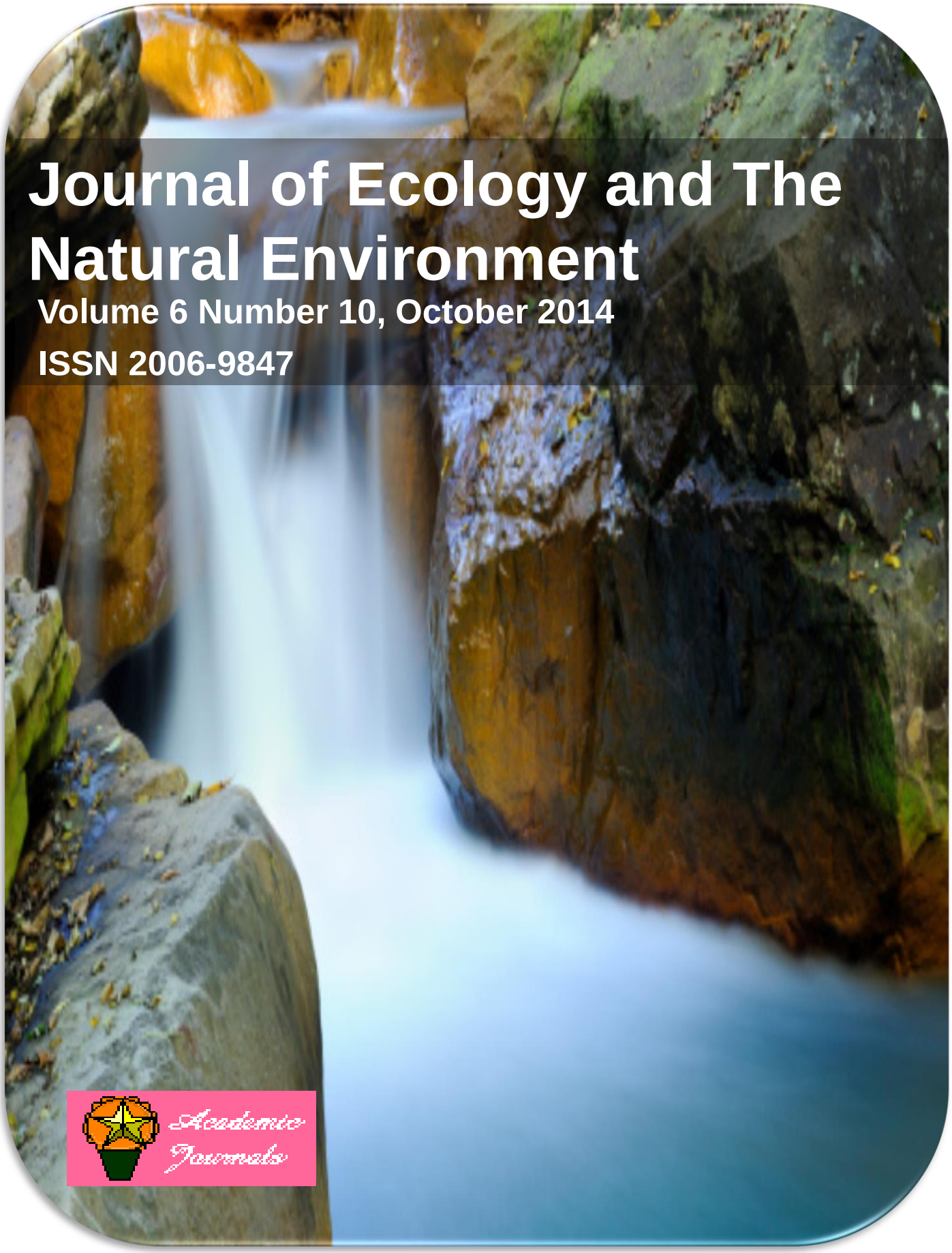

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Full Length Research Paper

Assessing the diversity and intensity of pesticide use in communal area cotton production in Zimbabwe

W. Mubvekeri[1]*, J. Bare[2], Caston Makaka[2] and F. Jimu[1]

[1]Cotton Research Institute, Kadoma, Department of Research and Specialist Services Zimbabwe.
[2]Department of Biological Sciences, Faculty of Science and Technology Midlands State University Gweru, Zimbabwe.

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A survey was conducted in Checheche, Nemangwe, Sanyati and Tafuna areas of Zimbabwe to assess the level of insecticide use and use of protective clothing in smallholder cotton production areas where the Cotton Research Institute conducted cotton experiments. Compliance with the closed season legislation, the Plant Pest and Diseases Act, Chapter 19, Section 8 of 1988 was checked because of its role in seasonal pest survival. Generally, pest management was found to be anchored on the use of insecticides with 71.9% of the farmers having positive indications regarding dependence on insecticides for pest control. Fifty nine percent of the farmers did not use scouting as a method to determine the need to spray insecticides. The closed season that helps break life cycle of insects was predominantly not observed. Integrated pest management approaches need to be promoted for the sack of the environment and the future of humanity.

Key words: Closed season, insecticide, integrated pest management.

INTRODUCTION

Cotton plays a significant role in the economy of Zimbabwe as it is the second largest export crop after tobacco (Esterhuizen, 2009). In 2008 the crop earned the country about US $150 million (Esterhuizen, 2009). However, in spite of its contribution to national economies, cotton is regarded as the most environmentally “toxic” crop on the planet (Cummins, 2003). Cotton covers 2.5% of the world’s cultivated land yet it accounts for 24% of the world’s insecticide use making it the most insecticide intensive crop globally (Laura, 2010). Chemical insecticides are used extensively in cotton production to control insect pests, with the primary target being bollworms (Vitale et al., 2007). Bollworm pressure has a positive impact on insecticide use (Qaim et al., 2003; Cotton Handbook Zimbabwe, 1998). Studies have shown that in Zimbabwe chemical pesticides alone can account for 70% of the variable costs in cotton production (Mudimu et al., 1995). Chemical insecticides when used carelessly can harm not only the environment, but also valuable pest predators, and the health of growers. The purpose of this study was to assess and establish the range and quantities of pesticides that are used by cotton growers in Zimbabwe. The results of the study would provide baseline information for further survey at a national scale. The objectives of the study were: To determine level of pesticides use in smallholder cotton production sector of

*Corresponding author. E-mail: wmubvekeri@yahoo.com.

Zimbabwe and determine the extent of use of protective clothing

MATERIALS AND METHODS

Study areas

The study was carried out in the cotton growing areas of Checheche, Nemangwe, Sanyati, and Tafuna.

Checheche

Checheche is located in the South Eastern Lowveld, approximately 80 km north northeast of Chiredzi town along the highway to BirchnoughBridge. It is in Natural Region V. The study area is located approximately 20°49' S and 32° 15' E. The altitude of the area ranges from 395 m in the south to 404.4 m in the north.

Nemangwe

The area is located approximately 30 km west of Gokwe Growth Point. The study area lies within the 18° 11' 00 S to 18°^{o} 12' 17 S and 28° 50' 25 E to 28° 51' 10 E coordinates in Natural Region IV. The altitude is about 1175 m. Soils are of loamy sand texture. The area is dominated by Mopani (*Colophospermunmopani*) woodlands. It is a smallholder communal area. The main landmark is Half-way Business Centre (H. B. C).

Sanyati

Sanyati area is located in Natural Region III on 17° 54' 47 S and 29°15' 15 E. The general altitude for the area is 832 m. Soils are of loamy sand texture. It is a smallholder communal area as well to the west of the area in Munyati river that flows northward.

The survey

The survey involved questionnaire interviews to collect baseline data on level of synthetic pesticide usage, and challenges regarding cotton stalk destruction in the areas under study.

Method of sampling

Sampling of respondents for questionnaire interviewees

Personal interviews were carried out using a designed questionnaire. Interviews were conducted in the villages of cotton growers who hosted Cotton Research Institute experiments in the same areas selected above. At each site, villages in which farmers hosting Cotton Research Institute experiments were located, identified and 50% of the villages were picked using simple random sampling. Heads of the selected villages were requested to provide names of all cotton growers in their villages. Fifty percent of the cotton growers in each village were randomly picked using simple random sampling method, and interviewed using prepared questionnaires. The interviewing team underwent a process of rehearsals to prepare them for the interviews. In Checheche, 13 farmers from Matikwa village in ward 26 of Chief Garawa were interviewed. In Nemangwe, eight farmers from Ndziko village in ward 12 of Chief Nemangwe were interviewed. In Sanyati, 11 out 12 farmers from Madhuveko village in ward 12 of Chief Wozhele were also interviewed. The twelfth farmer had gone to attend a funeral of a relative.

The questionnaire

The questionnaire was in four parts.

Part one

The first part sought to gather the farmer's location, average cotton hectares, and years of experience as a cotton grower.

Part two: pesticides

The second part was concerned with pesticides. Section one gathered information about a variety of insecticides and average quantities of each that a cotton grower applied seasonally. Seven insecticides were used on lepidopteran pests.

Section two sought to collect information on the standard of grower protection against insecticides. Chemicals sprays contaminate the environment and human beings and more-so those who conduct the spraying which poorly protected. Insecticides are mostly toxic chemicals. The assumption is that people who care less about their own personal safety against poisons would care lesser against poisoning the environment as well.

Part three: Slashing and destruction of cotton stalks to determine level of farmer compliance.

This part of the questionnaire collected information regarding slashing and destruction of cotton stalks. The information would help understand the causes behind ratoon cotton production and whether the cotton growers appreciated the ecological value of residue destruction as a cultural, non-chemical pest management tool. The information would also help to determine the level of compliance with regulations guiding cotton stalk destruction. The team leader of the plant inspectorate was also asked to tell the constraints regarding enforcement of the closed season regulation through personal one on one communication.

Statistical analysis

Statistical Package for Social Scientists (SPSS) was used for data entry and analysis of frequencies. Data from questionnaires were analysed for frequencies. Cross tabulation was done using SPSS to determine relationships between variables.

