European Journal of Science, Innovation and Technology

ISSN 2786-4936

Vol. 2 No. 3 (2022)

Impact Study and Farmers' Plans for Climate Change Risk Management in the Yanonge Region (Tshopo, DRC)

Makangi W.K.C[1], Bwira M.M.[2], Bambale B.L.[3], Befonga M.A.[3], Pyame M.L.D.T.[4], Mbura K. G.[5], Muhindo B.S.[5], Wemba L.L.[5], Kakuru B.B.[6], and Utshudi D.J.B.[7, 4*]

[1]Rural Development Section, Higher Institute of Rural Development of Goma, North-Kivu, D. R. Congo

[2]General Agronomy Section, Higher Institute of Agronomic Studies of Mweso, North-Kivu, D. R. Congo

[3]Rural Development Section, Higher Institute of Agronomic Studies of Yatolema, BP 2324 Kisangani, D. R. Congo

[4]Laboratory of Agroecology, Faculty of Management of Renewable Natural Resources, University of Kisangani, D. R. Congo

[5]Rural Development Section, Higher Institute of Rural Development of Walikale, North-Kivu, D. R. Congo

[6]Section of Public Health, Higher Institute of Medical Techniques of Walikale, North-Kivu, D. R. Congo

[7]General Agronomy Section, Higher Institute of Agronomic Studies of Yatolema, BP 2324 Kisangani, D. R. Congo

Abstract. The general objective of this study in the Yanonge Forest Region was to identify the main impacts and plans of farmers to manage the risks related to climate change. This general objective was broken down into 3 specific objectives.

To achieve these objectives, the survey method was required. These results revealed that drought, flooding and erosion are the main impacts of climate change in this region of Yanonge with the respective proportions of 68%, 17% and 15%.

For crops, as far as farmers' strategies for combating drought are concerned, it was noted that the population uses the technique of sowing deeper (10 cm), but also the technique of indirect sowing by passing the seeds through the germarium. These farmers' strategies for combating drought recorded 16% and 17% respectively. The planting of bamboo, the filling of bags with sand corresponded to 40% of the population surveyed and add to that, the planting of *Paspalum notatum*, which noted 15%, remain the main farmers' strategies to fight against erosion in the Yanonge region.

In light of the results obtained in this research, it is essential to explore other explanatory variables while expanding the scope of the study in order to identify the different variabilities of climatic characteristics of different periods.

Keywords: Impacts, farmers' plans, management, risk, climate change, Yanonge

Introduction

Climate change is an undeniable reality. To address it effectively, we must act urgently to avoid an irreversible buildup of greenhouse gases (GHGs) in the atmosphere and global warming that could have adverse economic and social consequences around the world. The accumulation of greenhouse gases (GHGs) in the atmosphere, largely due to human activities, is already changing the global climate. According to current projections, GHG concentrations will continue to increase indefinitely, causing a process of continuous warming of the global climate (OECD, 2008).

The African continent is at greatly accelerated risk of vulnerability to disruptions caused by climate change. The impacts of climate change are progressively altering the climatic

[*]Corresponding Author

characteristics of the seasons leading to the disruption of the agricultural calendar, changes in crop cycles and many others in the world in general and in Africa in particular. (IPCC, 2007).

Africa remains the only continent considered the poorest, the most affected, the most targeted by future climate disasters and the most exposed to these risks due to a very deficient political, economic, scientific and ecological governance (CED, 2010; Beucher & Bazin, 2012).

Rising temperatures, irregular and poorly distributed rainfall, and extreme events all threaten the livelihood security of poor people. In order for development programs to reduce people's vulnerability to climate change, it is essential to identify affected populations and understand their practices and coping strategies. Then we need to apply this information to the design, implementation, monitoring and evaluation of activities (De Perthuis *et al*., 2010).

