

## UNDERSTANDING LOCAL BENEFICIARIES OF ECOSYSTEM SERVICES IN THE BIA-TANO FOREST RESERVE FOR SUSTAINABLE FOREST GOVERNANCE

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### Understanding local beneficiaries of ecosystem services in the Bia-Tano Forest Reserve for sustainable forest governance

Following the Rio Statement on Forest Principles, it is imperative to understand the socio-demographic characteristics, livelihoods activities and the kinds of NTFPs (Non-Timber Forest Products) that fringe communities of Bia-Tano Forest Reserve (Ghana) harvest or collect in order to provide useful insights into planning, managing and governing to achieve sustainability of the reserves' resources. Three hundred sampled household heads from nine fringe communities of the Bia-Tano Forest Reserve assisted in answering our questionnaire, from which we derived our findings. The study showed that the households in fringe communities obtain several NTFPs from the reserve to support their livelihoods and well-being. The findings showed a high dependence by the households in the fringe communities on the reserves' resources. These forest ecosystem services, the most important being food, are collected or harvested for household consumption or income. However, the availability of these NTFPs has decreased due to frequent harvest and collection, overexploitation of the reserve's ecosystem services, illegal and legal harvesting of timber, and illegal farming in the forest reserve. The frequency of assessing the reserves NTFPs resulted from the reserve's closeness to the fringe communities. Although the forest guards prevent the fringe communities from illegally harvesting and collecting the reserve's NTFPs, the finding shows that some household members offer bribes to the forest guards to have their way through. The study further showed other anthropogenic activities such as encroachment, excessive poaching/hunting, and forest/bushfires as factors driving the depletion and degradation of the forest reserve. These activities have largely contributed to the reserve's cover changes and degradation. The lack of punitive actions against perpetrators of these illegal activities has caused a decline in the reserve's closed and open forests. The need for urgent management and governance strategies and actions is imminent to ensure the reserves' sustainability for sustained provision of NTFPs and carbon mitigation. The study recommends offering alternative livelihoods for the reserve fringe communities to reduce their high dependence on the reserve's resources to ensure sustainability.

**Key words:** Statement of Forest Principles, local beneficiaries, forest ecosystem services, sustainable forest governance, Bia-Tano Forest Reserve, Ghana

## INTRODUCTION

In 2022 we commemorated the 30th anniversary of the UN Conference on Environment and Development (also UNCED or Earth Summit) in Rio de Janeiro.

The Rio Statement on Forest Principles highlights the need to manage, conserve and sustain the development of all types of forests. Globally, forests occupy about 30% of the Earth's surface land area (Kogo et al. 2019) and are home to over three-quarters of the global terrestrial biodiversity (FAO 2018). A forest serves as a habitat for billions of flora and fauna species diversity which serve as critical bedrock for providing ecosystem services (Prip 2018) as well as sources of employment and income generation. Additionally, forests contribute significantly to carbon cycle processes (Pan et al. 2011) as well as mitigating carbon emissions from anthropogenic sources (Hurteau et al. 2019), making the forest's role in the global carbon cycle very crucial (Yaduv et al. 2018). Broadly forests belong to tropical, temperate, and boreal forests (Führer 2000).

Forest ecosystems provide services categorized into provisioning, regulating, cultural, and supporting services. These services benefit humans and the environment (Mace et al. 2012). The provisioning services (e.g. food, water, wood, fibre and fuel); regulating services (climate regulation, flood regulation, disease regulation and water purification); cultural services (recreation, spiritual, visual enjoyment, tourism, ethical values, and education) and supporting services (cycling of nutrients, the formation of soil and photosynthesis for primary production); (Millenium Ecosystem Assessment 2005). Tropical forests are the most productive terrestrial ecosystems that maintain and support various life forms and global biodiversity (Yaduv et al. 2018). Globally tropical forests cover 12% of the landmass, 25% of biomass carbon and 40% of net primary production – NPP (Townsend et al. 2011). In many regions and countries, tropical forests assist in poverty reduction, ensuring food security, improving human well-being and progress, and combatting climate change to promote efficient and sustainable resource use (Bukoski et al. 2018).

However, anthropogenic factors, including the rising global population, urbanization, habitat loss, unsustainable agriculture, legal and illegal logging, mining, fires and climate changes, pose substantial risks and dangers to tropical forests (Yaduv et al. 2018). Similarly, deforestation and forest degradation constitute the greatest threats to tropical forests' sustainability (Nasi et al. 2011). The causes of tropical forests' deforestation and degradation result from direct and indirect anthropogenic factors. Ghana's tropical forests provide numerous resources to benefit the local communities and the economy. The country has two hundred and eighty forest reserves that cover approximately 23,729 km<sup>2</sup>, constituting 11% of the country's total land area; 75% and 25% are classified as production reserves and protected reserves, respectively (Forestry Commission 2016). However, the rapid rate of deforestation and forest degradation, which stands at 2%, translates into 135,000 ha/year of forest cover loss due to mining activities, agricultural expansion, wildfires, illegal logging, and poaching (Forestry Commission 2016). These anthropogenic factors threaten Ghana's forest sustainability.

The Bia-Tano Forest Reserve, belonging to the eight Gaoso Forests Districts, provides numerous services to benefit the local fringe communities, Ghana's economy, and climate mitigation. It is the second-largest among the eight forest reserves within the Gaoso Forest Districts (Lossou et al. 2019). The recent study in the Bia-Tano Forest Reserve by Lossou et al. (2019) indicated that the reserve was degraded, with closed forest decline, while bare land/built-up, open forest surge due to wildfires and illegal logging. This study aims to (1) understand the socio-demographic background and livelihood activities of the fringe communities of the

Bia-Tano Forest Reserve, (2) to ascertain the kinds of forest goods, products and services they derive from the forest reserve, and (3) to find out their knowledge on the changes in the availability of the reserves' resources and the drivers causing the changes. The original management plan and objective of the Bia-Tano Forest Reserve were restricted to protection, where only minimal exploitation of the non-timber forest ecosystem services (NTFPs) was allowed for harvesting by the local fringe communities (Asare 2000). However, its current rated condition of (4) indicates that the reserve is generally degraded, visibly disturbed, and patchy due to light forest burns (Abugre et al. 2019). However, currently, the reserve is managed for production and protection purposes. While the production objective ensures timber production by approved timber contractors, the protection objective seeks to govern, conserve, and protect portions for sustained flora and fauna.

The challenge of tropical deforestation and forest degradation presents major forest governance issues in many developing countries, including Ghana. According to the Food and Agriculture Organization (FAO), between 1990 – 2020, Ghana lost its closed natural forest from 3,108,508 ha to 1,204,372 ha, although the open forest loss was marginal from 6,765,748 ha in 1990 to 6,484,336 (FAO and UNEP 2020). According to Ghana Forestry Commission (2016), Ghana contributed 25% of greenhouses gases emissions through Land Use, Land Cover Change and Forestry. Ghana's adoption of REDD+ (Reducing emissions from deforestation and forest degradation) attempts to govern its forests by tackling the direct and underlying anthropogenic drivers of deforestation and forest degradation (Forestry Commission 2016).