RESULTS

Factors affecting grower compliance with plant pests and diseases act; chapter 19:08 of the republic of Zimbabwe

Cotton growers gave a variety of reasons why the closed season legislation was being ignored by some of the growers. Farmers who rent rather than own land were also cited though rarely as the ones who leave standing cotton over the off season. The ratoon cropping, and laziness were cited as the major reasons for not complying with the closed season legislation. The price and unavailability of planting seed, and labour constraint were also common responses (Figure 1).

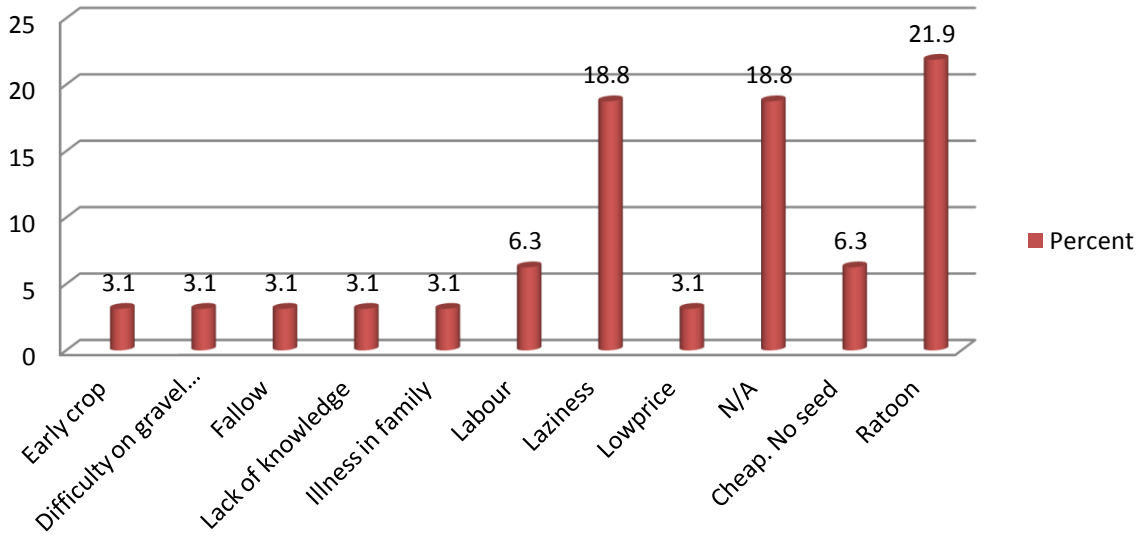

Figure 1. Diversity of reasons the farmers gave for not destroying cotton stalks.

Figure 2. Graphical presentation showinglevelof compliance with closed season regulations.

Compliance with closed season regulations

Results from the interviews showed that 71.9% of the farmers claimed to have had slashed cotton stalks in their fields while 28.1% admitted not to have slashed cotton stalks (Figure 2). However visits to the field by the survey team revealed that only 34.4% of growers had slashed while 65.6% had not slashed. Therefore the actual level of compliance with the above legislation by the time the survey was conducted was 34.4%. Under consideration also was whether the grower had slashed cotton stalks by the legislated date and not by the date of the interview.

Dependance on insecticides in the study areas

Cotton pest management in the study areas is dominated by use of insecticides.

A total of eight insecticides and two acaricides namely Mitac (Amitraz) and Tedion (Tetradifon) were recorded as having been used by cotton growers in the study area.

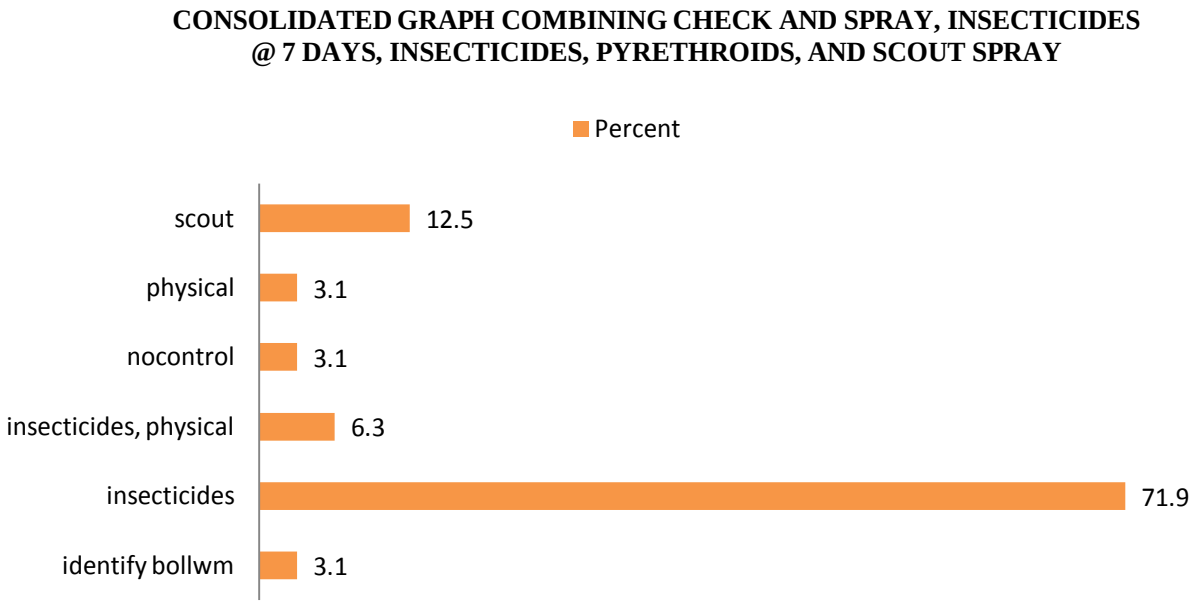

Figure 3. Showing the extent of reliance on chemicals for pest control by cotton growers.

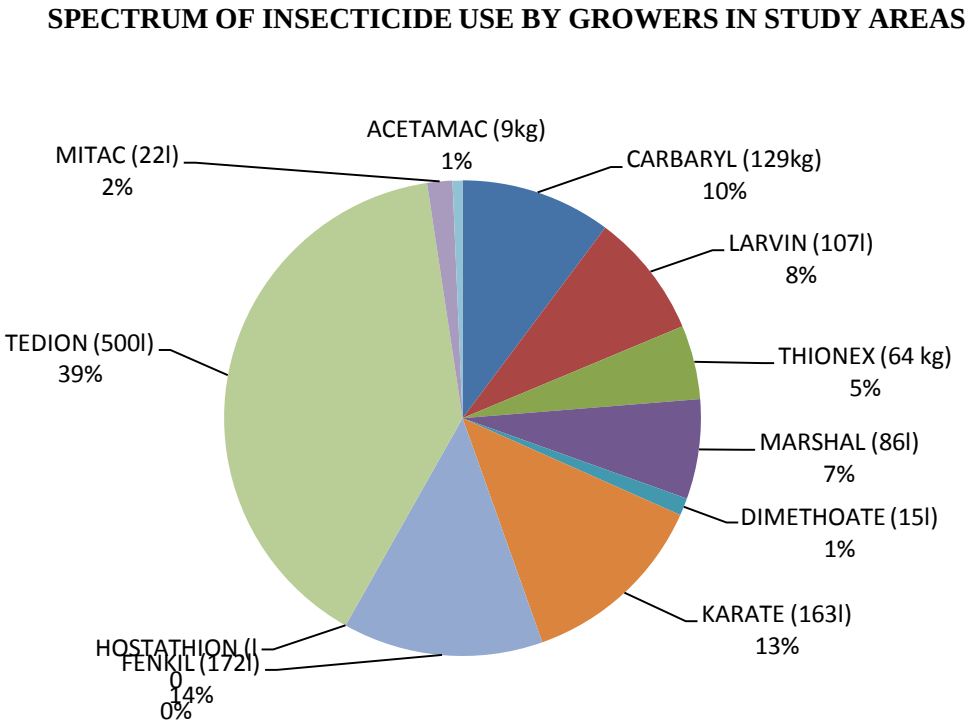

Figure 4. Showing a range of chemicals farmers said they used.

Insecticides accounted for 71.9% of responses given by cotton growers in the study areas (Figure 3).

Karate (lambda) and Fenkil (Fenvelarate) Carbaryl, Larvin (Thiodicarb 37.5 FW), and Thionex (Endosulphan 35 EC) were being used mainly against bollworms (Figure 4). Together the chemicals accounted for 50% of all chemicals used in the study areas. That could imply considerable bollworm pressure. Monocrotophos was also in use at Checheche. Such a highly poisonous product is not recommended for application using hand held equipment

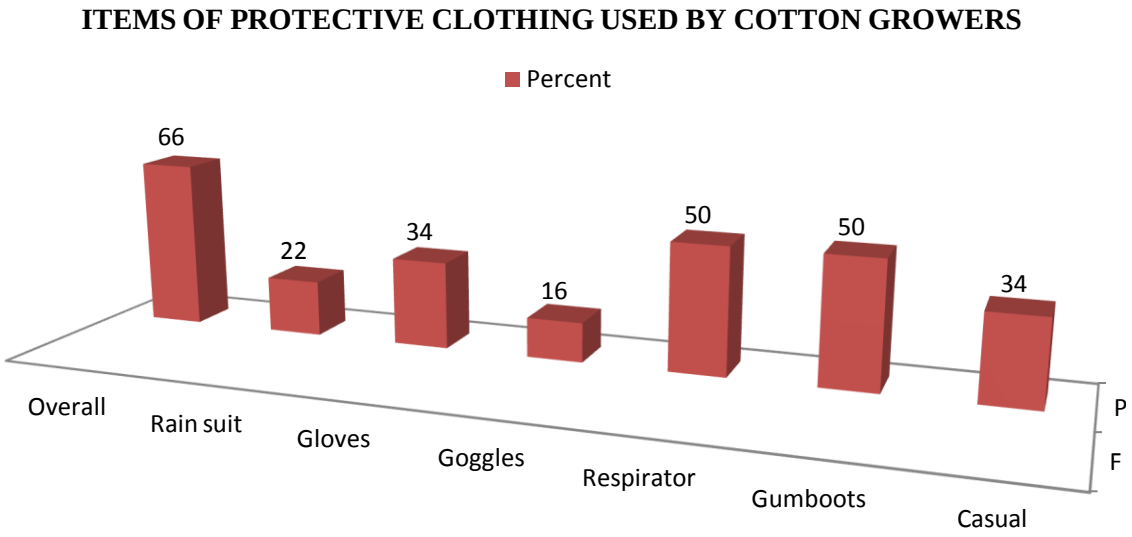

Figure 5. Graphical presentation of items of protective clothing used by growers in study areas combined.

as was the case in Checheche.