People in the developing world, who are already vulnerable and food insecure, are likely to be the most severely affected (IFPRI, 2009). The adverse effects of climate change on these countries are already being felt and are placing considerable stress on sectors important to national development such as agriculture and natural resource exploitation (Bele *et al*., 2010).

To build an effective climate change strategy, Congo Basin countries need timely and appropriate information for relevant stakeholders. However, the climate change response process in the Congo Basin countries is polarized between adaptation and REDD+, with contradictions arising due to the lack of adequate knowledge and information of stakeholders influencing the design and implementation of intervention strategies (Somorine *et al*., 2011; Tiani *et al*., 2014).

The Yanonge region is threatened by drought, erosion and flooding causing enormous damage on all levels, views the living conditions of the riparian population which is not spared by all these scourges that gangrene this environment hence the need to conduct this research.

The Yanonge region, which is essentially forested, is gradually experiencing climatic disturbances. The in-depth study on the main impacts of climate, will allow to evaluate the vulnerability and to identify farmers' strategies of management of the risks related to the climate change in the Yanonge area. These main impacts progressively lead to a certain modification of the natural environment in general and forest ecosystems in particular.

It is in this perspective that we are conducting this research on the "*Study of impacts and farmers' plans for managing risks related to climate change in the Yanonge region*". Overall, this study aims to investigate the main impacts and plans that farmers use to manage the risks of climate change in the Yanonge region.

The following specific questions form the main thread of the scientific investigations envisaged:

- ✓ What are the impacts of climate change encountered by farmers in Yanonge in their daily lives?
- ✓ What are the different farmers' plans for managing the risks of climate change in the Yanonge region?

The specific answers formulated from the above questions are as follows:

- ✓ Flooding, drought and erosion are the main impacts of climate change encountered by Yanonge farmers in their daily lives;
- ✓ The dispersion of fields and the development of market gardening (in case of floods), manual watering (in case of drought), planting of bamboo and filling of bags with sand (in case of erosion) are the main farmers' plans for managing the risks of climate change in the Yanonge region.

The objectives of this study were to:

- ✓ Identify the main impacts of climate change encountered by Yanonge farmers in their lives;

- ✓ Determine the different farmers' action plans for managing the risks of climate change in the Yanonge region.

Materials and Methods

Environment

Cartographic Circumscription of the Environment

Located 59 km from Kisangani (ex-Stanley town), Yanonge is at an altitude of 470 m in the heart of the African continent in the northeastern part of the central basin of the Democratic Republic of Congo. Its geographical coordinates are 0° 35' 34" North latitude and 24° 43' 02" East longitude.

Biophysical factors of the Yanonge Region

Ecoclimatic conditions

The Yanonge region is located in the northern equatorial climatic zone of the DRC, between 0 - 2°N (Vandenput, 1981), a zone subject to the Af de Köppen type of climate (Bultot, 1977) where it rains practically every month of the year. In this region, there are two dry periods that alternate with two rainy periods: a long dry season from December to mid-March followed by a short rainy season from April to May, and a short dry season covering the months of June and July followed by a long rainy season from August to November.

This variability of seasons throughout the year can greatly influence the phenology and growth of vegetation (Toirambe *et al*., 2011).

Geological and soil conditions

The geological substratum was deposited by torrential fluvial inputs and aeolian sands under an arid to semi-arid climate (Van Wambeke & Evrard, 1954; Ngongo *et al.*, 2009; Toirambe *et al*., 2011). This outcrops along the right bank of the Congo River and in several valleys of its tributaries and sub-tributaries.

The vast majority of the Yanonge area is formed of ancient, ferralitic soils favored by extensive weathering of all primary minerals due to the climatic conditions of the humid tropics (hot and rainy climate) (Ngongo *et al*., 2009; Toirambe *et al*., 2011). Recent hydromorphic soils, weakly evolved and the most fertile (Fahem, 1978) occupy only the low and poorly drained part of the area corresponding to the valleys and tributaries of the Congo River.