Forest governance issues became topical even as far back as 1992 during the UN Conference on Environment and Development (also UNCED or Earth Summit) in Rio de Janeiro 1992, where the Statement of Forest Principles was highlighted. The preamble of the Statement of Forest Principles from the Rio Earth Summit underlined the most important principles, challenges and tasks concerning all types of forests. Some of the key points include the following: the subject of forests is related to the entire range of environmental and development issues and opportunities, including the right to socioeconomic development on a sustainable basis, and the guiding objective of these principles is to contribute to the management, conservation and sustainable development of forests and to provide for their multiple and complementary functions and uses. However, despite the Rio Earth Summit principles, challenges and tasks regarding proper forest governance comprising direct and indirect factors drive global forest depletion and degradation. The people's demographic characteristics, including unemployment, ageing, depopulation, migration, rural poverty, and change of values, constitute major socioeconomic drivers that influence the use and dependence on forest resources (Melnykovich et al. 2018).

Thus, demographic characteristics influence the local people's perception and forest ecosystem services (Da Ponte et al. 2017). Therefore, understanding the reserve-fringe communities' livelihood activities is critical as it determines how they impact forest reserve resources' use. At the local level, a majority of people are the actual and potential beneficiaries of a wide range of forest ecosystem services and resources (Kim et al. 2018); however, there is often a lack of clarity regarding how ecosystem services are delivered, accessed and used by these beneficiaries (Jones et al. 2016). The lack of alternative livelihoods for forest-fringe communities leaves them with no option but to depend heavily on forest ecosystems, leading to

ecosystem services degradation and loss (Fagariba et al. 2018). The forest-dependent people and communities' limited livelihood assets are critical drivers of anthropogenic LULCC activities that degrade forest landscapes (Peprah et al. 2017). Livelihood activities are driven by poverty which drives people into game meat hunting, palm-wine tapping, and charcoal burning, where these activities often cause bushfires to destroy large forest resources (Owusu and Essandoh-Yeddu 2018).

Forest ecosystems are essential services that people depend on for livelihood and income; hence a breakdown of ecosystems and their services can endanger millions of local forest communities (Kandel et al. 2018). Thus, understanding the local fringe communities' socio-demographic and livelihood activities provides the idea of the kinds of forest products they harvest or collect and whether they do so sustainably (Yaduv et al. 2018). However, managing ecosystems to provide services for humanity while ensuring sustainability and resilience is a major challenge that requires governance and management research mechanisms and strategies (Falk et al. 2018). Therefore, the study is justified as, in most cases, attempts to ensure proper governance and management of forest resources fail to understand the local fringe communities' perceptions and other general characteristics that influence the use of forest ecosystem services. Therefore, the study's empirical findings will foster governance and management alternatives to promote and sustain the biodiversity and ecosystem services of the Bia-Tano Forest Reserve for sustained non-timber forest products and services to foster fringe communities' well-being and carbon mitigation to avert the emission of greenhouse gases.

## MATERIAL AND METHODS

### Study area

This research was conducted in the Bia-Tano Forest Reserve in Ghana (Fig. 1), located between 6°55 and 7°05 north and longitude 2°45 and 2°30 west, with an average land elevation of 244 m above mean sea level. The forest reserve was constituted under the Forest Ordinance Cap 157 and was protected under the Land Administration Act 1962, the Forest Protection Decree 1974 and Forest Protection Law 1986 (PNDCL 142). The reserve is managed for production and research purposes. The reserve covers 181.97 km<sup>2</sup> comprising 113 compartments of timber production, 2 swampy compartments (Elephant Pool), and 10 Convalescence areas.

In addition, the reserve comprises six compartments earmarked as research areas, while two compartments were demarcated for Provenance Trial (*Guibourtia ehie*) and Provenance Trial (*Chrysophyllum* spp), respectively. The reserve lies in a tropical humid climatic zone with forest Ochrosol as the primary soil type. The annual average rainfall ranges between 1200.9 mm and 1524.2 mm, while the annual mean temperature ranges from 28°C to 34°C. The production side of the reserve was assigned by concession to Ayum Forest Products Limited (AFPL) due to the divesture package by Mim Timber Company Limited in 2002. The other portion of the production reserve was allocated to F.D. Nsiah Timbers Limited as a Timber Utilization Contract (TUC) for 40 years beginning in 2002. The provision was granted under the Timber Resources Management (Amendment) Act and Timber Resources Management (Amendment Regulations 2002). The Forestry Commission in the Goaso Forest Districts governs and manages the reserve. The reserve provides numerous ecosystem services, of which the common ones include timber

and non-timber forest ecosystem services (NTFPs). The fringe communities, such as Fianko, Dominase, Kokofu, Gambia No.1, Nsuta, Tokurom, Duaso, Aboagyaa and Bediako, have the communal rights to collect and harvest NTFPs for consumption, although they are forbidden from harvesting timber from the reserve.

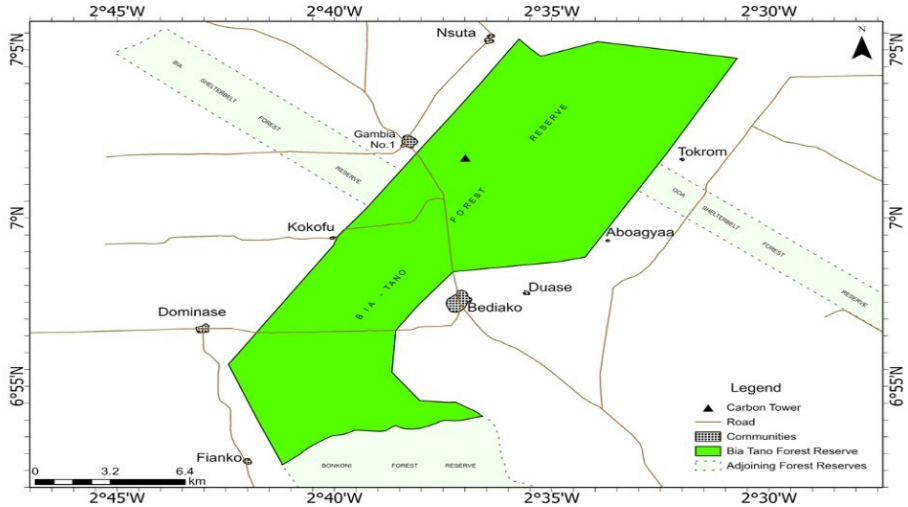


Fig. 1 The location of the Bia-Tano Forest Reserve in Ghana

### Sampling and data collection methods

The sampling technique used a simple random method to select the households in the nine (9) forest fringe communities located 5 kilometres within the forest reserve. The procedure was as follows:

$$s_i = (n_i / n_t) * n_s,$$

where  $s_i$  is a sample from group  $i$  (number of samples which we take from village/town  $i$ )  $n_i$  is the total number of samples in group  $i$  (number of households in village/town  $i$ )  $n_t$  is the total number of samples (total number of households).  $n_s$  is the total number of samples we want to take (300).

For example, the computation works this way for Bediako, one of the nine (9) forest-fringe communities, as follows:  $n_i = 690$ .  $n_t = 1757$  (sum of all  $n_i$ )  $n_s = 300$ . then  $s_i = (690/1757) * 300 = 117.81446$  after rounding 118.

A semi-structured questionnaire interview was developed and administered to the randomly selected households in the nine fringe communities of the Bia-Tano Forest Reserve. However, in each household, the household heads were the ones who answered the questionnaire with the aid of the trained research assistants. The household heads were chosen to answer the questionnaire because they decided on what to consume and what sources. Therefore, the questionnaire was structured to capture information on the socio-demographic characteristics of households, livelihood characteristics and activities of household heads, and household heads' access to the reserve's resources, as well as their knowledge of the drivers of the reserve's cover changes and degradation.