Assessment of protective clothing for use during handling of insecticides

Sixty six percent of respondents applied chemicals without any form of protective clothing while 66% handled chemicals with bare hands and 50 % without respirators (Figure 5). An important observation was that in some cases what respondents regarded as respirators were actually dust masks.

DISCUSSION

Factors affecting grower compliance with plant pests and diseases act chapter 19:08.

Level of compliance

The level of compliance with the closed season regulation by the time the survey was conducted was 34.4%. Under consideration also was whether the grower had slashed cotton stalks by the legislated date and not by the date of the interview. In the Low veld, Checheche included, the closed season started on 1st August and ends on 5th October each year. The survey was conducted from 6 to 8 September 2010 and most farmers had not slashed cotton stalks by that time; that was five weeks into the closed season. In the Middle veld, where Nemangwe, Sanyati, and Panmure are located, the closed season starts on 15 August and ends on 20 October each year. Most cotton growers had not slashed cotton stalks by 16-18 September 2010 when interviews were conducted in Nemangwe and Sanyati. That was a full month into the closed season.

Factors affecting compliance

Production of seed cotton from ratoon was cited by most growers as the major cause for not destroying cotton stalks. Ratoon is becoming popular because it ensures an early cotton crop which normally matures before a crop established from seed. The ratoon crop establishes quickly with the first rains of the season. The ratoon grows from a well-established root system hence can better survive through mid-season droughts. Farmers are able to sell their seed cotton and earn money earlier in the harvest period. Production of ratoon crop is cheap considering the current price of US $1.00 per kg of cotton seed. The recommended seed rate for cotton is 25 kg/hectare implying that the grower would have saved US $25.00 for every hectare.

Destruction of cotton stalks is becoming unpopular because of the low market price for seed cotton. There is no grower motivation to go back to the fields to slash and destroy cotton stalks after selling the crops at “unviable prices”. Destruction of cotton stalks does not offer a direct monetary benefit hence the reluctance to commit labour, the laziness, and, the prioritization of other family welfare issues over the future of the crop. Issues of labour, laziness and family illnesses are linked. When combined they account for 28% frequency.

From the point of view of the plant inspectorate there are several factors that led to complacency towards destruction of cotton stalks by cotton growers chief among them being lack of visibility of inspectors in cotton growing areas due to poor mobility and delayed amendment of the legislation to enable the inspectors to issue United

States dollar (US$) tickets (*Pers. Com,* 2010). At the time of the survey the Plant Pest and Diseases Act still stipulated fines in Z$ but the economy was using US$ it is not possible to punish offenders. The closed season regulation would continue to be ignored for as long as the enforcement agent remains logistically and legally incapacitated.

Pest management practices existing in the study areas

Over 70% of cotton growers in the study areas relied on insecticides alone for pest control. This is consistent with situations where the closed season is not strictly observed in cotton production. The only other method which rarely cited though was physical control, whereby grower pick and kill pests they find as they walk through the field. Scouting for pests before chemical application was mentioned although most growers failed to explain the technique.

The total area put to cotton by the study areas' sampled cotton growers in Checheche, Nemangwe and Sanyati was 137.5 hectares. Karate (Lambda) and Fenkil (Fenvelarate) are systemic pyrethroids used for the control of bollworms. Combined these chemical accounted for 335 L over 137.5 hectares, which is 2.4 L/hectare instead of about 0.8 l/hectare (Cotton Handbook, 1998). Conventional contact insecticides that growers indicated to have been using to target bollworms were Carbaryl, Larvin, and Thionex all of which account for 300 kg over 137.5 hectares, which is 2.2 kg/hectare. The national average cotton area is 360000 hectare/year. Assuming that each grower applies 2.4 L of pyrethroids per hectare and 2.2 kg of conventional insecticides per hectare, then, 877 090 L and 785 454 kg respectively could be sprayed into the environment annually. Such generous applications of insecticides to control crop damage by pests increases the direct risk of environmental pollution and kill non target pests. The environment is suffering. Growers are suffering too. Their standard of protection when handling insecticides is low.

The main ecologically appropriate cotton pest control tool is observance of host-free period. The low level of compliance with the closed season is linked to general "indiscipline" in the whole pest management regime at the expense of the environment. It was observed that even the acaricide rotation scheme is not being observed. In 2009/2010, Tedion (Tetradifon) was supposed to be used for red spider mite control in Region II only.Tedion is a sulphur compound with a long residual action (Mabveni, 2000). Cotton growers in Region III also used the same thereby increasing the risk RSM developing resistance to acaricides.Some 500 L of tedion was applied on 137.5 hectares that is 3.5 l/hectare against a recommended rate of 1.2 l/hectare (Cotton Handbook, 1998). Assuming that each grower in Zimbabwe applied 3.5 L, then, 1 2 million L of tedion alone could be sprayed into the environment annually. Of interest was that two growers in Checheche were using nuvacron (monocrotophos), a highly poisonous organophosphate. They got it from neighbouring Mozambique.

The latest global trends in pest control in cotton show that insecticide use is on the decline in most countries and cotton producers are rapidly moving toward minimal insecticide dependent cotton production systems (ICAC, 2007). It appears that Zimbabwean farmers are going in the opposite and wrong direction. There is need to rigorously promote environmentally friendly sustainable pest control systems. The closed season is environment friendly and will undoubtedly reduce insecticide use when strictly observed. While the total elimination of insecticides may not be feasible everywhere it is certainly possible to drastically reduce their use.

Conclusions

Cotton bollworm management in Zimbabwe was largely insecticidal. Cotton growers had a high risk of contamination by insecticides due to poor protection during handling. Integrated pest management was not popular among cotton growers.

Recommendations

Recommendations for future research and pest management practices are given below:

1) The legislation governing cotton closed season and destruction of cotton stalks should be enforced by Plant Quarantine Services as a matter of national priority. That could have the effect of suppressing pest population and of cutting down on the level of insecticide application into the environment.
2) Cotton growers should be trained in the application of integrated pest management techniques most of which are environment friendly and economically sustainable. Rigorous extension is essential in order to increase the level of social and environmental responsibility of cotton production.
3) Finally, legislation alone cannot bring about cooperation. Cotton merchants have to address growers'' grievances regarding producer prices and cost of input.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Journal of Ecology and the Natural Environment

Full Length Research Paper

Regulation of usages and dependency on indigenous fruits (IFs) for livelihoods sustenance of rural households: A case study of the Ivindo National Park (INP), Gabon

Mikolo Yobo Christian[1]* and Kasumi I. T. O.[2]

[1]Department of Bioengineering Science, Graduate School of Bioagricultural Sciences, Division of International Cooperation in Agricultural Science Laboratory of Project Development, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan.
[2]International Cooperation Center for Agricultural Education, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan.

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The dependency of many rural people on restricted access and use of natural resources of national parks for livelihoods sustenance is poorly acknowledged and detailed surveys clarifying usages and dependency on forest resources by local people are often lacking, especially for regulations and laws improvement purposes. A semi-structured questionnaire was administered to six villages of 252 households (152) in close and (100) far areas following about 80% sampling intensity coupled with focus groups' discussions, to clarify usages and the dependency of rural people on indigenous fruits' species around the Ivindo National Park in Gabon. The results of the study revealed that these forest products collected represent an important component of the household livelihoods as source of food and income generation. Almost all the people, 250 (99.2%) reported harvesting all the six forest products in both locations of the park. Among the harvested products, three out of the six were considered as most popular such as *Coula edulis, Dacriodes buettneri* and *Irvingia gabonensis* while the others three were perceived as less popular ones, for example *Baillonella toxisperma, Gambeya lacourtiana* and *Trichoscypha abut.* In addition, purpose of forest products harvesting were both directed to household consumption, 250 (100.0%) and income generation, 88 (75.2%). Moreover, two out of the three most popular fruit species are sold at higher price per unit including *C. edulis* and *I. gabonensis.* Since the trends on usage were different mainly by ethnic group, distance and residential period, therefore it is necessary to be flexible when designing future rules and regulations on resources utilization of the Ivindo National Park that ensure livelihood of rural people in the meanwhile.

Key words: Usages, dependency, indigenous fruits species, regulation, Ivindo National Park, Gabon.

INTRODUCTION

National parks are one of the typical and worldwide approaches for protection and sustainable management of natural resources. However, difficulties in keeping the balance between protection and resource utilization by

rural people for their livelihood have been reported from many countries such as Indonesia, India, Malaysia, Nepal and Zimbabwe (Wells et al., 1999; Agrawal, 2001; Lynam et al., 2007; Spiteri and Nepal, 2008; Frost and Bond, 2006). According to past studies and experiences, natural resources management by preventing rural people from using resources for their livelihood tend to fail (Beltrán, 2000; Bawa et al., 2007; Naughton-Treves et al., 2005). Responding to the lessons learned, natural resources management especially in developing countries have been gradually shifting from protection by prohibiting usages of resources to sustainable utilization by rural people including participatory natural resources management which will provide resources for basic human needs (Beltrán, 2000; Agrawal and Ostrom, 2006; Hayes and Ostrom, 2005; Naughton-Treves et al., 2005). However, there are still many countries falling behind the trend such as the Gabon.

The republic of Gabon is located on the Atlantic coast of Central Africa, and covers a total area of 267,667 km^2 with 1.50 millions of people (UNDP, 2010). The country with an equatorial climate is partly covered by the Congo Basin, the second largest tropical forest after the Amazon Basin. Necessity of its protection and sustainable management of its valuable biodiversity has been gradually recognized after Nobel Prize winner Wangari Maathai became roving ambassador for its protection and sustainable management. More than 80% of the country is recognized as rich diversified forests with more than 6,500 plant species, 3,020 mammal species and 617 bird species (Blaser et al., 2011). Thanks to its abundant natural resources endowment, the economy of the country is largely dependent on natural resources especially exporting oil, timber and manganese. With per capita gross national income (GNI) of USD 7,370, Gabon is classified as middle income country in the world, or one of the highest among African countries (AFDB, 2011). On the other hand, agriculture accounts for only 4% of gross domestic product (GDP) of the country, and nearly 85% of foods are imported due to an undeveloped agriculture and its manufacturing (AFDB, 2011).