Relief and hydrography

The relief of the Yanonge region is made up of a plateau dissected by wide, flat valleys. These bottoms are occupied by rivers, the main ones, the tributaries, being tributaries of the Congo River.

Vegetation

The vegetation of the Yanonge region is part of the Regional Center of Guinean-Congolese Endemism. Its evaluation has shown that there is a diversity of plant formations that can be explained both by the physical environment (notably the presence of several rivers) and by the influence of man, who has redesigned the habitats at different times (White, 1986).

Materials

The materials used for the realization of this work are: the GPS; the camera; the survey questionnaire and the printed interview grids, the pen, the notepad, a laptop computer and the office materials.

Methods

According to Coté, (2005), Mampeta (2012), "there is no one-size-fits-all method, every research is first a research of method". The choice of methods and techniques depends primarily on the objectives of the study and the means available (Mampeta, 2012). However, as it straddles the natural and human sciences, the present study proceeds with the use of a single methodological approach: the one employed for the collection of socio-economic data (survey). All field data were collected in the Yanonge area.

Methods and techniques used for survey data

These are the methods used for the collection, processing and analysis of data related to the different farmers' practices, the different risk management plans related to climate change, the main climate impacts identified by the farmers of Yanonge in their daily life, the different farmers' strategies to fight against climate change but also for the case of crops, etc.

General and specific literature was read and analyzed, then field surveys were conducted with farmers and chiefs of different villages to identify the impacts of climate change and the action plans developed to improve their living conditions. It should be noted that the questions addressed to the village chiefs also allowed us to have an idea of the number of households in each village in order to help us to know the exact number of households in each village and based on a formula using the data of the latter (all households in each village), we ended up determining the households to be surveyed for each village

Selection criteria

Four selection criteria were used for the field surveys. Farmers had to be both:

- ✓ be resident in a village in the Yanonge region;
- ✓ have ± 10 years of residence;
- ✓ be ± 18 years old and finally ;
- ✓ have agriculture as their main activity.

Thus, 175 households meeting the above criteria were interviewed, as well as some technicians specialized in the agricultural sector in the Yanonge region.

Finally, we also conducted field visits to understand the various impacts of climate change (drought, erosion, flooding, etc.) threatening farmers in the region.

Actual surveys

Two surveys were conducted in the villages of Lokomba, Mungando, Yakamba, Yangandi and Yaosenge from December 5, 2021 to April 5, 2022. They were carried out in two stages:

- ✓ In the first stage, a questionnaire was sent exclusively to the heads of these different villages chosen with the objective of collecting basic data such as demographics (composition and number of households) and geographical boundaries. This allowed us to have an overview of what the population could also provide us with.
- ✓ Then another questionnaire was administered to the populations of the different villages selected to highlight their activities in order to identify those that contribute to forest degradation and deforestation. We wanted to know their perceptions on the issue of climate change. Direct observations and various information allowed us to confirm the information gathered during these two surveys.

In the final sequence, systematic random sampling is then conducted as a sampling method (United Nations, 2010). The sampling frame is drawn from in a systematic manner, establishing a "draw step" or sampling increment. The following relationship is used to determine the draw step:

$$\text{Draw step} = \frac{\text{(number of units in the sampling frame (parent population))}}{\text{(number of units to be sampled)}}$$

Before determining the draw step, the definition of the sample size was necessary. To do this, we estimated that the population in the Yanonge area is made up of at least 90% of people with an activity that could generate negative impacts on the forest (prevalence), and 10% made up of people assigned to other activities. We also accepted a 5% risk of error or 95% confidence with a precision of i = 7%. Thus, the sample size is determined by the following formula:

$$n=Z^2_{1-\alpha/2}\frac{p(1-p)}{d^2}$$

Where:
- ✓ n = sample size
- ✓ $z^2_{1-\alpha/2}$ = the reduced variance for the statistical risk α admitted (1.96 for the 5% risk)
- ✓ p = expected prevalence (90%)
- ✓ d = desired relative precision (7%)

Given this, we needed a minimum of 160 households to be surveyed to have credible results. An additional 8, 57% (or 15 households) were added to preserve the integrity of the sample size that could be corrupted by absences and/or refusal to respond. This gives a total of 175 households surveyed. The contribution of villages to the sample size calculated for this survey is weighted according to the population size of each village. People at least 18 years old were selected to participate in this survey.

