituents characterized from the *A. melegueta* samples from Liberia (Table 8.12 and Table 8.13). From the sample obtained from Ghana, high levels of relative percent concentration of total essential oil were recorded in Cumacrene (51.31%) and Caryophyllene <(E)-> (13.79%), while 1,8-Cineole (14.64%) showed high levels of relative percent of total essential oil from the 2010 compared to the 2009 sample (8.52%) obtained from Ghana (Table 8.12). Similarly, there were high levels of relative percent concentration of total essential oil content of Bergamotene <α-trans-> (31.8%, 35.83%, 33.74%), Ylangene <α-> (10.37%, 11.56%, 9.43%), Farnesene <(E)-β-> (7.86%, 8.52%, 8.16%), trans-Muurola-4(14),5-diene (7.65%, 8.16%, 8.65%), and Cadinene <γ-> (6.88%, 7.58%, 7.9%) recorded in the *A. melegueta* samples from Monrovia, Jenepleta and Gbarnga markets, respectively, in Liberia; with the sample from the Jenepleta market emitting the highest of the three in the content of Bergamotene <α-trans-> and Ylangene <α-> (Table 8.13). Others emitting volatile composition with relative percent concentrations of total essential oil more than 1% from either one or more market areas include Copaene <β->, Cumacrene, α-Humulene, Nepetalactone [Z,Z], Cadinene <δ->, Camphenone <6->, Pinene <β->, Germacrene D, Cineole <1,8->, Cuprenene <δ->, Cubebene <α->, and Cymene <p->. All others emitted relative percent concentration lower than 1% (Table 8.13).

Table 8.12: Chemical composition and relative percentage concentrations of seeds of *Aframomum melegueta* obtained from Ghana in 2009 and 2010

Name	Retention Time	Retention Index	2009 % Conc.	2010 % Conc.
Heptanol <2->	7.225	894	1.22	2.3
Pinene <β->	8.181	976	0.09	0.11
Cineole <1,8->	8.738	1030	8.52	14.64
Ocimene <(E)-β->	8.842	1041	-	0.33
trans-Linalool oxide (furanoid)	9.245	1085	0.93	0.83
Camphenone	9.333	1094	3.95	2.77
Fenchocamphorone <α->	9.452	1108	0.42	0.39
Methyl octanoate	9.523	1116	0.06	-
Decanal <n->	10.222	1200	0.59	1.14
Isobornyl acetate	10.802	1277	0.34	0.33
Copaene <α->	11.543	1381	-	0.06
Cubebene <β->	11.587	1387	0.11	0.24
Elemene <β->	11.655	1397	0.09	0.09
Caryophyllene<(E)->	11.92	1436	31.79	28.73
Cumacrene	12.157	1472	51.31	44.11
Amorpha-4,7(11)-diene	12.243	1485	-	0.13
Thujaplicin <γ->	12.25	1486	0.09	-
Bulnesene <α->	12.459	1519	-	3.3
Cadienene <δ->	12.506	1526	0.13	0.24
Caryophyllene oxide	12.98	1601	0.09	0.06
Bisaboladien-4-ol <2,(7Z)->	13.145	1628	0.27	0.2

Table 8.13: Chemical composition and relative percentage concentrations of seeds of *Aframomum melegueta* obtained from three market areas (Monrovia, Jenepleta and Gbarnga markets) in Liberia

Name	Retention Time	Retention Index	Monrovia % Conc.	Jenepleta % Conc.	Gbarnga % Conc.
Octene <(2Z)->	5.964	808	0.11	0.22	0.29
Octene <(2E)->	6.026	812	-	-	0.04
Tricyclene	7.559	921	0.25	-	921
Pinene <α->	7.657	930	0.96	0.42	0.62
Sabinene	8.115	970	0.23	0.08	0.13
Pinene <β->	8.182	976	1.74	0.45	0.83
Menthadiene	8.31	987	0.18	-	-
Phellandrene <α->	8.474	1002	0.66	0.53	0.5
Mentha-1(7),8-diene <p->	8.505	1005	-	0.23	-
Carene <δ-3->	8.51	1006	0.25	-	0.22
Terpinene <α->	8.59	1014	0.04	-	-
Cymene <p->	8.658	1022	1.07	0.4	0.6
Limonene	8.712	1027	0.97	0.53	-
Cineole <1,8->	8.744	1031	1.89	1.64	1.88
Ocimene <(E)-β->	8.842	1041	0.18	0.24	0.09
Camphenone <6->	9.334	1094	2.39	1.92	1.8
Thujanol <iso-3->	9.653	1132	0.03	-	-
Nopinone	9.755	1144	0.03	-	-
Dihydro carveol	10.193	1197	0.09	-	-
Myrtenal	10.223	1200	0.15	-	-
Dihydro carveol <iso->	10.319	1213	0.07	-	-
Piperitone	10.67	1259	0.06	-	-
Carvenone	10.71	1265	0.15	0.1	-

Name	Retention Time	Retention Index	Monrovia % Conc.	Jenepleta % Conc.	Gbarnga % Conc.
Linalool propanoate	11.268	1341	0.82	0.74	0.67
Cubebene <α->	11.358	1354	1.13	1.12	1.15
Copaene <α->	11.481	1372	0.07	-	-
Ylangene <α->	11.588	1387	10.37	11.56	9.43
Nepetalactone [Z,Z]	11.655	1397	4.99	5.5	5.3
Copaene <β->	11.823	1422	1.19	1.18	0.98
Caryophyllne <(E)->	11.92	1436	31.8	35.83	33.74
Farnesene <(E)-β->	11.996	1448	7.86	8.52	8.16
Alloaromadendrene	12.095	1463	0.65	0.64	0.61
α-Humulene	12.157	1472	5.23	4.91	6.1
Germacrene D	12.239	1485	1.73	1.6	1.78
Trans-Muurola-4(14),5-diene	12.312	1496	7.65	8.16	8.65
Cadinene <γ->	12.398	1509	6.88	7.58	7.9
Cadinene <δ->	12.508	1526	4.35	4.3	4.96
Cuprenene <δ->	12.611	1543	1.14	0.89	1.2
Germacrene B	12.703	1557	0.75	0.18	0.25
Thujopsan-2-α-ol	12.829	1577	0.85	0.66	0.76
Caryophyllene oxide	12.9	1588	-	-	0.03
Cinnamaldehyde <hydro->	12.981	1601	0.67	0.2	0.71
Atlantol <β->	13.05	1612	0.06	-	-
Humulene oxide I	15.58	2049	-	-	0.06