The undiversified economy appears to be a cause of unstable economy by fluctuating international price of oil, reduction and loss of forest resources and biodiversity by exporting timbers, and acceleration of rural poverty by restricting access and usage of forest resources such as fruits, nuts, tree leafs for wrapping, medicinal plants, construction material and wild animal for meats (AfDBG, 2011), especially inside national parks. Additionally, since agricultural sector of the country is very weak, people in rural area tend to depend more on collection of natural resources rather than production. It means that forest resources are the important lifeline for livelihood of local people as well as the economy of the country. The recent national development strategy of the country therefore prioritizes conservation of natural environment while seeking to develop competitive manufacturing industries and services sector, and exporting raw timber was already prohibited by law in 2010 (AfDBG, 2011).

In Gabon, protection of natural resources has started since colonial period with Lopé reserve establishment in 1946 followed by the Ipassa Makokou Biosphere Reserve in 1979 and more recently with a network of 13 national parks established throughout the country covering nearly 2.9 million (11%) ha of total land area (Blaser et al., 2011) with some of them representing extensions of the previous biosphere reserves. The main objectives of establishing such parks were strict biodiversity conservation and ecotourism development for the most part (Gabonese Republic, 2001, 2007). Rules and regulations of the national parks, as a part of natural resources management of the country, are existing under the decree on Customary Rights Law of 2004 (Gabonese Republic, 2004), Forestry Code of 2001 (Gabonese Republic, 2001), and the National Parks Law of 2007 (Gabonese Republic, 2007). Access and use of resources are strictly prohibited in the core area by the National Park Law of 2007, regulated in the buffer zone and let free of use in the transition area.

However, these laws and regulations have not fully considered the livelihoods of rural people even though most park areas used to be utilized by them. As a result, firewood is the only forest product allowed to be collected from the national parks to sustain the livelihoods of rural people, other forest products even non-timber forest products (NTFPs) including nuts and fruits from indigenous trees, known as indigenous fruits (IFs), have been prohibited from use inside the park, regulated in the buffer zone, and let free of use outside by the above mentioned laws and regulations on forest and national parks. The harvesting, utilization and marketing of indigenous fruit and nuts have been central to the livelihoods of majority of rural communities throughout Africa (Akinnifesi et al., 2007; Leakey et al., 2005).

In Gabon, it is also recognized as one of the important traditional resources for rural people and that restrictions on usages may have enormous negative impact on their livelihood. Although buffer zone is available in all national parks of Gabon, rules of resources use by local people for their livelihood are not clearly mentioned by current laws and regulations. Setting up restrictive measures without securing livelihoods of rural people could threaten their lives as well as biodiversity and natural resources as the other countries have experienced. It is therefore urgently necessary to set clear rules and regulations by concerning livelihood of local people as well as

*Corresponding author. E-mail: yobo.mikolo@g.mbox.nagoya-u.ac.jp. Tel: +81-52-789-4225. Fax: +81-52-789-4222.

sustainable forest resources management.

However, only a limited numbers of quantitative studies based on field survey have been conducted to understand reality of usages and dependency on forest resources by local people, which is urgently necessary for the improvement of regulations and laws on national park management that ensure livelihood of rural people. This study therefore aims to clarify the current situation of natural resources utilization and dependency by rural people near the national park. The Ivindo National Park (INP), one of the oldest protection areas in Gabon, is selected as a case study of typical national park of Gabon.

MATERIALS AND METHODS

Study area

The study was carried out in communities around the Ivindo National Park (INP) in the province of Ogooué-Ivindo, north-eastern Gabon, about 620 km from Libreville, main capital city of Gabon. This area is located in Central African region (0° 23'-0° 33'N, 0° 42'-12° 49E) (Figure 1). The population of the area is about 15,000 people (IRET/CENAREST, 2003). The poor development of roads in this area makes difficult commercial exchanges between towns and other parts of the country coupled with a poor development of agricultural and tourism industries (Lescuyer, 2006). Therefore, people in this region probably need to depend more on natural resources for their livelihood as compare to the urban area. The region of Makokou is characterized by an equatorial climate, marked by a high humidity, middle high rainfall of 1,700 mm, temperature averaging 24°C year round with four distinguished seasons: small dry (from December to February), rainy (from March to May), dry (from June to August) and small rainy (from September to November) (IRET/CENAREST, 2003).

The forest of the area is known as dense evergreen and humid type (Cabalé, 1978), and has characteristics of the Guineo-Congolese forests (White, 1992) of rich fauna and floristic composition. According to the existing report, about 1,200 floral species have been inventoried in this area as total (IRET/CENAREST, 2003). Among valuable timber and non-timber forest products commonly encountered around the study area include *Scorodophleus zenkeri, Santiria trimera, Coula edulis, Anonidium mannii, Afrostyrax lepidophyllus*, *Baillonella toxisperma*, *Dacriodes buettneri*, *Irvingia gabonensis* and *Coula edulis.* The park hosts also a large variety of wildlife species including mammals, birds species, etc. (Vander Weghe, 2006).

The current area of the park formerly known as Ipassa Biosphere Reserve of 10,000 ha was established in 1979. The reserve area was then extended to form the actual Ivindo National Park covering area of 300,000 ha today. The park is composed of three main areas including transition area, buffer zone and central or core area. Access and use of resources are strictly prohibited in the core area, regulated in the buffer zone and permitted in the transition area, as well as the other national parks in Gabon as an adopted type of management approach. The population in this area consists of many ethnic groups including the Bantus and the Baka Pygmies who live near the park area. The Bantus break up into small groups including Fang, Kwélé and Kota. The Fang and Kota are the main dominant ethnic groups with a small number of migrants' people in the area (IRET/CENAREST, 2003).

According to the several existing reports, rural people are using the areas of the park for their livelihoods activities such as slash and burn agriculture, hunting, fishing, gathering resources and unsustainable forest resources utilization through illegal access especially by people who live close to the park has been suspected (Okouyi-Okouyi, 2006; Lescuyer, 2006; Sassen and Wan, 2006). Although logging operations inside of national parks have been banned for conservation purposes, several important species including IFs appear to be threatened or vulnerable. For instance, multiple use plant species such as Moabi (*Baillonella toxisperma*) has been included as Red List of Threatened Species under International Union for Conservation of Nature and Natural Resources (IUCN) due to overexploitation by logging companies and rural people unsustainable harvesting of its fruits or seeds for oil making (Sassen and Wan, 2006; White, 1998). A past study on small number of households carried out mainly in Loaloa, the closest village of this area revealed that forest products including indigenous forest products near the Ivindo National Park are valuable sources of food and revenue for livelihoods of rural people living nearby (Sassen and Wan, 2006). However, usages and dependency of rural people on indigenous fruits based on detailed survey is not identified yet for the improvement of regulations on national park management.

Data collection and analysis

In this study, several preliminary surveys were conducted near the Ivindo National Park to select appropriate study area by identifying migration history, social structures, popular fruit trees and general resource usage through workshops for key informants such as leader or village chiefs. As a result of the preliminary surveys, a total of six villages, three villages each, close (less than 3 km from the park gate) and far (more than 3 km from the park gate) were selected as target area for this study. This study attempted to access 80% of all the existing households in each village for semi-structured interviews based on questionnaire form. A well conducted semi-structured interview contributes to yield of an appropriate relationship between researcher and the respondents (Longhurst, 2003; Whiting, 2008).

In order to clarify resources usages and dependency on indigenous fruits species for livelihoods sustenance of rural households around the park, questions on socio-economic status, resources utilization tendency and awareness and knowledge on the park were prepared and pretested before the survey. The first part of the interview consisted of the questions on socio-economic status such as academic background, employment status and residential period. The second part of was questions on name of harvested fruits species, amount of harvesting, amount of selling and income by selling the fruits were asked to identify tendency of resources utilization in the study area. This study focused on six popular indigenous fruit species, Coula edulis, Inrvingia gabonensis, Dacriodès buettneri, Gambeya lacourtiana, Trichoscypha abut and Baillonella toxisperma, according to the results of preliminary survey of the key informants. Final part of the interview was awareness and knowledge on the national parks such as its boundary, protection status and issues affecting its development, roles of national park's staff, and available laws or regulations on resources utilization. Tendency and characteristics of resource utilization and people's dependency were analyzed by distance, socio-economic status and awareness on the park. SPSS (17.0) was used for all the statistical tests for comparative analysis.