**Tab. 1. Household sample size**

Forest-fringe communities	Total households	Relative frequency of households	Ideal sample of 300 HH	Sample 300 HH
Bediako	690	0.39	117.81	118
Gambia No. 1	402	0.23	68.64	69
Fianko	120	0.07	20.49	20
Dominase	200	0.11	34.15	34
Kokofu	40	0.02	6.83	7
Nsuta	180	0.10	30.73	31
Tokrom	60	0.03	10.24	10
Aboagyaa	25	0.01	4.27	4
Duaso	40	0.02	6.83	7
Total	1 757	1	300	300

The individual items in the questionnaire comprise open-ended and close-ended questions that offer the household heads the opportunity to express their opinions, views and knowledge as they prefer. This offered the opportunity to obtain primary qualitative and quantitative data leading to enriching the results (Barnard et al. 2000). Household questionnaires took the form of face-to-face interviews administered by trained research assistants. Each questionnaire lasted a minimum of 30 minutes and 45 minutes maximum. The trained research assistants who administered the questionnaire assisted the 300 randomly selected household heads in answering the questions. Pre-testing questionnaires carried out in 3 of the nine forest-fringe communities in the case study areas allowed us to identify and correct some minor difficulties associated with some questions. The questionnaires were written in English, and in some cases where the household heads could not read and write in English, the research assistants explained the questions to them in a local vernacular (TWI). The data collection took three months, from 1st October 2020 to 31st December 2020. Although a questionnaire can be administered through the internet, telephone, and postal, we took the challenge to adopt the face-to-face type even though it involves a high cost. It also enables the researcher to elicit vital in-depth information to address the research objectives and sub-questions. Using a questionnaire to solicit data or information is advantageous because it brings a possible high return rate, standardization of questions, and guaranteed respondent anonymity (Munn and Drever 1990). However, it entails some limitations, including high time consumption in drafting and piloting. Another limitation is that it produces superficial information as it tends to describe rather than explain a situation, problem or phenomenon (Munn and Drever 1990). These limitations were overcome because the questionnaire was based on closed-ended and open-ended questions that often prevent superficial and descriptive answers.

#### Socio-demographic characteristics of household heads

The study involved 300 household heads in the questionnaire interview conducted in Bia-Tano Forest Reserve fringe communities. The primary respondents in the survey were household heads whose socio-demographic characteristics are presented in Tab. 2.

**Tab. 2. Characteristics of 300 household heads**

Variable	Category	No (%)	Variable	Category	No (%)
<b>Age</b>	20 - 30 years	36 (12.0)	<b>Marital status</b>	Never married	24 (8.0)
	31 - 40 years	61 (20.3)		Married	150 (50.0)
	41 - 50 years	68 (22.7)		Living together	72 (24.0)
	51 - 60 years	65 (21.7)		Divorced/Separated	24 (8.0)
	61 years and above	70 (23.3)		Widowed	30 (10.0)
<b>Sex</b>	Male	192 (64)	<b>Education</b>	No education	76 (25.3)
	Female	108 (36)		Primary	56 (18.7)
<b>Ethnicity</b>	Akan	205 (68.3)		Middle/JSS	115 (38.3)
	Northerner	57 (19.0)		Secondary	33 (11.0)
	Ga	6 (2.0)		Tertiary	20 (6.7)
	Ga-Adangbe	18 (6.0)	<b>Occupation</b>	Farmer	247 (82.3)
	Ewe	14 (4.6)		Teacher	11 (3.7)
<b>Household size</b>	1-5 people	108 (36.0)		Timber operator	11 (3.7)
	6-10 people	156 (52.0)		Government worker	5 (1.7)
	11-15 people	25 (8.3)		Trader	20 (6.7)
	16-20 people	11 (3.7)	Carpenter	4 (1.3)	
<b>Building type</b>	Block	160 (53.3%)	Driver	2 (0.7)	
	Brick	77 (25.7)	<b>Religion</b>	No religion	16 (5.3)
	Mud	58 (19.3)		Traditionalist/Spiritualist	4 (1.3)
	N/A	5 (1.7)		Muslim	50 (16.7)
		Christianity		230 (76.7)	

## RESULTS

Respondents were asked during the survey to indicate their livelihood and other household characteristics.

### Important livelihood activities of households

Household heads indicate the main livelihood activities to meet their food, water, shelter, clothing, and other household needs (Fig. 2). Overall, cocoa farming was the main livelihood activity among households in reserve-fringe communities, where 194 households representing 64.6%, consider cocoa farming as an “extremely” important livelihood activity, while 45 households (15%) indicate cocoa farming as a “very important” livelihood activity. However, 30 households (10%) indicated that cocoa farming is a “not at all important” livelihood activity. On the other hand, food/cash crop farming, excluding cocoa, was “extremely” important for 75 households representing 25%, and 108 households (36%) indicated “very” important livelihood activity, with 27 households (9%) indicating food/cash cropping “not at all” important. In each of these livelihood categories, 38 households (12%) found full-time employment, 32 (10%) livestock/animal rearing, and chainsaw operation in nine households (3%) as “extremely” important livelihood activities, respectively.

**Tab. 3. Household head's livelihood characteristics**

Question	Category	No (%)
Is the household head a native of the community?	YES	123 (41.0)
	NO	177 (59.0)
	Total	300 (100.0)
If "no", where did the household head migrate from?	N/A	21 (11.9)
	Akan area	93 (52.5)
	Ga	4 (2.3)
	Ewe	11 (6.2)
	Northerner	40 (22.6)
	Krobo	7 (4.0)
	Foreigner	1 (0.6)
	Total	177 (100.0)
	Why did you migrate to this community?	N/A
Farming		166 (65.5)
Marriage		13 (7.3)
Timber operations		1 (0.6)
Teaching		7 (4.0)
Job transfer		17 (9.6)
Join family/friends		2 (1.1)
Total		177 (100.0)
How long have you lived in this community?	N/A	21 (11.9)
	1-10 years	43 (24.9)
	11-20 years	29 (16.3)
	21 years and above	83 (46.9)
	Total	177 (100.0)
If you are a farmer, do you own the land you farm on?	YES	174 (58.0)
	NO	126 (42.0)
	Total	300 (100.0)
If no, how did you acquire the land for farming?	Rent	20 (15.9)
	Purchase	23 (18.3)
	Share-cropping	83 (65.9)
	Total	126 (100.0)

The chi-square analysis shows significant relations between household heads' demographic characteristics and the sampled household's important livelihood activities from the reserve-fringe communities. The study showed a significant relationship between household head gender concerning cocoa farming and petty trading. One hundred and forty male household heads consider cocoa farming extremely important compared to 54 female household heads. Also, more women find petty trading extremely important compared to male household heads. The finding is not surprising because, in Ghana, females are the ones who engage in petty trading more than males. In addition, there was a significant relationship between the



household head's marital status and food/cash crop farming, where more male households than females engaged in it. Similarly, the religion of the household head was significantly related to livestock/animal rearing. Regarding livestock/animal rearing, the significant relationship shows that Christian household heads engage in it, compared to their Muslim counterparts. Interestingly, the occupation of household heads was significantly related to all the four important livelihood activities engaged in by the reserve-fringe communities with food/cash crop farming, cocoa farming, petty trading, and livestock/animal rearing. Statistically, all four important livelihood activities were significant in all nine reserve-fringe communities. Cocoa farming was a significant livelihood activity in all the communities, as well as food/cash crop farming, petty trading and livestock/animal rearing. However, the Bediako community indicate cocoa farming as extremely important compared to the other communities. The household heads' age, education, and ethnicity showed no significant relationship between household heads and livelihood activity.