8.4 Conclusion

The strengthening of current culinary uses and local uses along the value chain as well as the development of new products from spices such as *Piper guineense, Xylopia aethiopica* and *Aframomum melegueta* requires various standard controls that set the qualification of the product. These are often related to cleanliness are product definition and as such would include macroscopic analytical profiling, such as seed color and aroma, particulate matters as foreign particle and botanical dust, moisture level, total ash content, and mass distribution of the product, as well as chemical characteristic profiling, such as protein analysis, total fats analysis, bulk density, total phenol analysis, optical density, and the essential oil chemical composition analysis. With these trade standards which could be used in the establishment of grades, the spice products from the both countries can be developed into well defined products for international commercial markets for food, flavors, beverages and personal care products. Results from the chemical analysis of the aroma from the three Liberian spices were promising for each spice and that can encourage the development of value-added products and new plant-based products. The study also showed that there was chemistry and nutritional values of Liberian spice products, *X. aethiopica* and *P. guineense*.

The results demonstrated that from an aroma chemistry perspective the spicy and minty fresh notes of the various spices from Ghana and Liberia are due to the levels of pinenes and 1,8 cineole that are emitted, respectively, which are the basis for their use as condiments with enhanced sensory profiles. This study also suggests that the seed can then provide fresh 1.8 cineole notes to a spice blend. Future sensory studies are needed to determine whether the seeds will have better acceptance by consumer than the whole pods.

This study also demonstrates the potential new uses for the parts of *Xylopia aethiopica* dried fruits as well as the seeds of *Piper guineense* and *Aframomum melegueta* based on the chemical compositions of their volatile oils. Further, the West African black pepper (*P. guineense*) may be of interest in blending with the traditional black pepper (*P. nigrum*) as well as a nice spice on its own. The Grains of paradise (*A. melegueta*) from Liberia may be of particular interest for the potential development of new uses, due to its numerous volatile aromatic constituents characterized, many of which are found in other spices including *P. guineense* and *X. aethiopica*.

The use of the static headspace (SH) Shimadzu instrument, linked to sensitive GC/MS, provides fast and efficient ways to drive the development of new plant products.

9 Chapter IX: Conclusion and Recommendations

9.1 Conclusion

The value and importance of NTFP is widely recognized, as there is the need to address economic and environmental approaches for the development and sustainable exploitation of Liberian NTFP that can build upon promoting biodiversity conservation, management of community-based forests, economic growth and trade development while ensuring NTFP sustainability. Addressing these approaches can create potential for natural products commercialization in local, regional and international markets, with returns of socio-economic development and livelihood sustenance as well as income generation for rural communities. Such benefits enhance rural economies and contribute to poverty alleviation, thus supporting the national Liberia Poverty Reduction Strategy plan (PRS, 2008).

Studies in the approaches for sustainable management and development of NTFP is important, considering the wide range of forest products coupled with the lack of basic knowledge about their sustainability and potential for commercialization. While it is clear that NTFP are of great importance to rural communities in Liberia, as the majority of these communities depend on forest products for their subsistence and income generation, creating a development and management programs for the sustainability of NTFP provides an added value to rural livelihoods and the conservation of biodiversity. These studies while considering an economic perspective, focus on the biological and environmental management approach advocated for the sustainability and development of forest resources, considering longer-term benefits of the resources to local community livelihoods from sustainable forest management and conservation of biodiversity. The studies not only provide and contribute toward scientific, ecological and traditional knowledge of forest resources in Liberia, but also strongly emphasize the need to integrate sustainable harvest systems in forest management programs for sustainability and development of NTFP. The application of good forest management practices unquestionably assists to maintain the value of forests as sources of its products, while helping to maintain biodiversity conservation and ecosystem function.

This study investigated local knowledge on the traditional use of Liberian NTFP in 82 local communities within seven counties in Liberia. The assumption that traditional knowledge on use of NTFPs is essential in the development and sustainability of the NTFP industry as a potential contributor to the livelihood of rural communities showed that local communities are knowledgeable about the traditional use of their many of their NTFP. The majority of local plant uses are for medicinal purposes that meet their health needs, followed by edible plants as food, and building materials and fibers that serve the need of shelter. A relatively equal number of male to female respondents showed that both genders are the repositories of traditional knowledge in the ethnobotany of local NTFP in Liberia. However, the low number of young people and their supposedly lack of interest poses critical concerns for continuous generational transfer of such wealth of local knowledge on natural resource utilization. This suggests a continual documentation of the wealth of knowledge that is bestowed in the minds of the elderly about the use of local resources, so as to pass such knowledge on to many more generations via documentation. The documentation of the traditional use of Liberian NTFP is essential in the conservation management and sustainable use of the biological resources. This also provides a means for the appreciation of the economic potential and importance to rural communities for the delivery of adequate policy to develop practical management programs for NTFP sector in Liberia.

The concept that traditional collection and harvesting practices of local communities meet their livelihood needs but may have adverse impact on plant species population and biodiversity can be seen through the unsustainable collection practices of rural communities in the harvest of important products from the wild. Often as harvesting satisfies the livelihoods of rural communities, they create challenges should the demand grow, wild collection grow and without an awareness and practical solution to a sustainable system of collection there could be loss of biodiversity and/or decline in species population in a particular location. These challenges are often due to lack of knowledge about sustainability, which can be mitigated through the shared traditional knowledge to that of the scientific knowledge on sustainability of NTFP. Traditional knowledge helps to understand the nature and concept of harvest practices and paves the way for sustainable management and development of NTFP. Knowledge on best collection practices highlights promising directions for the management and sustainability of NTFP to provide longer-term economic benefits to beneficiaries.

The assumption that sustainable exploitation of NTFPs can provide a stimulus to the conservation of forest biodiversity and increased longer-term economic benefits for forest-dwelling people can be validated through changes in behavior patterns of local collectors towards sustainable harvesting practices that create a win-win situation wherein collector earn continuous harvesting yields while the forest biodiversity is conserve. This assumption is only valid if the adoption toward a sustainable harvest is practical, easy and without local barriers. Good collection practices for medicinal plants should follow the overall guidelines promoted and recommended by the WHO (2003) and the studies presented here provide specific details as to the development of sustainable harvesting practices for Liberian NTFP using Country Spice, Bush Pepper and Griffonia as the case studies. It is presumed that local methods of harvesting may yield less and possibly lead to destruction and/or wastefulness of plant populations, which may lead to population decline and loss overtime all because of lack of knowledge of a better harvesting method. Thus, the training of local collectors to follow sustainable harvesting practices that minimize damage to plants and their populations and yet generate maximum yield has huge impact on sustainability that leads to conservation and continuous yield production. Hence, a change in behavior patterns towards sustainable collection of NTFPs ensures the preservation of forest biological diversity, with a longer-term benefit of productivity and continuous income. Should the recommendations for sustainable harvest be costly, overly difficult or culturally foreign, the probability of adoption and thus, behavior change is reduced drastically and it then becomes more of a theoretical argument than a real solution that collectors, growers and agents can all accept and promote.