RESULTS AND DISCUSSION

Respondents and their socio-economic status

As a result of field survey, 79.8% (260) of all households in the target villages were visited for interview, and which

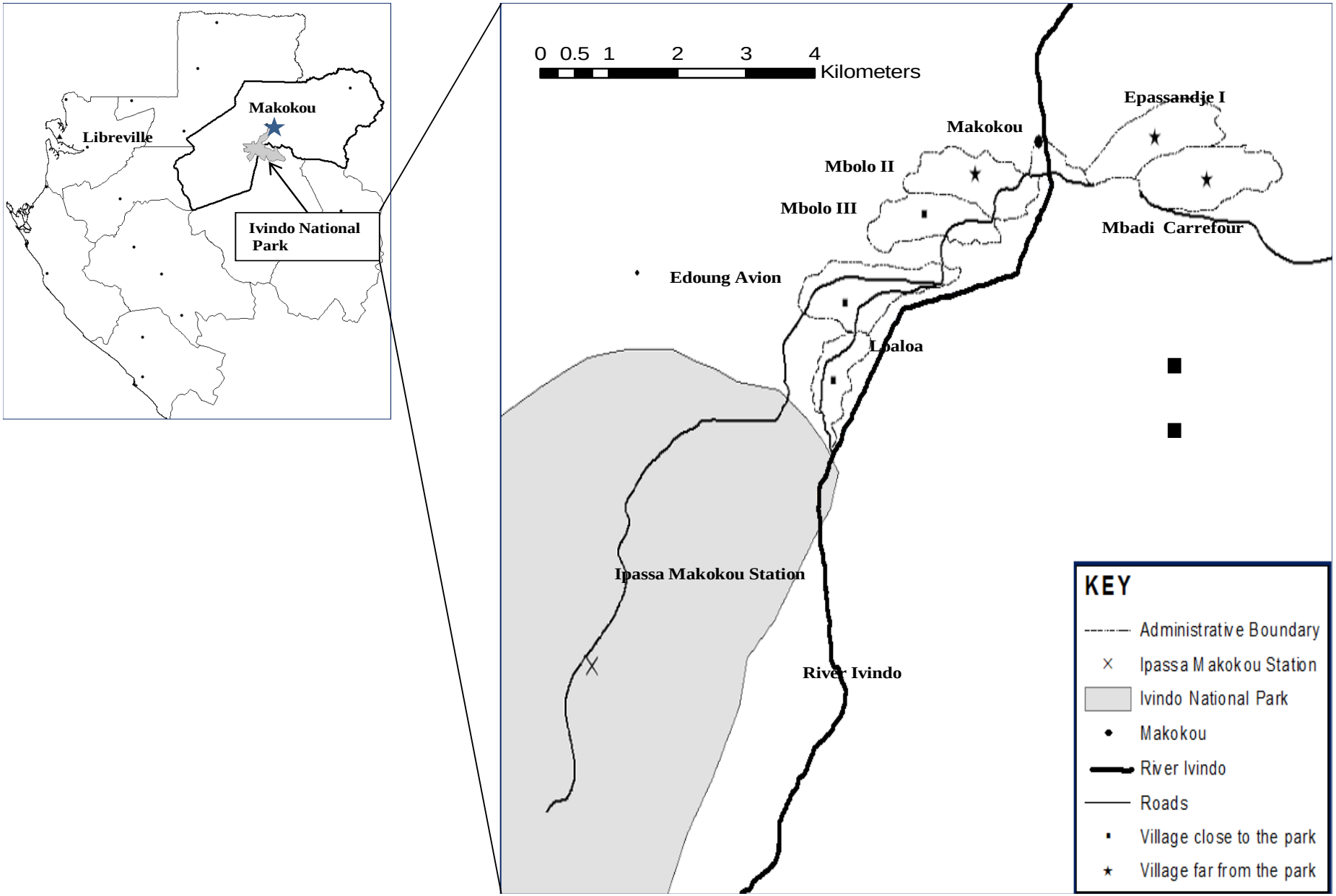

Figure 1. The study area around the Ivindo National Park in Makokou, north east of Gabon.

Table 1. Results of sampling.

-	Target villages	Existing HHs	Sampled HHs (%)		Valid response (%)	
	A	60	50	(83.3)	50	(100)
Close	B	56	51	(91.1)	50	(98.0)
	C	70	58	(82.9)	52	(89.7)
-	Sub total	186	159	(85.5)	152	(95.6)
	D	80	51	(63.8)	51	(100)
Far	E	20	15	(75.0)	15	(100)
	F	40	35	(87.5)	34	(97.1)
	Sub total	140	101	(72.1)	100	(99.0)
Total		326	260	(79.8)	252	(96.9)

consists of 159 households in close area and 101 households in far area, (Table 1). Among all respondents, 95.6% (152) in close area and 99.0% (100) in far area, a total of 252 (96.9%) households, were accepted as valid responses. The number of respondents was considered as sufficient to analyze tendency and characteristics of resources usage and dependency of this area were obtained.

Table 2 shows the socio-economic status of respondents in the study area. As a result of sampling, this study succeeded in collecting nearly half (42.5%) of the female respondents among 252 responses. Since Kota (57.5%) and Fang (27.8%) groups represent majority of the total respondents, the samples of this study were presumed to reflect real social structure of the study area. According to the sampled data, almost all the Fang households were located in close area and there was only one Fang households in far area. Therefore, it is considered that Fang households are concentrated only in close area while Kota households spread into the both close and far villages. Education level of respondents was considered as relatively low since more than half (50.8%) of the respondents have received only primary education. Education level of respondents found in close area was slightly higher than that of far area with regards to the proportion of people who have reached both primary (52.6%) and secondary (42.8%) education than in far area.

Regardless of the slightly higher education status of close respondents, their unemployment rate was lower than that of far area. Generally, education status and employment stats tend to have positive correlation. However, the study area did not show such typical trend. The employment status in this area may be influenced by geographical conditions because areas near the city such as three villages in the far area may have more job opportunities than rural area of close area. The results also indicated that most people in both close and far area have migrated about thirty years ago from the other areas. Average residential period is slightly higher in the close area of 28.8 years than the far area of 25.6 years therefore, migrants might start to occupy near the current national park at the beginning, and gradually expand their residential area to the farther area.

Resource utilization

The results of the study showed that almost all respondents (99.2%) were engaged in harvesting of at last one of the six indigenous fruits species (Table 3). Of the six produces, three of them such as *C. edulis, D. buettneri* and *I. gabonensis* seemed more popular than the other three because they were harvested by more than 80.0% of the respondents. By contrast, other three produces including *G. lacourtiana*, *T. abut* and *B. toxisperma* were identified as less popular ones with utilization of 65.2, 48.4 and 45.2% of respondents, respectively. Seasonality of harvesting the fruits was observed since the more popular species were harvested during the dry season and more often while the less popular ones were harvested in the big dry season and less often. The seasonal nature of such forest based activities refers to the fact that resource users harvest them only at certain periods of the year (Timko et al., 2010). Consequently, out of these given periods, resource users tend to depend on other forest products to meet their households' livelihoods needs.

Additionally, trends for harvesting were different by species because average harvesting amount and frequency of less popular species for both consuming and selling purpose were only half of the popular species. According to these results, availability of more popular species assumed to be higher than the less popular ones, and it may influence the resources utilization trend.

With regards to purpose of fruits' utilization, all the respondents were consuming them while 75.2% of respondents were selling at least one of the six indigenous fruits therefore; more respondents were engaged in consumption than sales of these produces. However,

Table 2. Social structure of sampled area.

-		Distance				Total: 252 HHs (%)	
		Close: 152 HHs (%)		Far: 100HHs (%)			
Gender	Male	87	(57.2)	58	(58.0)	145	(57.5)
	Female	65	(42.8)	42	(42.0)	107	(42.5)
Ethnicity	Kota	62	(40.8)	83	(83.0)	145	(57.5)
	Fang	69	(45.4)	1	(1.0)	70	(27.8)
	Kouele	7	(4.6)	1	(1.0)	8	(3.2)
	Sacke	2	(1.3)	2	(2.0)	4	(1.6)
	Ossamaye	8	(5.3)	7	(7.0)	15	(6.0)
	Massango	4	(2.6)	6	(6.0)	10	(4.0)
Education	None	5	(3.3)	11	(11.0)	16	(6.3)
	Primary	80	(52.6)	48	(48.0)	128	(50.8)
	Secondary	65	(42.8)	41	(41.0)	106	(42.1)
	University	2	(1.3)	0	(0.0)	2	(0.8)
Employment status	Employed	104	(68.4)	80	(80.0)	184	(73.0)
	Unemployed	48	(31.6)	20	(20.0)	68	(27.0)
Residential period (yrs)	Average period	29.2		25.6		27.8	
Size of household	Average number	9.0		8.8		8.9	

average harvesting amount and frequency of each six species for selling were more than that of consumption as mentioned above. It means that indigenous fruits harvesting for selling purpose is considered as major usage and that large amount of resources have been utilized even by fewer respondents. In addition, the purpose of indigenous fruits' use depended on species since the number of respondents was more than 100 in popular species while it was less than 30 in less popular ones. This tendency may be influenced by price as well as resources' availability because both the number of harvesting respondents and selling price per kg of less popular species were smaller than that of more popular species. Thus, both selling and consuming purpose were considered as main purpose of fruits usage in the study area.

Similar results have been stressed by Awe et al (2011) who have revealed that objectives of NTFPs gathering is to meet households sustenance's needs since almost (98%) of rural people collect and use NTFPs as source of food in Kogi State (Nigeria). In the case of Pachmarhi Biosphere Reserve (India), Kala (2011) showed that out of a total of 46 tree species gathered from the wild by local people, 41% of them are used as source of food with trees used for medicine purposes representing fifty percent of response in terms of usage. These results indicate the importance of indigenous fruits in sustaining the livelihoods of people engaged in their harvesting as source of income generation and food (Awe et al., 2011).

Moreover, the popularity of these forest products is also revealed by their mean market price per unit since *I. gabonensis* and *C. edulis* represent the two species fetching higher market price per FCFA out of the six species in the study area, 500 and 300 FCFA, respectively while *G. lacourtiana, T. abut* and *Baillonella toxisperma* fruits species averaged 200 FCFA each. Thus, mean price of forest products may reflect the importance or direct use values that the respondents have for the resources in terms of consumption and income generation from sale. Given this importance, uncontrolled price (demand) driving resources supply may have serious implications on forest resources management, livelihoods sustainability and conservation goals (Duchelle et al., 2011; Saha and Sundriyal, 2012).

Resource use and socio-economic status of the respondents

Table 4 shows amounts of resources harvested (T), consumed (C) and sold (S) for each of six indigenous fruits species and the total with regards to socio-economic status of the respondents such as ethnic group, family size and residential period. According to the results, all ethnic groups were involved in harvesting some of the six indigenous fruits species for both consumption and selling purposes, however, each ethnic group showed different trends by purpose and species. As total harvesting amount of the six produces, Ossamaye was the largest in harvest in average amount followed by Fang. For consuming purpose, the average harvesting amount was the largest for Massango then followed by Ossamaye while the Kouélé group had the largest harvested amount in average for selling purpose

Table 3. Resource utilisation in the study area.