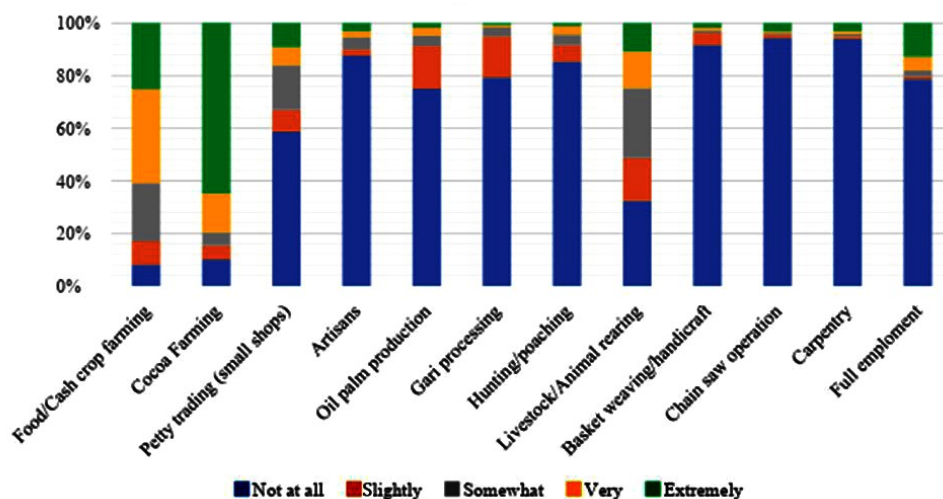


Fig. 2. Important livelihood activities of household heads

#### Household heads' main sources of income

Figure 3 illustrates diverse sources of household heads' income as well as which of the sources they regarded as "extremely", "very", "somewhat", "slightly", and "not at all" important. Many households (177) indicated cocoa farming as an "extremely" important income source, followed by food/cash crop farming (59 households), full-time employment (36 households), forest income (26 households), and livestock (16 households). As the main livelihood activity, cocoa provides the primary household head's income source for 194 households. However, over 150 households considered forest income as "not at all" important. Interestingly, pension income was regarded by 287 household heads as "not at all" important. Similarly, 228 households stated income from bank support as "not at all" important.

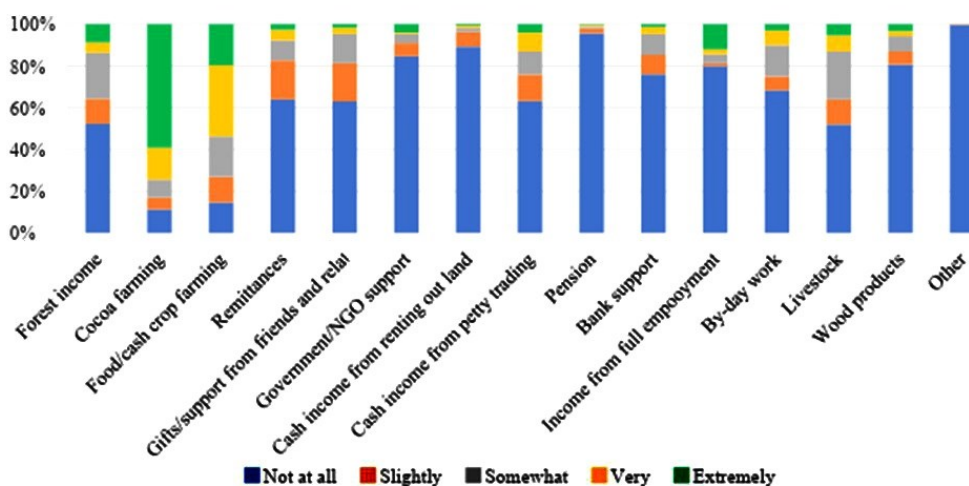


Fig. 3. Household heads' main sources of income

The Chi-square analysis shows the significant associations or relationships between household heads and the important sources of income, indicating a significant relationship between household head age and cocoa farming. There was also a significant relationship between marital status and food/cash crop farming among sampled households. Equally, the household head occupation was significantly related to forest income, cocoa farming, and food/cash crop farming. The result shows a positive relationship between the community and all four main income sources. On the other hand, religion, education and ethnicity had no statistical significance to household heads and their main sources of income.

#### Household heads annual income from the sale of forest ecosystem services

Figure 4 shows annual forest income from reserve-fringe communities' sale of forest goods and services. From the findings, 22% of household heads could not indicate any income sources from the forest, 30.7% from zero – 100 Ghc, 24.7% of household heads obtained between 101 – 500 Ghc, and 5.3% received 501 – 1000 Ghc. However, 17.3% indicated an annual forest income of 1000 Ghc and over.

#### Household food sufficiency and energy sources

Data on the main sources of energy for domestic use shows a high proportion (258 households, 86%) use fuelwood as the main energy source, followed by charcoal (31 households, 10.3%), while only nine households (3%) indicated LPG (liquefied petroleum gas) as their primary domestic energy sources. Additionally, the heads of the household were to indicate whether their households were food secured/sufficient over the last 12 months by stating YES or NO. Also, 151 households indicated they were food sufficient throughout the year, whereas 149 said they were food insecure/insufficient during the last 12 months.

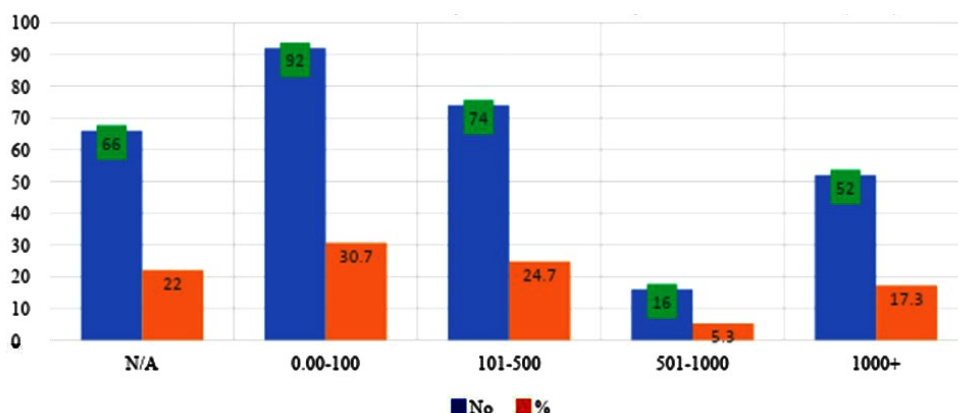


Fig. 4. Income from the sale of reserves' ecosystem services by household heads (Ghc)

#### Access to forest provisioning ecosystem services from the Bia-Tano Forest Reserve

Household heads' responses regarding the reserve owners show that 275 (91.7%) household heads thought the reserve belonged to the government, while 25 (8.3%) believed that the reserve belonged to the communities. Regarding whether they have ease of access to the reserve resources, 183 (61%) responded YES, while 117 (39%) said NO, indicating they do not have easy access to the reserve's resources. Besides, 133 (44.3%) were aware of other resource access forms, such as informal and formal access, while 167 (55.7%) answered NO, denoting not being aware of different access mechanisms to harvest/collect ecosystem services from the reserve. However, only 31 (10.3%) used the 'formal permit system' to obtain or access reserves' benefits or services.