The commercial extraction of NTFP that adds value to the forest provides an incentive to conservation and sustainability of forest management. This is viewed through the value chain of NTFP which is important in providing knowledge in factors for income generation across all stakeholders. Selected NTFP have socio-economic and commercial potential for local, regional, and international markets; their development can contribute to rural economic development, thereby contributing to poverty alleviation and the promotion of forest biodiversity conservation through sustainability and forest management. The fact that women are not as involved as men in the higher levels of value chain of NTPF, and that the majority of participants in the value chain have high school degree provided and important argument that promoting formal education of both men and women will contribute to the commercialization of NTFP in Liberia, as educated agents will drive the demand of NTFP that would be eventually covered by collectors.

Ecological survey is fundamental to the assessment of the conservation status of wild populations, and prerequisite for addressing harvesting sustainability of major or target species. It is known that policies are based on assessment and knowledge of particular situation or commodity. The undertaking of ecological surveys that concentrate on the distribution, abundance and population structures of important plant species is essential to valuating the conservation status of such wild populations, and prerequisite for addressing harvesting sustainability of key species. Hence, a comprehensive information about the state and dynamics of the plant species is necessary for strategic and management planning. The provision of reliable information can help decision makers concerning the potential for sustainable development and management of the plant species.

Forest enrichment planting ensures increases in population of plant species and the conservation of forest biodiversity. This can be seen in the germination and introduction of plant seedlings into natural habitat to increase population and yield production. This creates the potential for the alleviation of growing threats on natural population as well as potential for meeting increasing demands for product supply, all of which promotes genetic preservation and conservation of forest biodiversity.

Chemical analysis and development of standards for local products creates potential for commercialization and contribute to developing new products. The physicochemical characteristic compositions of local plant products is necessary for the development of quality of consumed products. While it is true that there may be major disadvantages of plant products due to lack of standardization and quality control, products with defined quality standards may have better entrance to more markets and with potential to capture interest in the market. Products that come to industry with product specifications sheets and backed-up scientific information from experience are known to capture higher value and higher returns for the traders and communities. Hence, chemical profiling and an appreciation of quality can lead to the creation of national standards for potential market and development of new products and provide confidence to the buyers when sourcing from new regions such as Liberia.

The development of new products from spices such as *Piper guineense* and *Xylopia aethiopica* requires various standard controls that set the qualification of the product. These may include macroscopic analytical profiling, such as seed color and aroma, particulate matters as foreign particle and botanical dust, moisture level, total ash content, and mass distribution of the product, as well as chemical characteristic profiling, such as protein analysis, total fats analysis, bulk density, total phenol analysis, optical density, and the essential oil chemical composition analysis. With these trade standards, the spice products from the both countries can be developed into product for international commercial markets as cuisine. Additionally, with the quality of the essential oil chemical characteristics, *Xylopia aethiopica* is a promising product and the development of new plant product is certain.

9.2 Recommendations

To achieve successful sustainable development and management of NTFP, and to ensure the benefits re realized in the long term for rural community economies, the following are recommended:

- A development of NTFP industry to include local communities for sustainable management of plant resources is needed;
- Capacity building and development to include local farmers, youths and women to assess and monitor sustainability and conservation status of NTFP;
- The market chain of commercial potential NTFP needs to be formalized, strengthened and promoted by public policy especially the spice and medicinal plant trades that have become highly commercialized;

- The socio-economic conditions of rural people dependent on forest resources need to be improved so as to have successful development and management systems of sustainable harvesting and a meaningful reduction in uncontrolled and unsustainable collection of NTFP;
- Participatory researches to integrate indigenous as well as scientific knowledge regarding the uses, value, ecological requirements, and regeneration of potential income generating NTFP;
- Organization dealing with the conservation biodiversity, together with government agencies and private sectors, must provide practical and innovative contributions that increase value to NTFP products;
- Continue to document traditional knowledge in various aspects of NTFP and to involve the younger generation through media and academic levels;
- Examination and follow-up studies needs to be done for the enrichment planting to assess continual survival and production of introduced plant species in new natural habitat, with further research to ascertain opportunity of yield optimization and uniform high quality product;
- Good forest governance to be ensured by the government with participation of local communities, together with clear proper law enforcement and tenure rights, which plays essential role for the sustainability of NTFP;
- Inclusion of women, youths and farmers in policies relating to the sustainable development and management of forest and NTFP at the local community levels;
- Sustainable harvesting techniques be provided through training and capacity building programs first to agents and subagents, who are the ones that will drive the demand for

the promotion of change in behavior patterns of local collectors that leads to increased benefits on both sides of the community and the forest at large;

- Training of NTFP collectors about forest ecology and the adverse impacts of unsustainable harvesting for conservation and sustainability of local livelihoods is paramount to the development of sustainable NTFP programs;
- To mobilize and educate local communities for sustainable use and proper management of different plant products, through proper awareness programs and projects;
- That NTFPs ventures be included in youth and gender empowerment programs, so as to encourage youths and women in NTFP initiatives, while enhancing livelihood strategies of communities that are dependent on forest products;
- The integration of potential marketable NTFPs into farming systems to improve on the farmer's yearly income and to draw lesson upon which to build further research and policy development;
- The knowledge of traditional resources and their importance and management be disseminated to the public through schools, and mass media so as to harness more resources in a sustainable manner; and
- The need for researchers, forest managers, and the government to work with local harvesters in designing and evaluating management practices that can mitigate negative effects of NTFP harvest to promote sustainability and forest conservation.