Species	Collection				Purpose (n=250)	No. of HHs (%)		Amount (kg) /season[2]	Income (FCFA[4]) /season[2]	Mean price (FCFA)/ kg
	No. of HHs (%)[1]		Season[2]	Frequency[3]				Mean±SD	Mean±SD	
All species	250	(99.2)			Selling Consuming	188 250	(75.2) (100)	21.4 ± 1.2 21.0±0.7	7,397.3± 397.2	326.5
Coula edulis	230	(92.0)	Small dry	2	Selling Consuming	152 230	(66.1) (100)	9.1±0.6 6.1±0.3	2,715.8 ±168.6	300.0
Irvingia gabonensis	227	(90.8)	Small dry	2	Selling Consuming	145 227	(63.9) (100)	10.3±0.5 6.8±0.3	5,162.1 ±270.2	500.0
Dacriodes buettneri	211	(84.4)	Small dry	2	Selling Consuming	111 211	(52.6) (100)	7.9±0.7 5.2±0.3	1,589.2 ±135.9	200.0
Gambeya lacourtiana	163	(65.2)	Big dry	1	Selling Consuming	30 162	(18.4) (99.4)	4.7±0.5 3.0±0.2	946.7 ±105.5	200.0
Trichoscypha abut	121	(48.4)	Big dry	1	Selling Consuming	10 119	(8.3) (98.4)	6.5±2.0 2.8±0.2	1,310.0 ±403.4	200.0
Baillonella toxisperma	113	(45.2)	Big dry	1	Selling Consuming	16 113	(14.2) (100)	3.6±0.6 3.2±0.2	725.0 ±118.1	200.0

1. N=252; 2. There are following four seasons in the study area, Small dry: December to February and from March to May and Big dry: June to August and from September to November. 3. Harvesting frequency per season; 4. Local currency of Gabon. This study calculated 1 FCFA = 655.957 Euro.

mainly. From the perspective of species, although three popular ones, C. edulis, D. buettneri and I. gabonensis were harvested for both consuming and selling purposes by all the six ethnic groups, however, Kouélé, Sacké and Massango were not involved at all in selling the less popular species of G. lacourtiana, T. abut and B. toxisperma. The less popular species were harvested for consumption and selling purposes by Kota group, the dominant ethnic group of far area.

Although, there is no data to show the availability of each of the less popular fruits species in this study, however, if those species were available in far area, Kouélé Sacké and Massango groups may have different customs from other ethnic groups since they were not involved at all in harvesting of those species. As another possibility, Kota people may be visiting near the national park for harvesting if the species are not available in far area. Highly significant relationships were found among the six ethnic groups for total harvested amount (p=0.00), consumed (p=0.00), sold (p=0.00) of all the six indigenous fruits species at 5% significant level, as a result of Kruskal-Wallis test. In addition, significant relationships among six ethnic groups were also found with regards to total harvested amount, consumed and sold amount of the three more popular species at 5% significant level, except for sold amount of *I. gabonensis* and consumed amount of *D. buettneri*. However, no significant relationships among the six ethnic groups were found for any of total, consumed and sold amounts of the less popular

Table 4. Amounts of resources used, income and socio-economic status of the respondents (N=250).

Variables	Contents	All species				*Coula edulis* (CE)				Irvingia gabonensis (IG)			
		Consumed	Sold	Total harvested amount	Total income	Consumed	Sold	Total harvested amount	Total income	Consumed	Sold	Total harvested amount	Total income
Ethnicity	Kota	18.3	18.3	32.0	6253.3	5.1	6.9	9.5	2082.4	6.0	9.3	11.3	4653.8
	Fang	23.9	27.3	45.0	9570.4	7.5	12.0	16.1	3600.0	8.1	12.0	17.4	6010.4
	Kouele	18.9	31.5	42.5	11250.0	9.7	23.3	25.2	6975.0	5.6	13.6	15.3	6800.0
	Sacke	22.5	13.3	32.5	4500.0	6.3	5.0	8.8	1500.0	5.0	5.0	8.8	2500.0
	Ossamaye	28.3	23.6	45.7	7990.9	7.9	8.9	12.7	2662.5	7.5	10.7	13.9	5333.3
	Massango	29.6	14.0	40.4	4300.0	6.1	8.6	12.8	2571.4	12.9	7.5	15.0	3750.0
	KW*[5]	10.4	10.4	10.9	13.6	24.0	24.0	21.4	24.0	9.8	2.7	16.2	2.7
	df*[6]	2	2	2	2	2	2	2	2	2	2	2	2
	P-value	0.00**	0.00**	0.00**	0**	0.00**	0.00**	0.00 **	0**	0.00**	0.26	0.00	0.26
HH size	Rs*[7]	0.07	0.06	0.13	0.04	0.02	0.10	0.09	0.09	-0.05	-0.06	0.06	-0.06
	P-value	0.24	0.40	0.03 *	0.54	0.76	0.23	0.16	0.23	0.50	0.46	0.40	0.46
Residence duration	Rs	0.16	0.21	0.21	0.23	0.12	0.28	0.22	0.27	0.12	0.27	0.20	0.27
	P-value	0.01**	0.00**	0.00**	0**	0.06	0.00**	0.00**	0**	0.06	0.00	0.00	0

*4 MW U: Mann Whitney U test; *5 KW: Kruskal Wallist test; *6 df: degree of freedom; *7 Rs: Spearmann correlation coefficient.

Table 4. Contd.

Variables	Contents	*Gambeya lacourtiana* (GL)				*Dacriodes buettneri (DB)*			
		Consumed	Sold	Total harvested amount	Total income	Consumed	Sold	Total harvested amount	Total income
Ethnicity	Kota	3.0	4.9	4.3	976.0	4.6	6.1	8.0	1214.5
	Fang	3.0	4.0	3.2	800.0	6.2	11.6	11.8	2325.9
	Kouele	1.5	0.0	1.5	0.0	4.6	14.0	10.2	2800.0
	Sacke	3.5	0.0	3.5	0.0	4.0	7.5	7.8	1500.0
	Ossamaye	3.1	4.0	3.8	800.0	6.9	10.4	12.4	2075.0
	Massango	4.2	0.0	4.2	0.0	5.8	7.7	8.3	1533.3
	KW*[5]	2.7	0.0	4.8	0.0	0.8	12.6	0.1	12.6
	df*[6]	2	1	2	1	2	2	2	2
	P-value	0.26	0.85	0.09	0.84	0.68	0.00	0.95	0.00 **
HH size	Rs*[7]	0.03	-0.11	0.10	-0.10	0.06	0.03	0.11	0.03
	P-value	0.68	0.57	0.22	0.57	0.39	0.72	0.11	0.72
Residence duration	Rs	0.00	-0.37	-0.07	-0.37	0.17	0.19	0.16	0.18
	P-value	0.99	0.04 *	0.39	0.04*	0.02	0.05	0.02	0.05*

indigenous fruits species.

The differences found may be due to ethnic groups' customs depending on usages. Therefore, resources usages tend to be influenced by ethnicity of the respondents as an illustration of their alimentary behavior, especially for the most popular ones. This result is in line with the study conducted by Ozanne et al. (2014) in Central Guyana which has revealed that variation in indigenous forest resource's use among communities could be attributed to socio-cultural drivers in terms of consumptive behavior. This means that ethnic groups have acquired complex knowledge on their environment that allow them to face challenges related to food security for example. As a result, ethnic groups' knowledge needs to be taken into account when management of the park resources in the country.

For all of the six indigenous fruits species, a significant correlation (Rs= 0.03) was only found between household size and total harvested amounts of all the six fruits species at 5% significance level through Spearman Correlation Coefficient. No significant correlations were found between household size and total amounts of the six indigenous fruits species consumed, sold on one hand and between household size and total harvested, consumed and sold amounts of the most and less popular species on the other hand. In addition, no significant relationships were also found among household size and income generated from each of the six indigenous fruits species, the most and the less popular species. These results imply that the size of the household tend to have a more direct influence on amounts of resources harvested (accessed) rather than usages (consumption and sale). This has probably to do with respondents' ability to mobilize their household labor to extract forest resources in time of needs. This result is in line with the study carried out by Ding et al. (2012) who showed that households' size represents one of the determinants of energy's consumption in a semi-arid rural area of northwest China. Consequently, family size may be a relevant variable to be taken into account to regulate resources usages in the study.

For all the six indigenous fruits species, significant correlations were also found between residence duration and total amounts harvested (Rs = 0.01), sold (Rs= 0.00), consumed (Rs= 0.01) of all the six fruits species at 1% significance levels, using Spearman Correlation Coefficient. Significant correlations were found only between residence duration and total amounts of *D. buettneri* harvested; sold and consumed at 1 or 5% significant levels, except for consumed amounts of *C. edulis* and *I. gabonensis*. In addition, significant correlations were also found between residence duration and total income of all the six indigenous fruits species (Rs = 0.00), all three of the most popular species *C. edulis* (Rs = 0.01), *I. gabonensis* (Rs = 0.00), *D. buettneri* (Rs = 0.05), and only one of the three less popular species *G. lacourtiana* (Rs = 0.04). Regarding the less popular species as well, significant correlations were found only between residence duration and amounts of *B. toxisperma* harvested (Rs = 0.05), consumed (Rs = 0.01) and amounts of *G. lacourtiana* sold (Rs = 0.04) at 1 or 5% significant levels. On the contrary, no significant correlations were found at all between residence duration and total amounts of *T. abut* harvested, sold and consumed. As a result, residence duration in terms of respondents' knowledge (affinity) with natural resources or experience (market involvement) seemed to drive respondents' usages and dependency on the resources. Residence duration may also represent a key variable that needs to be taken into account while designing resource usages.

Resource use and distance

Total amounts of indigenous fruits used (harvested (T), consumed (C), sold (S) and income (I) gained) all tend to vary according to respondents' distance (proximity) to the park (Table 4). Regarding all the six indigenous fruits, respondents closer to the park harvest larger amounts of all of the six produces than farther ones. Resources harvested were more importantly directed towards sales than households' consumption, especially for respondents closer than farther from the park. In addition, respondents closer to the park also harvest larger amounts of each of the three most popular fruits species in comparison with the ones living further away from the park. The three most popular harvested fruits were all directed more importantly for sale (income generation) than households' consumption. Similar trends were also observed for the less popular fruits species, except for harvested amounts of *G. lacourtiana* and *B. toxisperma.* These results imply that sale (income generation) represents one of the most important usage of the resources by respondents living close to the park (Table 5). However, respondents living farther away from the park have also managed to enter an activity dominated by respondents living close to the park as a result certainly of the importance of the resources to them.