#### Different persons in households that collect forest reserve ecosystem services

The household survey revealed the reserve's benefits, and ecosystem services/goods can be collected/harvested by different household members. Figure 5 shows that most benefits are collected/harvested only by the household's head, husband, and wife. Children also collect benefits or ecosystem services for either household consumption or sale or both, while both husband and wife collect or harvest benefits/services from the reserve together.

#### Consumption and sale of reserve ecosystem services by households

Household heads indicated the ecosystem services they collect or harvest for consumption, sale, and consumption. Figure 6 shows that household heads collect/harvest almost all the selected NTFPs and other products for consumption and sale. However, most products are collected for personal consumption rather than for sale only. For example, many households (70.9%) harvest mushrooms for consumption only. Also, 65.4% of households reported harvesting fuelwood for domestic/household energy sources, 22.1% harvesting it for consumption and sale, while 12.5% reported sale only. For 52.7%, they harvest timber for sale, while 32% for personal use and sale. Thus, food is collected for consumption purposes in 53.3% of households, 36.7% for consumption and sale, and 10% for sale only.

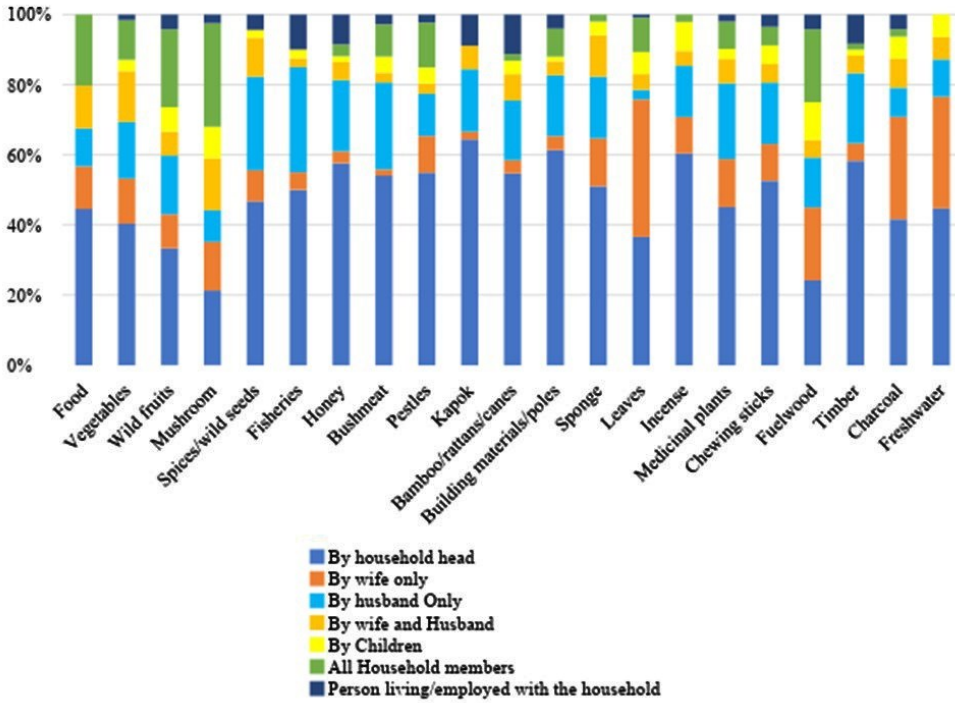


Fig. 5. Different household persons that collect/harvest reserve services

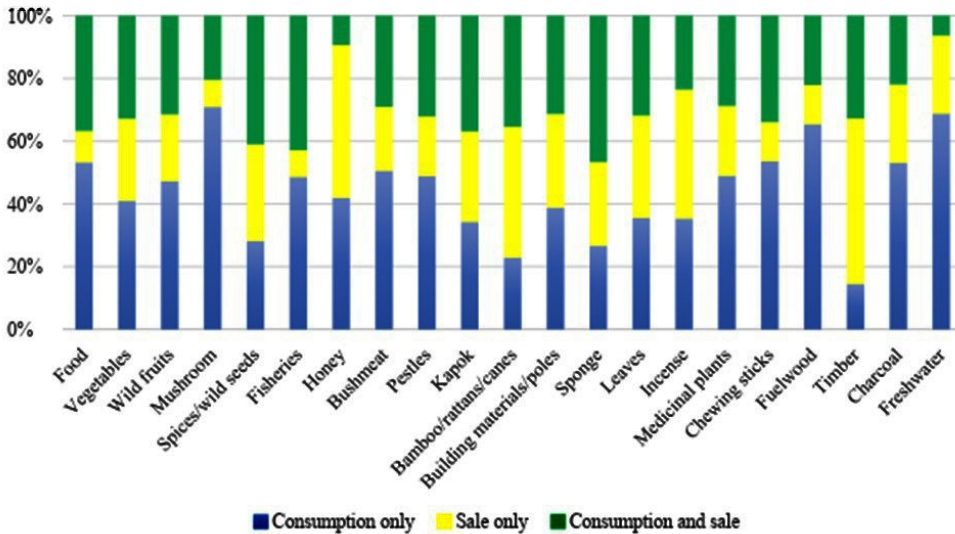


Fig. 6. Types and proportion of reserve's ecosystem services for sale and consumption

## Household heads' knowledge of forest reserve ecosystem services availability

During the survey, household heads indicated whether the ecosystem services they obtain from the reserve have decreased, increased, remained the same, or they do not know over the past ten years (Fig. 7). Respondent's responses indicate a decrease in almost all the forest ecosystem services over the past ten years with no significant increase or remained the same. In particular, pestles, mushrooms, fuelwood, bushmeat, leaves, and medicinal plants have decreased considerably over the past ten years. However, most respondents do not know whether these ecosystem services have increased, decreased, or remained unchanged over the years.

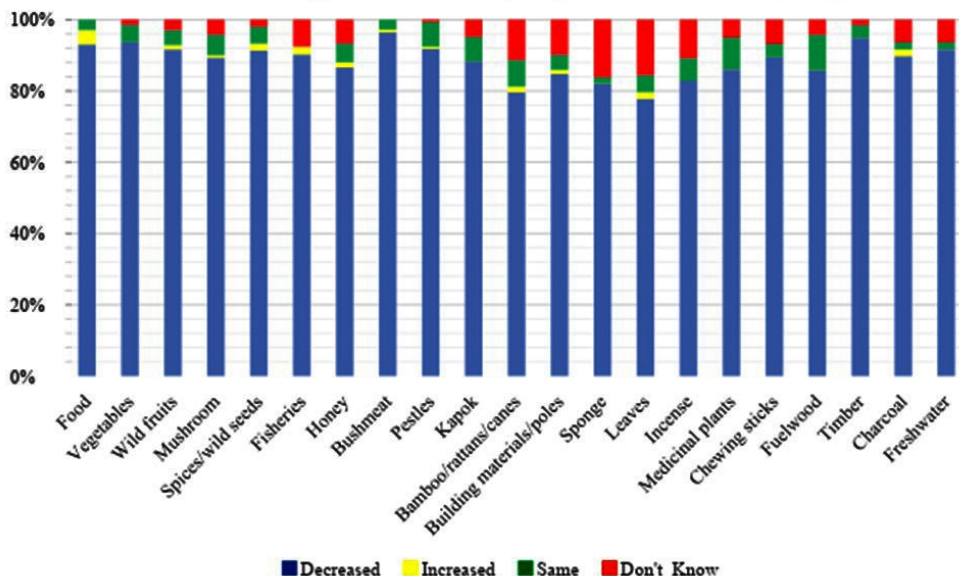


Fig. 7. Changes in the availability of forest reserve ecosystem services

## Distance in time used to collect forest reserves' ecosystem services

The distance, in minutes, household heads cover to collect/harvest ecosystem services from the forest reserve shows the communities' closeness to the reserve. A larger proportion of households, 70%, use between 1 – 30 minutes to harvest or collect reserves ecosystem services, while others use 31-60 minutes. Some respondents indicated that collecting some forest ecosystem services takes over 60 minutes (Fig. 8).