Table 1 below presents the weighted number of households to be surveyed per village including the sampling step.

Table 1: Surveyed villages, weighting, number of households and drawing step

Villages	Number of households	Weighting (%)	Surveyed villages	Drawing step
Yangandi	643	30,7	54	12
Yaosenge	320	15,2	27	12
Elongolongo	136	6,4	11	12
Mungando	299	14,2	25	12
Yakamba	380	18,1	32	12
Lokomba	315	15	26	12
Total	**2093**	**100**	**175**	

The draw step calculated for each village is 12. To constitute a systematic sample in this case, it was therefore necessary to randomly select one element (a respondent) from the first 12 elements of the population list for each village. The second element corresponded to the 12th element that followed the first element selected, and so on.

Weighting

$$\mathbf{W}=\frac{n.totl.M/V}{n.totx.MV}\times 100$$

Where:
- ✓ W: Weighting;
- ✓ n.totl.M/V: Total number of households per village;
- ✓ n.totxMV: Total number of households in all villages; and
- ✓ 100: expresses the conversion in percent (%).

Households to be surveyed

$$\mathbf{H.S.}=\frac{n.totl.\frac{M}{V}\times n.totxM.EV}{n.totx.MV}$$

Where:
- ✓ H.S. = Households to be surveyed;
- ✓ n.totl.M/V: Total number of households per village;

- ✓ n.totxMV: Total number of households in all villages; and
- ✓ n.totxM.EV: Total number of households to be surveyed from all villages.

Drawing step

$$\mathbf{D.S.} = \frac{\text{n.totl.}\frac{\text{M}}{\text{V}}}{\text{n.totl.M.E/V}}$$

Where:
- ✓ D.S. = Drawing step;
- ✓ n.totl.M/V : Total number of households per village; and
- ✓ n.totl.M.E/V: Total number of households to be surveyed per village.

Analysis of Population Survey Data

The data collected for this survey was entered into an Excel spreadsheet (Microsoft office, Windows 8, USA) for cleaning and further analysis. The qualitative data was coded and quantified to facilitate the various analyses of the data.

Identification of the main impacts of climate change

The surveys of the populations and village chiefs located in the Yanonge region allowed us to identify the main impacts of climate change that they encounter in their daily lives. The different data and/or answers provided by the respondents were cleaned and processed using the Excel tool to determine the proportion in terms of percentage of each of the impacts of climate change encountered by them in the Yanonge region.

Before finding the percentage (proportion) of each of these climate change impacts, this formula was useful:

$$\text{Either:} \qquad \mathbf{\% = \frac{n \times 100}{nt}}$$

Where:
- ✓ n = number of respondents supporting an opinion (on climate impacts); and
- ✓ nt = total number of respondents interviewed (175).

Using the above formula, we were able to determine which of the various impacts of climate change would be selected as the main one in the Yanonge region, taking into account the order of importance of each impact, i.e. the percentage that corresponded to each of them.

Determination of the different farmers' plans

The surveys of the populations and village leaders of the Yanonge region were used to determine the different farming plans. The data and/or answers provided by the respondents were cleaned and processed using the Excel tool to determine the percentage proportion of each of the peasant plans. This same logic was followed for the determination of the farmers' plans for the case of crops.

Before finding the percentage (the proportion) of each of these peasant plans, this formula was used:

$$\text{Either:} \qquad \mathbf{\% = \frac{n \times 100}{nt}}$$

Where:
- ✓ n = number of respondents supporting an opinion (on country plans); and
- ✓ nt = total number of respondents interviewed (175).