Since significant differences were found between total amounts of all the six indigenous fruits' species harvested (P= 0.00), consumed (P= 0.00), and sold (P= 0.05) and distance at 1% significance level as a result of Mann Whitney U test. Significant differences were also found between distance and amounts of each of the more popular indigenous fruits' species such as *C. edulis* consumed and sold*,* amount of *D. buettneri* sold at 1% significance level while no significant differences were found between distances and mean amounts of *I. gabonensis* consumed and sold, and mean amount of *D. buettneri* consumed. On a contrary, a significant relationship was only found between distance and mean amount of *T. abut* consumed. Lastly, significant differences were found between distance and mean income all of the six indigenous fruits' species (P = 0.00),

Table 5. Amounts of resources used, income and respondents distance from the park (N=250).

Variables	Contents	All species				*Coula edulis* (CE)			
		Consumed	Sold	Total harvested amount	Total income	Consumed	Sold	Total harvested amount	Total income
Distance	Close	22.83	24.84	42.07	5369.44	6.76	11.13	14.01	1860.94
	Far	18.23	15.82	29.62	2597.50	5.19	6.20	9.37	1584.50
	MW U*[4]	5952.00	2767.50	5342.50		######	1584.50	4926.00	
	P-value	0.05	0.00	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**

*4 MW U: Mann Whitney U test; *5 KW: Kruskal Wallist test; *6 df: degree of freedom; *7 Rs: Spearmann correlation coefficient.

Table 5. Contd.

Variables	Contents	*Irvingia gabonensis* (IG)				*Dacriodes buettneri* (DB)			
		Consumed	Sold	Total harvested amount	Total income	Consumed	Sold	Total harvested amount	Total income
Distance	Close	7.38	11.00	15.47	4411.11	5.78	9.98	10.91	1034.04
	Far	6.01	8.82	10.21	######	4.45	5.17	7.24	796.00
	MW U*4	5720.50	1976.00	4357.00		######	796.00	4883.00	
	P-value	0.29	0.23	0.00**	0.22	0.09	0.00 **	0.23	0.00

*4 MW U: Mann Whitney U test; *5 KW: Kruskal Wallist test; *6 df: degree of freedom; *7 Rs: Spearmann correlation coefficient.

Table 6. Respondents' awareness on the Ivindo National Park.

Questions on awareness	Aware		Unaware	
	Respondents (%)		Respondents (%)	
Date of laws & regulations establishment	95	(38.0)	155	(62.0)
Boundaries of the Ivindo National Park	42	(16.8)	208	(83.2)
Any problems about the park	74	(29.6)	176	(70.4)
Villages visited by-National Park' staff	64	(25.6)	186	(74.4)
Protection status of the INP	233	(93.2)	17	(6.8)
Issues of elephants destroying agricultural fields	189	(75.6)	61	(24.4)

N=250.

mean income of two of the three most popular species including *C. edulis* (P = 0.00), *and D. buettneri* (P = 0.00) as well as with one of the three less popular species mainly *T. abut* (P = 0.04) at 1 or 5% significance levels via Mann Whitney U tests. These results may mean that spatial proximity plays a crucial role in driving people's access and use of the resources, especially the most popular ones. Scholars such as Timko et al. (2010) and Yemiru et al. (2010) have all stressed that physical location (distance) has a potential impact on people's ability to access and use forest resources and marketplaces. On the contrary, when resources are so valuable to the people distance does not matter since local people can walk long distance to collect the needed resources. Inappropriate policies and legal and/or traditional institutions arrangements that restrict or enable people to access forest and marketplaces may also yield illegal access and use of the resources (Laird et al., 2009, Timko et al., 2010). Subsequently, encroachments of forested areas are among the common challenges faced by forest and land managers (Biswas and Choudhury, 2007, Laudati, 2010, Balilla et al., 2012).

Respondents' awareness level on information on the park

Table 6 further stresses respondents' awareness on information about the park. Respondents' awareness on information about the park tends to vary with regards to questions asked as an indication of their levels of

expectations or knowledge. Since almost all respondents, 233 (93.2%) were aware of the protection status of the park therefore it can be assumed that awareness campaigns carried out by relevant institutions of the park prior to its establishment have contributed to raise respondents' knowledge on protection status of the park. Given that 189 (75.6%) of them were also aware of issues of elephants destroying agricultural fields therefore mean that wildlife damages caused by *Loxodonta africana* (especially) represents one of the major concerns affecting the livelihoods of people in Gabon at large and the study in particular.Given that most of the respondents were unaware of each of the following questions: (i) the date upon which the laws and regulations of the park have been established (62.0%), (ii) the boundaries of the Ivindo National Park (83.2%), (iii) any problem about the park (70.4%) and (iv) whether villagers have been visited by national park staff (74.4%). These results contradict not only the previous results but also contribute to raise several questions. Awareness campaigns previously carried out by park authorities prior to the establishment of this park appeared not to be effective in raising respondents' awareness on the park and revealing "physical" boundaries of the park. In addition, communicational issues seemed to exist between park authorities and local people since they were talking less about issues affecting their daily livelihoods in general, probably due to retliation from park authorities (Sassen and Wan, 2006). Alleviting the previous issues will more likely contribute to a proper management of the park and increase people's awareness on the park through more targeted awareness campaigns and communicational approaches as suggested by Katel and Schmidt-Vogt, (2011) in the case of Jigme Singye Wangchuck National Park in Bhutan.

Resource use and respondents' awareness level

Table 7 shows relationships between resources use and respondents' awareness level on the previously asked questions (six) about the park. Amounts of resources use (species) and purposes all tend to vary according to respondents' awareness. For all of the six indigenous fruits' species, aware respondents tend to harvest (sale and consume) larger amounts of resources than unaware ones, especially with regards to all the six questions asked. Thus, resources accessed are more importantly directed for sale and household consumption for the most part. Significant relationships were found between all the six harvested indigenous fruits species (sold, consumed) and some of the questions asked including boundary of the park, its protection status, issues affecting its development, roles of national park's staff, and respondents awareness on available laws or regulations on resources utilization. These results imply that awareness on information on the park including restriction of access does not prevent people from accessing and using these forest products of the park for meeting their households' needs in terms of sale (income generation) and consumption. Thus, the current encroachments (entering the park) observed by surrounding communities may raise some concerns about the effectiveness of the management (land tenure) of the park resources by national park authorities (Sassen and Wan, 2006). Proper management or interventions will more likely contribute to enhance respondents' awareness on the park while reducing their dependency in terms of access and usage (sale and consumption) of forest resources of the park as suggested by various scholars (Blouch, 2010; Khan and Bhagwat, 2010, Van der Ploeg et al., 2011, Vedeld et al., 2012; Gandiwa et al., 2013; Gandiwa et al., 2014).

For the most popular indigenous fruits species, more knowledgeable respondents on questions asked were also harvesting larger amounts of C. edulis and D. buettneri, except for I. gabonensis. Two of the most popular harvested species (C. edulis and D. buettneri) were more importantly directed towards selling (income generation) and consuming by more knowledgeable respondents, except for I. gabonensis sold and consumed for the most part. These results mean that purposes of most popular species used are for meeting household needs in terms of income and consumption as already mentioned in the previous sections.

On the contrary, respondents well-informed about the six questions asked were harvesting lesser amounts of G. lacourtiana and T. abut, except for B. toxisperma. Two of those lesser popular harvested species (G. lacourtiana and T. abut) were more importantly directed towards both income generation and households consumption, especially for respondents well-informed about the following questions: i) the date upon which laws and regulations of the park have been established, ii) issues affecting the park, iii) boundaries of the park, and iv) visit of villages by park's staff and its protection status. Consequently, respondents' awareness on national parks status does not prevent them from entering and making use of forest resources of the park, even the less popular ones. Raising people awareness may therefore drive well informed people to obey restriction of access and use of resources, however, proper alternatives have also to be provided to the affected people including a greater management and improved governance over natural resources access and use (Campbell et al., 2013).

Since significant relationships were found between total amount harvested, consumed, sold (income generation) for all the six indigenous fruits' species and respondents awareness on each of the following question: i) date of laws and regulations establishment, ii) issues of elephants, iii) boundaries of the park, and iv) visit by the park staff to villages therefore management of forest resources based on restriction of access and use of resources may not stop people from accessing and using resources of the park. Thus, reducing well informed people's dependence on resources use may call for providing alternative livelihoods opportunities as stressed

Table 7. Relationship between amounts and income gained from IFs and awareness on INP (N=250).