## Important reserves' ecosystem services to households

Overall, household heads mentioned food, fuelwood, bushmeat, timber, medicinal plants and pestles as "extremely" important to their households. However, all other reserve benefits played an important role in various households for consumption, sale or both. However, other forest benefits or services were regarded as "not at all important", although some households consider those to play important roles in households in the reserve-fringe communities (Fig. 9).

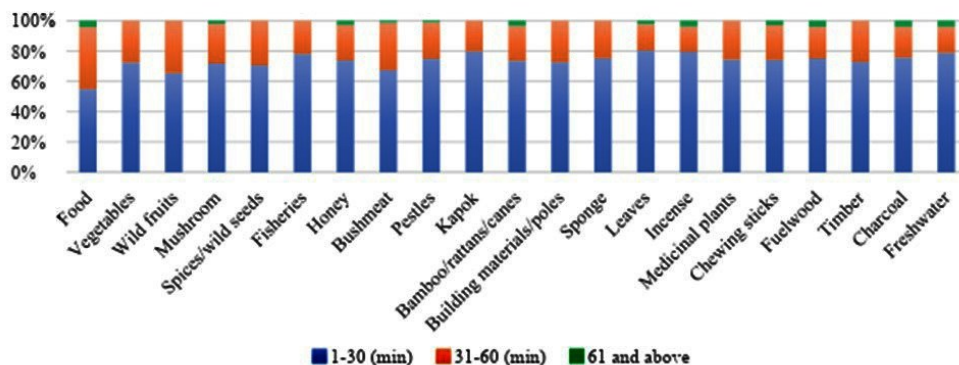


Fig. 8. Distance in minutes to collect reserve ecosystem services

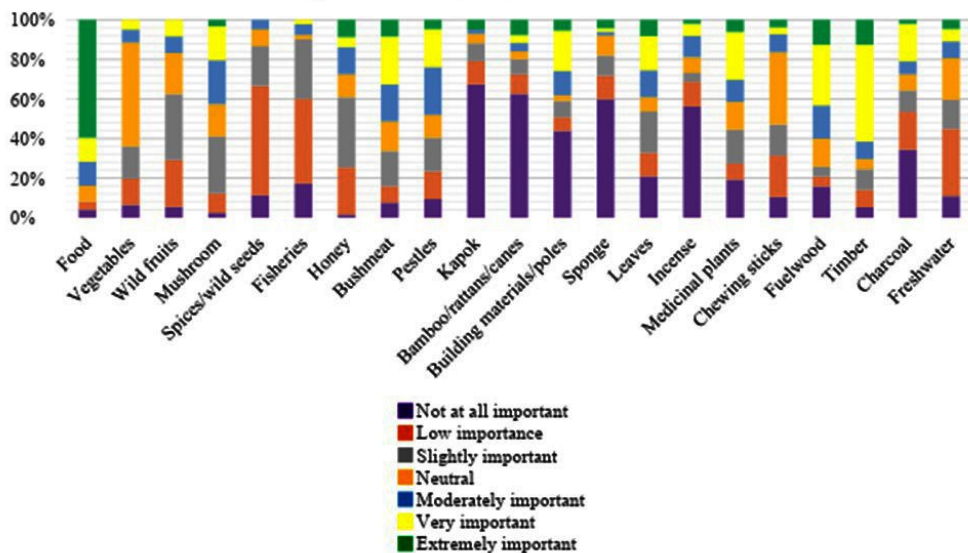


Fig. 9. Household heads rating the importance of reserve's services

### Frequency of times households collect forest reserves' ecosystem services

Figure 10 indicate how frequently households collect the reserves' ecosystem services. It shows that many household heads collect food, timber, and fuelwood more frequently than other forest reserves' ecosystem services. It also indicates goods or services that household heads never, rarely, occasionally and frequently collected from the reserve. The Chi-square analysis presents the statistical significance of collected/harvested benefits/products from the forest reserve and the household background characteristics. There is a statistical significance between age and wild fruits collection, whereas marital status was statistically significant with food and mushroom. However, in all cases, there was a statistical significance between the communities and forest goods/services, including food, vegetables, wild fruits, mushroom, and spice/wild seeds. Food, vegetables, and spices/wild fruits were statistically significant at the community level. There is a significant

relationship between marital status and how frequently they harvest fisheries and pestles, while at the community level, only pestles were significant.

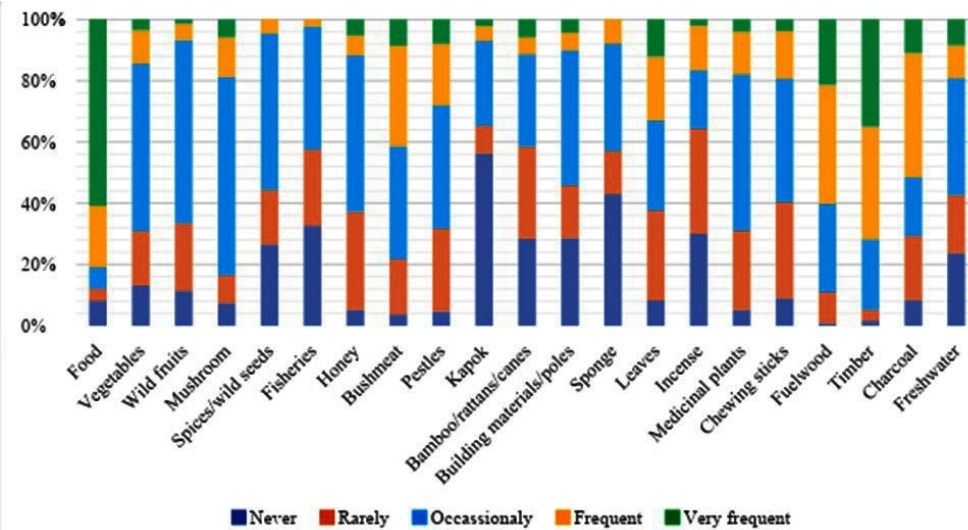


Fig. 10. Frequency of collection/harvesting of reserve ecosystem services

At the community level, leaves and kapok harvest are significant. The study finds a significant relationship between age and marital status in fuelwood collection. In addition, a significant relationship existed regarding how often freshwater is collected by household head occupation. At the community level, incense, fuelwood, charcoal and freshwater had significant relationship regarding how often they are collected/harvesting.