As a result, the above-mentioned formula was used to determine which of the different farm plans is the main one in the Yanonge area, always taking into account the order of importance. The determination of the main farmer plan for the case of crops followed the same procedure.

Data Analysis and Processing

The software used to analyze and process the statistical data was Excel. Excel was used to create all the tables. In addition, it was also used to design the diagrams.

Results

This phase is of great importance and invaluable in any work of a purely scientific nature. It allows us to present and interpret the different results obtained. Firstly, we will present the main impacts of climate change in the study area and secondly come the different farmer plans for managing the risks related to climate change. Namely:

Main Impacts of Climate Change in the Yanonge Region

The main impacts of climate change in the Yanonge region are: drought, flooding and erosion.

Figure 1 shows the main impacts of climate change recorded in the Yanonge region.

- ❖ Percentage calculation for each of the climate change impacts:

a) *Case of the Drought*

$$\% = \frac{\boldsymbol{n}\times\mathbf{100}}{\mathbf{nt}} = \frac{119\times 100}{175} = 68\%\;;$$

b) *Case of the Floods*

$$\% = \frac{\boldsymbol{n}\times\mathbf{100}}{\mathbf{nt}} = \frac{26\times 100}{175} = 15\%; \text{ and}$$

c) *Case of the Erosions*

$$\% = \frac{\boldsymbol{n}\times\mathbf{100}}{\mathbf{nt}} = \frac{30\times 100}{175} = 17\%.$$

Where:

- ✓ n = number of respondents supporting an opinion (on climate change impacts); and
- ✓ nt = total number of respondents interviewed (175).

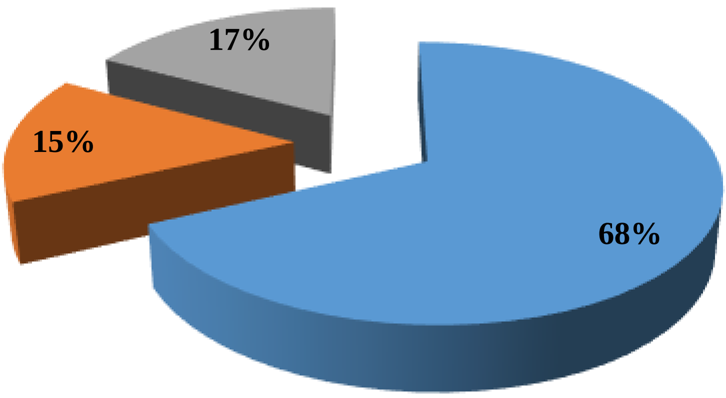

Figure 1: Major impacts of climate change

The analysis of the results of this figure shows that drought, erosion and flooding remain the main impacts of climate change in the Yanonge region. These have respective proportions of 68%, 17% and 15%. Drought is selected as the main impact of climate change because it occupies a higher proportion in the overall impacts identified in this region. This is followed by erosion and finally flooding, which occupies the last position.

Farmers' Plans for Managing Risks Related to Climate Change

Farmers' plans to combat drought (excessive heat)

Figure 2 shows the different farmer plans for drought in the Yanonge region.

❖ Percentage calculation for each of the farmers' plans for drought:

a) Peasant plan: wash and sleep late

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{84 \times 100}{175} = 48\%$$

b) Peasant plan: stay under the tree and sleep late

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{56 \times 100}{175} = 32\%$$

c) Peasant plan: dive into the river and sleep half naked

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{23 \times 100}{175} = 13\%$$

d) Peasant plan: the wearing of light clothing

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{12 \times 100}{175} = 7\%$$

Where:

✓ n = number of respondents supporting an opinion (on climate change impacts); and
✓ nt = total number of respondents interviewed (175).