Variable		All species				Coula edulis (CE)				Irvingia gabonensis (IG)			
		C[1]	S[2]	T[3]	TI[4]	C[1]	S[2]	T[3]	TI[4]	C[1]	S[2]	T[3]	TI[4]
Date of Laws and regulations establishment	Aware	25.4	23.1	41.7	8217.9	7.1	10.4	13.5	3105.6	8.0	12.6	14.8	6295.9
	Unaware	18.3	20.4	34.3	6943.0	5.5	8.3	11.2	2501.0	6.0	9.2	12.4	4583.3
	MW U[*5]	5262.0	3948.0	6208.5	3885.5	4693.5	2202.0	5382.0	2202.0	5156.5	1928.0	5987.5	1928.0
	P-value	0.00**	0.76	0.04**	0.64	0.00**	0.08	0.70	0.08	0.02**	0.07	0.67	0.07
Issues of the park	Aware	23.0	25.6	41.4	8520.8	7.1	11.2	14.0	3358.5	6.4	10.2	13.3	5102.3
	Unaware	20.1	19.7	35.3	6956.3	5.7	8.3	11.3	2478.4	7.0	10.4	13.4	5188.1
	MW U[*5]	5726.5	2961.0	5885.0	2974.5	4552.5	1692.5	4765.5	1692.5	4852.0	2069.5	5167.5	2069.5
	P-value	0.13	0.06	0.23	0.72	0.04*	0.01**	0.15*	0.12*	0.31	0.45	0.82	0.50
Issues of elephants	Aware	22.0	23.4	40.1	8196.6	6.5	10.0	13.1	2992.2	7.1	10.8	14.6	5418.0
	Unaware	17.8	14.2	27.7	4619.0	5.0	6.1	9.0	1825.0	5.8	7.6	9.2	3804.3
	MW U[*5]	4696.0	1763.0	3728.5	1697.0	3814.0	1233.5	3558.0	1233.5	4049.5	1055.0	3114.5	1055.0
	P-value	0.03*	0.00**	0.00**	0.00**	0.01*	0.00**	0.02**	0.00**	0.25	0.05	0.00**	0.05
Boundaries of the INP	Aware	23.6	28.5	44.7	10109.7	6.6	12.4	15.5	3717.9	7.2	11.3	15.2	5650.0
	Unaware	20.5	20.0	35.6	6861.8	6.0	8.3	11.4	2489.5	6.8	10.1	12.9	5034.8
	MW U[*5]	3708.0	1490.0	3336.0	1515.5	3274.0	1142.0	2968.0	1142.0	3859.5	1614.0	3532.0	1614.0
	P-value	0.12	0.00**	0.01*	0.00**	0.19	0.00**	0.04	0.00**	0.94	0.58	0.35	0.58
Visit of INP park staffs to villages	Aware	25.6	25.8	46.2	9086.3	7.6	12.0	16.0	3600.0	8.9	12.2	17.5	6122.0
	Unaware	19.4	19.7	33.9	6768.6	5.6	8.0	10.7	2389.2	6.1	9.6	11.9	4783.7
	MW U[*5]	4498.5	2354.0	3997.0	2423.5	3528.0	1360.0	3368.5	1360.0	1518.0	3366.5	3532.0	1518.0
	P-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**
Protection status of the INP	Aware	21.1	21.6	37.5	7468.9	6.1	9.0	12.1	2691.6	6.9	10.4	13.5	5215.3
	Unaware	19.7	17.7	31.2	6245.5	6.1	10.3	11.9	3100.0	6.5	8.5	11.8	4250.0
	MW U[*5]	1845.0	821.0	1714.0	842.5	1586.5	488.0	1655.0	488.0	1309.0	444.0	1322.0	444.0
	P-value	0.63	0.38	0.35	0.45	0.59	0.21	0.82	0.21	0.69	0.35	0.75	0.35

1:Amount for consumed, 2:Amount for sold, 3:Total harvested amount, 4:Total income, 5:Statistica value of U for Mann Whitney U test.

by Campbell et al. (2013) in the case of the Karimunjawa National Park in Indonesia.

CONCLUSION AND RECOMMENDATIONS

Indigenous fruits species harvested are important sources of food and income generation which are contributing to sustain the livelihoods of many rural people. In the study, almost all respondents (99.2%) were engaged in harvesting at least one of the six forest products. Out of the six indigenous fruits species harvested, *C. edulis, D. buettneri* and *I. gabonensis* seemed to be the more popular species as compared to G. lacourtiana, T. abut and B. toxisperma considered as less popular as a result of the proportion of people engaged in their harvesting, sale and consumption amounts and because of their

Table 7. Contd.

Variable		Dacriodes buettneri (DB)				Gambeya lacourtiana (GL)				Trichoscypha abut (TA)			
		C[1]	S[2]	T[3]	TI[4]	C[1]	S[2]	T[3]	TI[4]	C[1]	S[2]	T[3]	TI[4]
Date of Laws and regulations establishment	Aware	5.7	9.3	9.7	1852.9	3.4	3.9	3.7	771.4	3.0	1.8	3.1	350.0
	Unaware	5.0	7.4	9.2	1472.7	2.8	5.0	4.0	1000.0	2.7	9.7	3.6	1950.0
	MW U[*5]	4866.0	1018.0	5058.0	1018.0	2887.0	56.0	3169.5	56.0	1757.5	5.0	1782.5	3.5
	P-value	0.43	0.05	0.08	0.05	0.23	0.21	0.74	0.21	0.97	0.12	0.82	0.06
Issues of the park	Aware	6.5	10.3	11.7	2066.7	3.4	4.3	4.2	866.7	3.4	8.8	4.6	1760.0
	Unaware	4.7	6.9	8.4	1387.2	2.9	4.9	3.7	981.0	2.6	4.2	2.9	860.0
	MW U[*5]	4291.0	1062.0	4446.5	1062.0	2476.5	81.5	2456.0	81.5	1356.0	6.0	1341.0	7.0
	P-value	0.24	0.13	0.46	0.13	0.32	0.53	0.23	0.53	0.70	0.15	0.40	0.23
Issues of elephants	Aware	5.4	8.2	9.9	1646.5	3.1	5.0	4.1	1000.0	2.9	7.8	3.5	1550.0
	Unaware	4.9	7.0	7.9	1392.0	2.7	3.7	3.2	733.3	2.8	1.5	2.9	350.0
	MW U[*5]	3985.0	644.0	3652.5	644.0	2189.5	52.5	2213.0	52.5	1123.0	3.0	1163.5	4.5
	P-value	0.28	0.00**	0.06	0.00**	0.31	0.29	0.33	0.29	0.32	0.17	0.37	0.35
Boundaries of the INP	Aware	5.6	8.4	10.9	1680.0	3.2	5.3	3.8	1050.0	3.2	2.0	3.3	400.0
	Unaware	5.2	7.8	9.1	1569.2	3.0	4.7	3.9	930.8	2.8	7.0	3.4	1411.1
	MW U[*5]	2520.5	738.5	2437.0	738.5	1878.5	44.0	1824.0	44.0	1147.0	3.5	1161.5	3.0
	P-value	0.37	0.17	0.25	0.17	0.50	0.61	0.24	0.60	0.67	0.71	0.63	0.60
Visit of INP park staffs to villages	Aware	6.0	9.2	12.1	1843.8	3.2	6.3	3.6	1266.7	3.4	0.0	3.3	0.0
	Unaware	5.0	7.4	8.6	1486.1	3.0	4.6	4.0	911.1	2.6	6.5	3.4	1310.0
	MW U[*5]	3502.5	905.5	3090.0	905.5	2316.5	26.0	2234.5	26.0	1518.0	1553.5	3744.0	0.0
	P-value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	
Protection status of the INP	Aware	5.2	8.0	9.6	1605.6	3.1	4.9	4.0	971.4	2.9	6.5	3.5	1310.0
	Unaware	5.4	5.8	6.9	1150.0	2.2	3.0	2.6	600.0	2.1	0.0	2.0	0.0
	MW U[*5]	1405.5	177.5	1325.5	177.5	886.0	14.0	916.5	14.0	337.5	0.0	328.5	0.0
	P-value	0.76	0.54	0.52	0.54	0.35	0.22	0.44	0.22	0.23	0.0	0.06	

1:Amount for consumed, 2:Amount for sold, 3:Total harvested amount, 4:Total income, 5:Statistica value of U for Mann Whitney U test.

marketability. Although, harvested indigenous fruits species were directed to households' consumption and income generation, however, selling purpose is considered as major usage because it may influence resources management of the park.

Resources are accessed in a seasonal basis with the more popular species being harvested during the dry season and more often while the less popular ones were harvested in the big dry season and less often. Regarding species usage, harvested amounts and frequency of more popular

Table 7. Contd.

Variable		Baillonella toxisperma (BT)			
		C[1]	S[2]	T[3]	TI[4]
Date of Laws and regulations establishment	Aware	3.7	3.8	4.1	766.7
	Unaware	2.7	3.5	3.3	700.0
	MW U[*5]	1342.5	13.5	1399.0	13.5
	P-value	0.14	0.06	0.25	0.06
Issues of the park	Aware	3.0	3.3	3.6	657.1
	Unaware	3.3	3.9	3.8	777.8
	MW U[*5]	1431.5	27.5	1393.5	27.5
	P-value	0.65	0.65	0.50	0.66
Issues of elephants	Aware	3.1	3.8	3.7	757.1
	Unaware	3.4	2.5	3.6	500.0
	MW U[*5]	646.0	10.5	655.0	10.5
	P-value	0.16	0.56	0.19	0.56**
Boundaries of the INP	Aware	2.9	2.7	3.1	533.3
	Unaware	3.3	3.8	3.8	769.2
	MW U[*5]	986.0	17.0	955.0	17.0
	P-value	0.23	0.72	0.15	0.72**
Visit of INP park staffs to villages	Aware	3.3	3.3	3.6	666.7
	Unaware	3.1	3.7	3.7	738.5
	MW U[*5]	1365.5	18.0	1356.5	18.0
	P-value	0.00**	0.00**	0.00**	0.00**
Protection status of the INP	Aware	3.3	3.8	3.8	757.1
	Unaware	2.2	2.5	2.7	500.0
	MW U[*5]	420.0	10.5	464.5	10.5
	P-value	0.32	0.55	0.61	0.55

1:Amount for consumed, 2:Amount for sold, 3:Total harvested amount, 4:Total income, 5:Statistica value of U for Mann Whitney U test.

species for both consuming and selling purpose were twice of the less species as a result of certainly of resources availability. The latter result may influence the future management of the resources based on utilization by rural people if not properly taken into account. Although, total amounts of all the six indigenous fruits species, each of the more and less popular species harvested (T), consumed (C) and sold (S) all tended to vary with regards to socio-economic status of the respondents including ethnic group, family size, residential period, distance and awareness on information on the park to some extent, therefore it is necessary to be flexible when designing future rules and regulations on resources utilization of the park. Recommendations on potential regulation of resources utilization of the park are drawn in Table 8. Further studies need to focus on designing future rules and regulations on resources utilization by amounts, distance and seasons for both rural livelihoods and management of the Ivindo National Park.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Table 8. Recommendations on potential regulation of resources utilization of the park.

Regulation by			Inside	Buffer zone	Outside
Species	Most used	For selling	P to P	R to R	A to A
		For livelihood	P to R	R to A	A to A
	Less used	For selling	P to P	R to R	A to A
		For livelihood	P to R	R to A	A to A
By distance	More than 3 km		P to P	R to A	A to A
	Less than 3 km		P to R	R to A	A to A
Season			P to P	R to A	A to A

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