10 Chapter X: Bibliography

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Appendixes

Appendix A. Ethnobotanical Survey on the Use of NTFP

Graduate Student Research Project

Department of Plant Biology and Pathology
School of Environmental and Biological Sciences
Rutgers, The State University of New Jersey
New Brunswick, NJ, 08901

Ethnobotanical Survey on Use of NTFP

Demographics

1. Name: ____
   First   Middle   Last
2. Gender: ________ Ethnicity: _______________ Nationality: _________________
   (Male/Female)
3. Please indicate your age category: ☐ Under 20; ☐ 21-35; ☐ 36-50; ☐ 51-65; ☐ Over 65
4. Marital status: ☐ Single; ☐ Engaged; ☐ Married; ☐ Widow/Widower; ☐ Divorce
5. How many years have you been living at your current place or residence? ____years
6. Please indicate the highest level of education you have completed.
   ☐ No formal schooling ☐ Elementary school ☐ Up to high school
   ☐ 2 year college degree ☐ 4 year college degree ☐ Graduate degree
7. Which of the following best describes your primary occupation?
   ☐ Retired ☐ Self-employed ☐ Employed by others
   ☐ Homemaker ☐ Farmers ☐ Others ______________
8. Location/Residence: ______________________ _________________________
   Town/village   County
9. Number of persons, including yourself, in your household ___________________.
10. Number of persons aged 17 and younger in your household _________________.
11. Please indicate Annual-Income category of your household before taxes.
    ☐ $ Less than 1,000; ☐ $ 1,000 - 3,999; ☐ $ 4,000 – 5,999; ☐ $ 6,000 - 7,999;
    ☐ $ 8,000 – 9,999; ☐ $ 10,000 – 29,999; $ 30,000 – 50,000; ☐ $ 50,001 – 100,000.

Signed: ________________________________ Date: ________________________
(Signature)

Ethnobotanical Survey Questionnaire on Use of NTFP

12. Name of NTFP: ________________________ __________________________________
(Local name) (If known, Scientific name)
13. Type of plant: tree [ ]; shrub [ ]; vine [ ]. Estimated height (inches/ft.): ________
14. Part of plant used: leaves [ ]; seeds [ ]; stems [ ]; bark [ ]; roots [ ]; entire plant [ ]
15. Main Uses of the plant: Food [ ]; Medicine [ ]; Spice [ ]; Building [ ]; Others ____
16. How effective is its use? Very effective [ ]; normal effective [ ]; less effective [ ]
17. Collection/harvesting method(s): pick from ground [ ]; cut to get [ ]; climb to get [ ]; use stick [ ]
18. Who mainly collect the product? Women [ ]; Men [ ]; Children [ ]; only w/c [ ]; all [ ]
19. Who in charge of product? Collection: M [ ]; F [ ]; Processing: M [ ]; F [ ]
20. Demand for product: Extremely high [ ]; high [ ]; normal flow [ ]; upon request [ ]
21. Habitat where product is collected: Forest [ ]; high bush [ ]; farmland [ ]; swamp [ ]; backyard [ ]
22. Where do you get product from? Purchase from market [ ]; collect from forest [ ]
23. Season of collection during the year: Jan. Feb. Mar. Apr. May. Jun. Jul. Aug. Sept. Oct. Nov. Dec.
24. Frequency of Collection: daily [ ]; weekly [ ]; biweekly [ ]; monthly [ ]; quarterly [ ]
25. Effect on population development: Decreasing [ ]; Increasing [ ]; No change [ ]
26. Quantity used for home consumption: <10% [ ]; 11 – 25%[ ]; 26 – 50% [ ]; 51 – 85% [ ]; 86 – 100% [ ]
27. Quantity sold: <10% [ ]; 11 – 25%[ ]; 26 – 50% [ ]; 51 – 100% [ ]; >100% [ ]
28. Sale price per kg: L$ 5-50 [ ]; L$55-100 [ ]; L$105-150 [ ]; L$155-200 [ ]; L$205-250 [ ]; >250 [ ]
29. Sustainability impact from income generation: provide 75% of needs [ ]; 50% of needs [ ]; 25% [ ]
30. Is it cultivated, or only found in the wild? Cultivated [ ]; only in the wild [ ]; both [ ]
31. Degree of availability: Easy: < 1hr walk [ ]; difficulty: 1–3hrs walk [ ]; very difficult; > 3hrs walk [ ]
32. Estimated quantity in forest: Low: < 1ton [ ]; medium: 1–3tons [ ]; high: > 3tons [ ]
33. Threats affecting product: Farming [ ]; logging [ ]; cutting it down [ ]; mining [ ]; none [ ]
34. Major trading partners: Direct to consumers [ ]; retailers/wholesales [ ]; intermediators/commission agent [ ]; processing company [ ]

Appendix B. Ethnobotanical Survey on the Collection of NTFP

RUTGERS UNIVERSITY

Graduate Student Research Project
Department of Plant Biology and Pathology
School of Environmental and Biological Sciences
Rutgers, The State University of New Jersey
New Brunswick, NJ, 08901

Ethnobotanical Survey on Collection of NTF

Demographics

1. Name: ____
   First Middle Last
2. Gender: _______ Ethnicity: ________________ Nationality: ________________
   (Male/Female)
3. Please indicate your age category: ☐ Under 20; ☐ 21-35; ☐ 36-50; ☐ 51-65; ☐ Over 65
4. Marital status: ☐ Single; ☐ Engaged; ☐ Married; ☐ Widow/Widower; ☐ Divorce
5. How many years have you been living at your current place or residence? ____years
6. Please indicate the highest level of education you have completed.
   ☐ No formal schooling ☐ Elementary school ☐ Up to high school
   ☐ 2 year college degree ☐ 4 year college degree ☐ Graduate degree
7. Which of the following best describes your primary occupation?
   ☐ Retired ☐ Self-employed ☐ Employed by others
   ☐ Homemaker ☐ Farmers ☐ Others ______________
8. Location/Residence: ________________________ ________________________
   Town/village County
9. Number of persons, including yourself, in your household ___________________.
10. Number of persons aged 17 and younger in your household _________________.
11. Please indicate Annual-Income (USD) category of your household before taxes.
    ☐ $ Less than 1,000; ☐ $ 1,000 – 3,999; ☐ $ 4,000 – 5,999; ☐ $ 6,000 – 7,999;
    ☐ $ 8,000 – 9,999; ☐ $ 10,000 – 29,999; $ 30,000 – 50,000; ☐ $ 50,001 – 100,000.