#### Major challenges for accessing benefits from the reserve

Major challenges that respondents encounter in accessing/collecting benefits from the reserve show that 129 respondents (43.0%) did not encounter any major challenge. In contrast, 116 (38.7%) reported major challenges in harvesting/collecting the reserve's benefits/services. Of 116 who reported encountering problems, 105 (90.5%) mentioned problems with forest guards, seven respondents (6.0%) said they were afraid of wild animals in the forest reserve, while four respondents said they had to walk a long distance to access the benefits/services of the reserve.

#### Punishment for collecting/harvesting illegally from the reserve

Household heads' experiences with punishment meted out to those who collect/harvest forest reserve's benefits/services illegally, and are caught or arrested by forest guards. Overall, 85 respondents (28.3%) reported they were taken to court, 74 respondents (24.7%) said they were fined, 67 respondents (22.3%) said the collected/harvested ecosystem services were seized by the forest guards, while 36 respondents (12%) admitted to offering bribes.

## Key drivers of forest cover change and degradation of Bia-Tano Forest Reserve

During the survey, household heads were asked to indicate the direct and indirect factors that constitute the key drivers of forest cover change and degradation. The result is presented in (Fig. 11), where 216 household heads stated illegal logging/chainsaw operation as an “extremely” important driver of forest cover degradation and change of the reserve, followed by legal timber harvesting and illegal farming and overexploitation of forest services/goods. In addition, the reserve's encroachment, excessive poaching/hunting, and forest/bushfires are extremely important drivers of forest cover changes and degradation. On the other hand, illegal mining was unimportant because, within the reserve, no traces of illegal mining were reported.

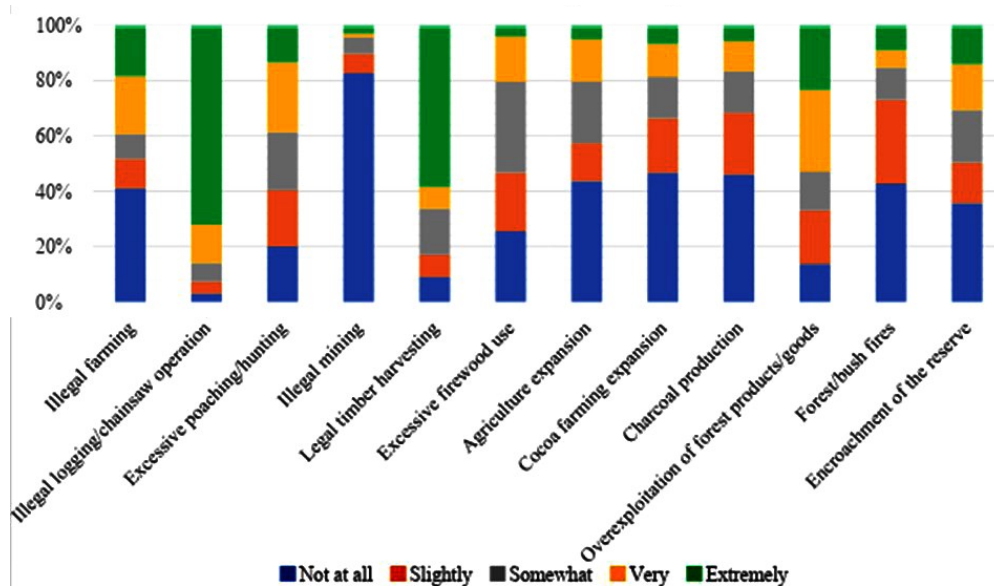


Fig. 11. Key drivers of reserves cover change and degradation identified by household heads

## DISCUSSION

Our findings revealed various socio-demographics, livelihood characteristics and the important livelihood activities of the selected households in the nine fringe communities of the Bia-Tano Forest Reserve. Cocoa and food/cash crop farming constitute the key livelihood activities engaged by the majority of the household heads as well as their key sources of income. The farming activities engaged by the households in the fringe communities pose major encroachment threats to the forest reserve. This is because cocoa farming expansion has been the major driver of deforestation in most parts of forest areas in Ghana (Benefoh et al. 2018), especially within the high forest zones of Ghana (O’Sullivan et al. 2018) through illegal farming and encroachment in the forest reserves. What makes the encroachment and illegal farming key threats to the Bia-Tano forest reserve are that most fringe communities whose major livelihood activity are farming live closer to the forest



reserve. The reason is that a large tract of Ghana's forest around the forest reserves suffers much encroachment (Benefoh et al. 2018). The situation could worsen as people often migrate to forestland areas for farming and other livelihoods (Derkyi et al. 2013 and Kansanga and Luginaah 2019). This means that proper forest governance mechanisms are required to prevent encroachment and illegal farming within and along the fringes of the Bia-Tano forest reserve. The findings further show that the forest fringe communities derive income from selling the reserve's services. Forest resource income significantly contributes to households in the Jhapa district, Nepal (Rijal et al. 2021).

The high proportion of fuelwood used as a domestic energy source also poses a significant threat to the reserves sustainability since fuelwood and charcoal burning are major drivers of forest degradation. The increasing demand for ecosystem provisioning services, fuelwood, and fibre, is associated with ecosystem modification, depletion and loss (Millennium Ecosystem Assessment 2005). Although the fringe communities have communal rights to access the forest provisioning services, their harvesting and collection of these ecosystem services must be checked to ensure sustainable use. Furthermore, the communal rights to access NTFPs could lead to overexploitation and abuse of the reserve's resources because the formal permit system often involves corruption, as tropical forestry is mostly characterized by corruption (McDermott 2014 and Melnykovych et al. 2018). The result shows that some forestry officials accept bribes to allow the collection/harvesting of forbidden ecosystem services and the overexploitation of NTFPs from the forest reserve. In most cases, corruption has driven illegal logging, as people who engage in illegal logging/chainsaw operations use a diverse network of forest guards to log illegally (Teye 2013).

Different households have the preferred goods and services they collect from the forest reserve, of which food constitutes the most important. The excessive harvesting of pestles and building materials/poles will negatively affect the future carbon storage and sequestration potentials from the Bia-Tano reserve. The high sale of timber from the reserve, where fringe communities are not permitted, indicates they harvest illegally, implying lapses in the monitoring and governance mechanisms. In some cases, the perpetrators of these illegalities connive with forestry officials to log illegally. In most cases, non-forest rules compliance and lapses in forest policy (Ramcilovic-Suominen and Epstein 2015) and institutional lapses and failures (Agyei and Adjei 2017) have fueled illegal forest logging. It implies they harvest timber illegally, as in other forests and reserves (Addo-Fordjour and Ankomah 2017 and Boakye 2018). These smaller trees are harvested early and will not grow into bigger trees to increase carbon sequestration potentials in the forest reserve. A breakdown in forest goods and services will make the livelihoods of millions of local forest communities vulnerable (Kandel et al. 2018). The reserve's ecosystem services are harvested/collected by all household members; however, household heads are mostly involved in collecting/harvesting. Mushrooms, freshwater, fuelwood, food, bushmeat, pestles, and charcoal are mostly consumed or used domestically.

The respondents' assessment of the reserve's ecosystem services available over the past ten years indicated that the reserve had declined dramatically in quantity and quality. The frequent harvest of food, timber, fuelwood, charcoal and freshwater and charcoal production has dire implications for the reserve's sustainability. In addition, the closeness of fringe communities to the reserve has resource access

and use implications since it could lead to frequent access to its resources. The high sale of timber harvested from the reserve indicates illegal logging activities in the forest reserve. This finding is consistent with several studies that find illegal logging a key driving force of Ghana's forest reserve degradation and cover changes and depletion. (e.g. Lund et al. 2012, Derkyi et al. 2013, Arcilla et al. 2015 and Boakye 2018).