Signed: ______________________________ Date: __________________________
(Signature)

ETHNOBOTANICAL SURVEY ON THE COLLECTION OF NTFP

12. Rate these four plant in the order of commonly used types

Rate: 1 = most commonly used; 2 = commonly used; 3 = used once a while; 4 = less used

a. **Griffonia** (*Griffonia simplicifolia*)
b. **Bush pepper** (*Piper guineense*)
c. **Country spice** (*Xylopia aethiopica*)
d. **Grain of Paradise** (*Aframomum melegueta*)

13. How do you harvest/collect these four common things from the forest?
    a. **GS:** pick fallen parts from ground [ ]; cut to get [ ]; use pole/stick to get [ ]; other _____________
    b. **BP:** pick fallen parts from ground [ ]; cut to get [ ]; use pole/stick to get [ ]; other _____________
    c. **CS:** pick fallen parts from ground [ ]; cut to get [ ]; use pole/stick to get [ ]; other _____________
    d. **GOP:** pick fallen parts from ground [ ]; cut to get [ ]; use pole/stick to get [ ]; other _____________
14. Who are mainly involved in collecting these plants from the forest?
    a. **GS:** female [ ]; male [ ]; both [ ] c. **CS:** female [ ]; male [ ]; both [ ]
    b. **BP:** female [ ]; male [ ]; both [ ] d. **GOP:** female [ ]; male [ ]; both [ ]
15. Part of plant used:
    a. **GS:** leaves [ ]; seeds [ ]; stems [ ]; bark [ ]; roots [ ]; liquid/latex [ ]; entire plant [ ]
    b. **BP:** leaves [ ]; seeds [ ]; stems [ ]; bark [ ]; roots [ ]; liquid/latex [ ]; entire plant [ ]
    c. **CS:** leaves [ ]; seeds [ ]; stems [ ]; bark [ ]; roots [ ]; liquid/latex [ ]; entire plant [ ]
    d. **GOP:** leaves [ ]; seeds [ ]; stems [ ]; bark [ ]; roots [ ]; liquid/latex [ ]; entire plant [ ]
16. How often/frequently do you collect them from the forest?
    a. **GS:** daily [ ]; biweekly [ ]; weekly [ ]; monthly [ ]; seasonal [ ], time of year ______________
    b. **BP:** daily [ ]; biweekly [ ]; weekly [ ]; monthly [ ]; seasonal [ ], time of year ______________
    c. **CS:** daily [ ]; biweekly [ ]; weekly [ ]; monthly [ ]; seasonal [ ], time of year ______________
    d. **GOP:** daily [ ]; biweekly [ ]; weekly [ ]; monthly [ ]; seasonal [ ], time of year ______________
17. Tool used for collection:
    a. **GS:** Cutlass to cut [ ]; stick to pick [ ]; hoe to dig [ ]; just pick from ground [ ]; pull whole plant out [ ]
    b. **BP:** Cutlass to cut [ ]; stick to pick [ ]; hoe to dig [ ]; just pick from ground [ ]; pull whole plant out [ ]
    c. **CS:** Cutlass to cut [ ]; stick to pick [ ]; hoe to dig [ ]; just pick from ground [ ]; pull whole plant out [ ]
    d. **GOP:** Cutlass to cut [ ]; stick to pick [ ]; hoe to dig [ ]; just pick from ground [ ]; pull whole plant out [ ]
18. How do you process your product?
    a. **GS:** Dry it in the sun [ ]; Leave it fresh and store [ ]; Pick for sale directly [ ]; Dry it on fire [ ]
    b. **BP:** Dry it in the sun [ ]; Leave it fresh and store [ ]; Pick for sale directly [ ]; Dry it on fire [ ]
    c. **CS:** Dry it in the sun [ ]; Leave it fresh and store [ ]; Pick for sale directly [ ]; Dry it on fire [ ]
    d. **GOP:** Dry it in the sun [ ]; Leave it fresh and store [ ]; Pick for sale directly [ ]; Dry it on fire [ ]
19. Difficulty to collect these things from the forest:
    a. **GS:** easy/< 1hr walk [ ]; difficulty/= 1–3hrs walk [ ]; very difficult/ > 3hrs walk [ ]
    b. **BP:** easy/< 1hr walk [ ]; difficulty/= 1–3hrs walk [ ]; very difficult/ > 3hrs walk [ ]
    c. **CS:** easy/< 1hr walk [ ]; difficulty/= 1–3hrs walk [ ]; very difficult/ > 3hrs walk [ ]
    d. **GOP:** easy/< 1hr walk [ ]; difficulty/= 1–3hrs walk [ ]; very difficult/ > 3hrs walk [ ]
20. How is the population development of these plants in the forest?
    a. **GS:** decreasing [ ]; no change [ ]; increasing [ ]
    b. **BP:** decreasing [ ]; no change [ ]; increasing [ ]
    c. **CS:** decreasing [ ]; no change [ ]; increasing [ ]
    d. **GOP:** decreasing [ ]; no change [ ]; increasing [ ]
21. Threats affecting these plants in the forest:
    a. **GS:** farming [ ]; logging company [ ]; individual cutting it down [ ]; mining [ ]; none [ ]
    b. **BP:** farming [ ]; logging company [ ]; individual cutting it down [ ]; mining [ ]; none [ ]

c. **CS:** farming [ ]; logging company [ ]; individual cutting it down [ ]; mining [ ]; none [ ]
d. **GOP:** farming [ ]; logging company [ ]; individual cutting it down [ ]; mining [ ]; none [ ]

22. Sale price per kilogram in Liberian dollars:
    a. **GS:** 5 – 50LD [ ]; 55 – 100LD [ ]; 105 – 150LD [ ]; 150 – 200LD [ ]; >200LD [ ]
    b. **BP:** 5 – 50LD [ ]; 55 – 100LD [ ]; 105 – 150LD [ ]; 150 – 200LD [ ]; >200LD [ ]
    c. **CS:** 5 – 50LD [ ]; 55 – 100LD [ ]; 105 – 150LD [ ]; 150 – 200LD [ ]; >200LD [ ]
    d. **GOP:** 5 – 50LD [ ]; 55 – 100LD [ ]; 105 – 150LD [ ]; 150 – 200LD [ ]; >200LD [ ]
23. Quantity of NTFP collected per visit (in Kilogram):
    a. **GS:** 1 – 5kg [ ]; 6 – 10kg [ ]; 11 – 20kg [ ]; 21 – 30kg [ ]; 31 – 50kg [ ]; above 50kg [ ]
    b. **BP:** 1 – 5kg [ ]; 6 – 10kg [ ]; 11 – 20kg [ ]; 21 – 30kg [ ]; 31 – 50kg [ ]; above 50kg [ ]
    c. **CS:** 1 – 5kg [ ]; 6 – 10kg [ ]; 11 – 20kg [ ]; 21 – 30kg [ ]; 31 – 50kg [ ]; above 50kg [ ]
    d. **GOP:** 1 – 5kg [ ]; 6 – 10kg [ ]; 11 – 20kg [ ]; 21 – 30kg [ ]; 31 – 50kg [ ]; above 50kg [ ]
24. How many visits per month? (# of times):
    a. **GS:** 1 – 2 [ ]; 3 – 5 [ ]; 6 – 10 [ ]; 11 – 15 [ ]; 16 – 20 [ ]; above 20 [ ]
    b. **BP:** 1 – 2 [ ]; 3 – 5 [ ]; 6 – 10 [ ]; 11 – 15 [ ]; 16 – 20 [ ]; above 20 [ ]
    c. **CS:** 1 – 2 [ ]; 3 – 5 [ ]; 6 – 10 [ ]; 11 – 15 [ ]; 16 – 20 [ ]; above 20 [ ]
    d. **GOP:** 1 – 2 [ ]; 3 – 5 [ ]; 6 – 10 [ ]; 11 – 15 [ ]; 16 – 20 [ ]; above 20 [ ]
25. Which month do you see a high quantity of collection per visit? (choose all that apply):
    a. **GS:** Jan☐; Feb☐; Mar☐; Apr☐; May☐; Jun☐; Jul☐; Aug☐; Sept☐; Oct☐; Nov☐; Dec☐
    b. **BP:** Jan☐; Feb☐; Mar☐; Apr☐; May☐; Jun☐; Jul☐; Aug☐; Sept☐; Oct☐; Nov☐; Dec☐
    c. **CS:** Jan☐; Feb☐; Mar☐; Apr☐; May☐; Jun☐; Jul☐; Aug☐; Sept☐; Oct☐; Nov☐; Dec☐
    d. **GOP:** Jan☐; Feb☐; Mar☐; Apr☐; May☐; Jun☐; Jul☐; Aug☐; Sept☐; Oct☐; Nov☐; Dec☐
26. Marketable quantity of NTFPs (in percentage):
    a. **GS:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
    b. **BP:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
    c. **CS:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
    d. **GOP:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
27. Consumable quantity of NTFPs (in percentage):
    a. **GS:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
    b. **BP:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
    c. **CS:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
    d. **GOP:** 90 – 100% ☐; 76 – 89%☐; 51 – 75%☐; 31 – 50%☐; 21 – 30%☐; 11 – 20%☐; 0 – 10%☐
28. On average, how many of your family members take part in the collection of NTFPs per visit?
    a. **GS:** [________]; b. **BP:** [________]; c. **CS:** [_______]; d. **GOP:** [________]
29. Has any of these been cultivated?
    a. **GS:** YES [ ]; NO [ ] b. **BP:** YES [ ]; NO [ ]; c. **CS:** YES [ ]; NO [ ]; d. **GOP:** YES [ ]; NO [ ]
30. What is the major purpose of collecting NTFPs:
    a. **GS:** Food [ ]; Medicine [ ]; Spice [ ]; Building [ ]; Income [ ]; Others ________________
    b. **BP:** Food [ ]; Medicine [ ]; Spice [ ]; Building [ ]; Income [ ]; Others ________________
    c. **CS:** Food [ ]; Medicine [ ]; Spice [ ]; Building [ ]; Income [ ]; Others ________________
    d. **GOP:** Food [ ]; Medicine [ ]; Spice [ ]; Building [ ]; Income [ ]; Others ________________
31. PERCENTAGE OF PURPOSE:
    a. GS: ________%; ________%; ________%; ________%; ________%; ________%
    b. BP: ________%; ________%; ________%; ________%; ________%; ________%
    c. CS: ________%; ________%; ________%; ________%; ________%; ________%
    d. GOP: ________%; ________%; ________%; ________%; ________%; ________%

32. Income generated from NTFPs collected:
    a. **<u>GS:</u>** 100–500LD ☐; 550–1,000LD ☐; 1,100–2,000LD ☐; 2,100–5,000LD ☐; 5,100–10,000LD ☐; >10,000LD ☐
    b. **<u>BP:</u>** 100–500LD ☐; 550–1,000LD ☐; 1,100–2,000LD ☐; 2,100–5,000LD ☐; 5,100–10,000LD ☐; >10,000LD ☐
    c. **<u>CS:</u>** 100–500LD ☐; 550–1,000LD ☐; 1,100–2,000LD ☐; 2,100–5,000LD ☐; 5,100–10,000LD ☐; >10,000LD ☐
    d. **<u>GOP:</u>** 100–500LD ☐; 550–1,000LD ☐; 1,100–2,000LD ☐; 2,100–5,000LD ☐; 5,100–10,000LD ☐; >10,000LD ☐
33. Experience in collecting NTFPs:
    a. **<u>GS:</u>** Very difficult ☐; difficult ☐; partly difficult ☐; easy ☐; very easy ☐
    b. **<u>BP:</u>** Very difficult ☐; difficult ☐; partly difficult ☐; easy ☐; very easy ☐
    c. **<u>CS:</u>** Very difficult ☐; difficult ☐; partly difficult ☐; easy ☐; very easy ☐
    d. **<u>GOP:</u>** Very difficult ☐; difficult ☐; partly difficult ☐; easy ☐; very easy ☐
34. Other means of generating income:
    a. Agriculture ☐;
    b. Livestock ☐;
    c. cash crop (cocoa, coffee ☐;
    d. palm oil sale ☐;
    e. wine (sugar cane, palm, raffia) ☐

Appendix C. Ethnobotanical Survey on the Value Chain of NTFP

Graduate Student Research Project

Department of Plant Biology and Pathology
School of Environmental and Biological Sciences
Rutgers, The State University of New Jersey
New Brunswick, NJ, 08901

<u>Ethnobotanical Survey on Value Chain of NTFP</u>

<u>Demographics</u>

1. Name: ____
   First   Middle   Last
2. Gender: ________ Ethnicity: ________________ Nationality: _________________
   (Male/Female)
3. Please indicate your age category: ☐ Under 20; ☐ 21-35; ☐ 36-50; ☐ 51-65; ☐ Over 65
4. Marital status: ☐ Single; ☐ Engaged; ☐ Married; ☐ Widow/Widower; ☐ Divorce
5. How many years have you been living at your current place or residence? ____years
6. Please indicate the highest level of education you have completed.
   ☐ No formal schooling ☐ Elementary school ☐ Up to high school
   ☐ 2 year college degree ☐ 4 year college degree ☐ Graduate degree

7. Which of the following best describes your primary occupation?
   ☐ Retired ☐ Self-employed ☐ Employed by others
   ☐ Homemaker ☐ Farmers ☐ Others ______________
8. Location/Residence: ________________________ ________________________
   Town/village   County
9. Number of persons, including yourself, in your household ___________________.
10. Number of persons aged 17 and younger in your household _________________.
11. Please indicate Annual-Income category of your household before taxes.
    ☐ $ Less than 1,000; ☐ $ 1,000 – 3,999; ☐ $ 4,000 – 5,999; ☐ $ 6,000 – 7,999;
    ☐ $ 8,000 – 9,999; ☐ $ 10,000 – 29,999; $ 30,000 – 50,000; ☐ $ 50,001 – 100,000.