Similarly, increased timber harvesting was found as the main driver of forest loss in the eastern upland region of Bangladesh (Ahammad et al. 2019), while illegal timber logging constituted the key driver of forest loss in the Ukrainian Carpathians (Melnykovich et al. 2018) where the continuous trend of forest biomass harvesting significantly leads to loss of carbon sequestration (Yan 2018). Therefore, if excessive illegal and legal timber harvesting is not curtailed, the Bia-Tano forest will soon lose its carbon storage and sequestration potential. According to the participants, the chiefs and political leaders intercede when illegal chainsaw operators are arrested and arraigned before the court. The powerful and influential political and traditional leaders' influence and interference make it difficult to arrest and prosecute the perpetrators of reserve illegalities before the law court.

## CONCLUSIONS

Using the questionnaire enabled us to achieve the objectives of the study: to understand the socio-demographic background and livelihood activities of the fringe communities of the Bia Tano forest reserve, to ascertain the kinds of forest goods, products and services they derive from the forest reserve and to find out their knowledge on the changes in the availability of the reserves resources and the drivers causing the changes. The study highlighted several NTFPs that the households in the fringe communities collect or harvest to support their livelihoods. The NTFPs harvested or collected are either consumed or sold to improve the well-being of the households. Largely food was the most important forest ecosystem service to the fringe communities' households. These ecosystem services are harvested or collected by different household persons. We found that there had been a decrease in the reserves' resource availability which could be attributed to frequent and unsustainable harvesting and collection of the NTFPs from the forest reserve. The frequency of assessing the reserve's NTFPs resulted from the nearness of the fringe communities to the forest reserve. However, forest guards prevent households from assessing NTFPs and often punish those who collect or harvest illegally by taking them to court and seizing the collected or harvested ecosystem services.

Notwithstanding, some forest guards accept bribes to allow people to harvest and collect illegally from the reserve. The study found that illegal chainsaw operation, legal timber harvesting, overexploitation of forest ecosystem services and illegal farming constitute the key drivers of the reserves's cover change and degradation. Therefore, we recommend providing alternative livelihood activities to the households in the fringe communities to reduce the high dependence on NTFPs in the forest reserve.

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## UDRŽATEĽNÉ LESNÉ HOSPODÁRSTVO V POŇÍMANÍ MIESTNYCH UŽÍVATEĽOV EKOSYSTÉMOVÝCH SLUŽIEB V LESNEJ REZERVÁCII BIA-TANO

V uplynulom roku sme si pripomenuli 30. výročie Konferencie OSN o životnom prostredí a rozvoji (tiež UNCED alebo Summit Zeme) v Rio de Janeiro. Jeden z piatich hlavných dokumentov, prijatých delegátmi Summitu Zeme, bolo Právne nezáväzné autoritatívne vyhlásenie k zásadám globalnej dohody o využívaní, ochrane a udržateľnom rozvoji všetkých typov lesov.

Táto štúdia vznikla v súlade so spomínaným dokumentom zo Summitu Zeme. Poznanie životných podmienok a sociálno-ekonomických charakteristík miestnych užívateľov, ktorí profitujú z lesných ekosystémov, prispieva k lepšej ochrane, plánovaniu, manažmentu a rozhodovaniu v záujme dosiahnutia dlhodobej udržateľnosti fungovania lesných ekosystémov. Opakom žiaduceho prístupu sú také ľudské aktivity, ktoré vedú k veľkoplošnému odlesňovaniu a degradácii lesov.

V tomto príspevku ide v prvom rade o výskum správania, postojov a názorov ľudí závislých na ekosystémových službách lesa v Ghane, konkrétne v lesnej rezervácii Bia-Tano

a v jej bezprostrednom okolí (vo vzdialenosti do 5 km od rezervácie), a o reflexiu potreby ochrany a udržateľného manažmentu týchto lesov v ich susedstve.

Tropické lesy v Ghane sú dôležitým zdrojom obživy pre miestnych obyvateľov. Na 11 % výmery štátu sa dosiaľ rozprestierajú lesné rezervácie, pričom tri štvrtiny z nich sú určené najmä na udržateľnú produkciu dreva a jedna štvrtina na ochranu prírodných lesov. Vplyvom odlesňovania, požiarov, poľnohospodárstva, banských aktivít a i. sa však vývoj v tejto oblasti ubera negatívnym smerom a Ghana prichádza v priemere o 2 % svojich lesov ročne. Pritom najrýchlejšie ustupujú práve prírodné lesy. Rastúca ťažba dreva (legálna aj nelegálna) a iné formy degradácie lesa znižujú aj jeho schopnosť uskladňovať uhlík a redukovujú celkový sekvestračný potenciál tunajších lesov.

Štúdia sa zakladá na odpovediach respondentov reprezentujúcich 300 domácností v deviatich komunitách spomínaného (mikro)regiónu. Pokiaľ ide o veľkosť dopytovaných domácností, najväčšiu skupinu (52 %) tvorili tie, ktoré pozostávali z 6 – 10 osôb, v 33 % domácností žilo 1 – 5 osôb a v 11 % domácností žilo 16 – 20 osôb. Hlavným zdrojom ich príjmov je pestovanie kakaa a iných poľnohospodárskych plodín. Z odpovedí respondentov vyplýva, že les je pre nich v prvom rade zdrojom potravy a potom dreva, či už na remeselné využitie, na predaj alebo ako palivo. Rezervácia Bia-Tano pritom poskytuje miestnym obyvateľom aj celý rad ďalších produktov a služieb na uspokojenie ich bezprostredných potrieb a v menšej miere aj na komerčné účely. Z odpovedí respondentov však zároveň vyplynulo, že prírodných zdrojov v rezervácii vplyvom ľudských aktivít za uplynulú dekádu ubudlo, pričom tento trend je dlhodobý. Napriek tomu, že ťažbu dreva v rezervácii miestne komunity nemajú povolenú, ťažba s využitím modernej techniky tu prebieha a predstavuje hlavnú hrozbu pre udržateľný manažment miestnych lesov a ich ochranu. Ďalšími negatívnymi faktormi prispievajúcimi k degradácii týchto lesov sú nelegálne poľnohospodárstvo, nadmerné využívanie rôznych lesných produktov (nielen dreva), neoprávnené zasahovanie do cudzích vlastníckych práv, nadmerný lov zveri (vrátane pytliactva). K znižovaniu výmery lesov prispievajú aj požiare.

Na druhej strane, právny či sankčný postih aktivít ohrozujúcich a degradujúcich lesy v rezervácii Bia-Tano je úplne nedostatočný. Napriek tomu prítomnosť lesnej stráže považujú respondenti za hlavnú hrozbu, resp. obmedzenie, mnohonásobne väčšie ako je napríklad zver alebo veľké dochádzkové vzdialenosti za prácou a zdrojmi lesa. Významný negatívny faktor predstavuje korupcia. Niekoľko respondentov priznalo, že dalo úplatok miestnym úradníkom za to, že im umožnili získavanie zakázaných produktov z lesa.

Z výsledkov prezentovaných v štúdiu vyplýva potreba urýchlene vypracovať, prijať a realizovať manažmentové stratégie na zabezpečenie ochrany a udržateľného využívania tunajších lesov, vrátane ich príspevku k dosiahnutiu uhlíkovej neutrality.



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