Signed: ______________________________ Date: ________________________
(Signature)

Ethnobotanical Survey on Value Chain of NTFPs

12. Name of NTFP: ____________________ ________________________________
(Local name) (If known, Scientific name)
13. Type of plant: Tree [ ]; shrub [ ]; vine [ ]. Estimated height (inches/ft.): ________
14. Part of plant used: Leaves [ ]; seeds [ ]; stems [ ]; bark [ ]; roots [ ]; entire plant [ ]
15. Main Uses of the plant: Food [_%]; Medicine [__%]; Spice [_%]; Building [__%]; Others _%
16. Your position as collector: Main agent [ ]; sub-agent [ ]; community collector [ ]; local collector [ ]
17. Where do you collect product from? Market [ ]; local collector [ ]; self-harvest [ ]
18. Processing method: Dry in sun [ ]; remain fresh and store [ ]; dry with fire [ ]; sell as fresh [ ]
19. Storage method: Store in bag [ ]; in barrel [ ]; on floor [ ]; on zinc [ ]; on mat [ ]
20. Quantity collection per season: ½ –2 tons [ ]; 3–6 tons [ ]; 1 truck [ ]; =/>20ft container [ ]
21. Number of season before export: 1 season [ ]; 2 seasons [ ]; 3 seasons [ ]; ½ season [ ]
22. Transport of product to storage: In pickup [ ]; in truck [ ]; on bike [ ]; in jeep [ ]; on head [ ]
23. Location of collection: Easy = 1–2hrs. [ ]; not too easy = 3–5hrs. [ ]; difficult = 6 – 10hrs. [ ]
24. Collection type: Mature [ ]; intermediate/half-mature [ ]; green/young [ ]
25. Product kind during collection: Fully dry [ ]; half dry [ ]; fresh/raw [ ]
26. Which month product is mostly collected/purchased? (Choose all that apply):
Jan☐; Feb☐; Mar☐; Apr☐; May☐; Jun☐; Jul☐; Aug☐; Sept☐; Oct☐; Nov☐; Dec☐
27. Quantity you can handle per year (tons): 1-10 tons ☐; 11-20 tons☐; 21-30 tons☐; 31-50 tons%☐; 51-100 tons☐; >100☐
28. Export product to: Do not export [ ]; Guinea [ ]; Ivory Coast [ ]; Ghana [ ]; Oversea [ ]
29. Quantity to be exported: 2 containers [ ]; 1 container [ ]; half container [ ]; 2 trucks [ ]; 1 truck [ ]
30. Moisture quality before export: 6–9% moisture [ ]; 10% moisture [ ]; more than 10% moisture [ ]
31. Purchase price per 50kg bag (in US$): $10–30 [ ]; $35–50 [ ]; $55–70 [ ]; $75 – 100; [ ]; above $100 [ ]
32. Demand for product: 80-100%-very high [ ]; 50-79% - high [ ]; 30-49% - low [ ]; <30% very low [ ]
33. Profit on product: 200% n above [ ]; 80-100% [ ]; 50-79% [ ]; 25-49% [ ]; <25% [ ]
34. Years of experience in dealing with product: 1-4yrs [ ]; 5-10yrs [ ]; 11-15yrs [ ]; 16-20yrs [ ]; 21+yrs [ ]
35. Major trading partners: Direct to consumers [ ]; retailers/wholesales [ ]; intermediators/commission agent [ ]; processing company [ ]
36. Is there any organization/association established for collection of product? Yes [ ]; No [ ]
37. If YES, please give name of organization/association: _______________________
38. Method of sale: Power [ ]; Oil [ ]; Cream [ ]; Wood [ ]; Others ___________

Appendix D. CONSENT FORM

Descriptive Analysis of Traditional Knowledge Relating to the Use, Collection, and Value Chain of NTFPs

Principal Investigator: Larry C Hwang
Graduate Candidate (PhD)
Department of Plant Biology and Pathology
School of Environmental and Biological Sciences
Rutgers, the State University of New Jersey
65 Dudley Road, New Brunswick, NJ 08901
732-853-2653; email: larryhwang22@yahoo.com

PURPOSE: The purpose of this study is to conduct surveys to identify new uses and applications on Liberian NTFPs, by interviewing forest dwellers we are expecting to collect information on the potential economic uses of forest products for future income generating opportunities. The surveys will also serve to understand the collection methods of Non-Timber Forest Products (Griffonia simplicifolia and others) to enable the use of sustainable practices on the collection/harvesting of NTFP to provide means of conservation of various community forests in Liberia while providing income for inhabitants.

PROCEDURES: You will be asked to participate in series of structured survey questionnaires relating to the use of NTFPs, including new and/or emerging ones. During this evaluation process, trained questioners will be given the survey questions, which they will sit with you on a household basis and will ask you to answer the various questions to the best of your knowledge. Where interpretation will be needed, an interpreter will be made to interpret the question in the local dialect that you (the respondent) can better understand so as to be able to provide the best answer possible. Once the set of questions is completed, the trained questioner will then move to another household and begin similar interview, until all is completed.

RISKS: The activities you will be participating in pose no foreseeable risks to your health at all. You will only be asked to answer various questions, and no more than that.

BENEFITS: Although you will receive no direct benefits from the participation in this study, this research will provide a basic knowledge on the use of NTFPs by you, data that would be added to other existing ones, all thanks to you because of knowledge you will provide.

COMPENSATION: This study provides no monetary compensation at all.

CONFIDENTIALITY: The information collected I n this survey will be kept strictly confidential. 'Confidential' means that your name and the information that you will provide will be linked by a code number, and the code number will be used to identify your data. All data will be kept in a locked filing cabinet or on a pass-word protected computer in the Principal Investigator's Laboratory. Only research staff involved in this study or the Institutional Review Board (a committee that reviews research studies in order to protect research participants) at Rutgers University will be allowed to see the data, except as may be required by law. If a report of this study is published, or the results are presented at a professional conference, only group results will be stated. You will NOT be personally identified in any report of this research.

YOUR RIGHTS AS A RESEARCH PARTICIPANT: Your participation in this study is completely VOLUNTARY and you have the right to withdraw at any time without explanation or penalty.

DISCLAIMER: Rutgers University has made no general provision for financial compensation or medical treatment for any physical injury resulting from this research.

CONTACT INFORMATION: You can contact the Principal Investigator at the number and/or address listed above if you have any questions about this study.

If you have any questions about your rights as a research subject, you may contact the IRB Administrator at Rutgers University at:

Rutgers, the State University of New Jersey
Institutional Review Board for the Protection of Human Subjects
Office of Research and Sponsored Programs
335 George Street
Liberty Plazza/3rd Floor/Suite 3200
New Brunswick, NJ08901
Tel: 848-932-0150
Email: humansubjects@orsp.rutgers.edu

______________________________	______________________________	________________________
Name of participant	Signature of participant	Date

______________________________	______________________________
Signature of Investigator	Date

Please confirm that you received a copy of this statement for your records with your initials:
___________.
(Initials)

This informed consent form was approved by the Rutgers Institutional Review Board for the Protection of Human Subjects on **October 22, 2015;** approval of this form expires on **November 21, 2017.**

Appendix E. Rutgers IRB Approval Letter

RUTGERS

Office of Research and Regulatory (rs
Arts and Sciences IRB
Rutgers, The State University of New Jersey
335 George Street / Liberty Plaza / Suite 3200
New Brunswick, NJ 08901

orra.rutgers.edu/artsci

732-235-9806

October 26, 2015

P.I. Name: Hwang
Protocol #: E16-235

Larry C Hwang
Plant Biology and Pathology
194 Commercial Avenue
New Brunswick, NJ 08901

Dear Mr. Hwang:

This project identified below has been approved for exemption under one of the six categories noted in 45 CFR 46, and as noted below:

Protocol Title: "The Economic and Environmental Approach to the Development and Sustainability of NTFPs in Liberia"

Exemption Date: 10/22/2015 **Exempt Category:** 2

This exemption is based on the following assumptions:

- **This Approval** - The research will be conducted according to the most recent version of the protocol that was submitted.
- **Reporting** – ORSP must be immediately informed of any injuries to subjects that occur and/or problems that arise, in the course of your research;
- **Modifications** – Any proposed changes MUST be submitted to the IRB as an amendment for review and approval prior to implementation;
- **Consent Form (s)** – Each person who signs a consent document will be given a copy of that document, if you are using such documents in your research. The Principal Investigator must retain all signed documents for at least three years after the conclusion of the research;

Additional Notes:	HSCP Certification will no longer be accepted after 7/1/15 (including for anyone previously grandfathered). CITI becomes effective on 7/1/15 for all Rutgers faculty/staff/students engaged in human subject research.

Failure to comply with these conditions will result in withdrawal of this approval.

Please note that the IRB has the authority to observe, or have a third party observe, the consent process or the research itself. The Federal-wide Assurance (FWA) number for the Rutgers University IRB is FWA00003913; this number may be requested on funding applications or by collaborators.

Sincerely yours,

Michelle Watkins

Acting For--
Beverly Tepper, Ph.D.
Professor, Department of Food Science
IRB Chair, Arts and Sciences Institutional Review Board
Rutgers, The State University of New Jersey

cc: Dr. James E. Simon, PhD

(MW:ck)

Appendix F. Phytosanitary Certificate – Ministry of Agriculture, Republic of Liberia

REPUBLIC OF LIBERIA

MINISTRY OF AGRICULTURE

P.O. BOX 10-90100

1000 MONROVIA 10, LIBERIA

TECHNICAL SERVICES

National Quarantine & Environmental Services

Phyto-sanitary Certificate

Official Receipt # Gratis

Certificate # MOA/RL/NQES/180716

Plant Protection Organization of: LIBERIA

To Plant Protection Organization (s) of: United States of America

I. Description of Consignment

Name and address of export: Larry C. Hwang, Cuttington University, Suakoko District, Bong County ,Liberia Cell# +231-776087416

Declared name and address of Consignee(s): Dr. Hector R. Julianl, Rutgers University, 59 Dudley Road, Foran Hall, Dept. of Plant Biology and Pathology, New Brunswick, NJ 08901 + 1-(848) 932-6240, New Jersey, USA

Number and description of pack: Four (4) plastic bags said to contain (STC) sample plant species.

Distinguishing marks: AS SEEN

Place of Origin: Bong and Montserrado Counties-LIBERIA

Means of conveyance: By Air

Declared point of entry: Newark, New Jersey, U.S.A

Name of product and quantity declared: Griffonia simplicifolia 1.98 kg, Aframomum melegueta 139.6 g, Piper guineese 417.0 g, Xylopia aethiopica 596.6 g

Botanical name of plant: **VARIETIES**

This is to certify that the plants, plant product (s) or other regulated articles described herein have been inspected and or tested according to appropriate official procedures and are considered to be free from the quarantine pests specified by the importing contacting party and to conform with the current phytosanitary requirements of the importing contacting party, including those for regulated non-quarantine pests.

They are deemed to be practically free from other pests.

II. ADDITIONAL DECLARATION

III. Disinfestations and/or disinfections Treatment

Date: Treatment: Active ingredient:

Duration and temperature: Concentration:

Additional information: NO CHEMICAL TREATMENT WAS DONE ONLY SEMI-PROCESSED HEAT SUN DRIED PLANT SAMPLE FOR ANALYSIS.

Date issue: 18/07/2016 Place of issue: Monrovia, Liberia

Official Stamp & Signature:

Name of authorized officer: Augustus B.G. Fahnbulleh
augustusfahnbulleh@ymail.com cell # +231-886-439982

BUREAU OF NATIONAL QUARANTINE, SERVICE TECHNICAL AFFAIRS DEPT. MOA / R.L.

Appendix G. NTFP Pictures

Fresh fruits of African Black Pepper (*Piper guineense*)

Dried fruits of Country spice (*Xylopia aethiopica*)

Various dried local medicinal plant roots parcel for sale locally

Fresh fruits of Grains of Paradise (*Aframomum melegueta*)

Green seeds from pods of Griffonia (*Griffonia simplicifolia*)

Conducting interview with local community members

A major road used as transport in Liberia to rural communities

Crossing a little creek to reach to a village in Bassa County

Profs. Mark Robson, Jim Simon, and Larry Hwang (PI) at Kpatawee waterfall area, Bong County

Larry at Griffonia germination experiment site

Seedlings of Griffonia growing in the wild