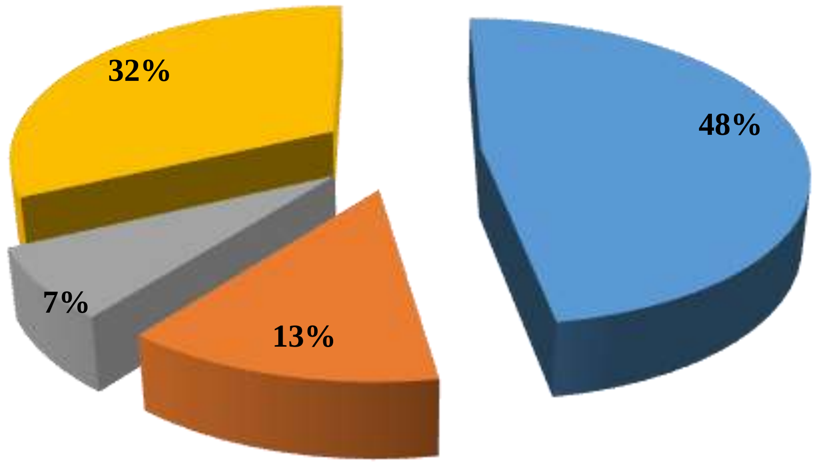

Figure 2: Illustration of different farmers' plans for managing climate change risks in the Yanonge region

The results of this figure show that the population of Yanonge region opts for bathing and sleeping late (48%), staying under the tree and sleeping while leaving the windows open (32%), diving into the river and sleeping half-naked (13%) as well as wearing light clothes (7%) constituting the different peasant plans to fight against the heat during dry periods. The main peasant plan to combat drought in this region is to wash and sleep late. The second most applied plan is to stay under the tree and sleep while leaving the windows open.

Farmers' drought control plans: the case of crops

Figure 3 shows the farmers' drought plans in the Yanonge region with respect to agriculture.

❖ Percentage calculation for each of the farmers' plans for drought: case of crops

a) Farmer's plan: sow deeper (10 cm)

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{28 \times 100}{175} = 16\%$$

b) Farmer's plan: indirect sowing (use of the germinator)

$$\% = \frac{n \times 100}{\text{nt}} = \frac{42 \times 100}{175} = 24\%$$

c) No plan

$$\% = \frac{n \times 100}{\text{nt}} = \frac{105 \times 100}{175} = 60\%$$

Where:

- ✓ n = number of respondents supporting an opinion (on climate change impacts); and
- ✓ nt = total number of respondents interviewed (175).
- ✓

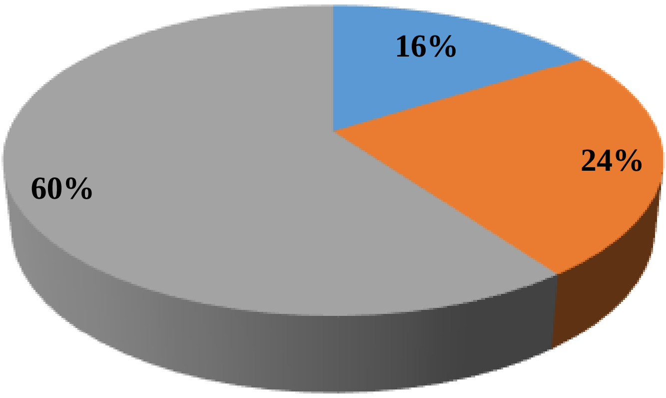

Figure 3: Farmers' plans to combat drought in the Yanonge region: case of crops

The results of this figure illustrate that the majority of the population (i.e., 60%) in the Yanonge region do not have any plans to combat drought in the context of crops. Among the other farmers' plans adopted by a category of the population in this study area; one is to practice the indirect sowing technique allowing the seeds to retain their germinative power in the germinator and the other is to sow deeper (10 cm) in order to obtain a certain humidity allowing the crops to grow well. The latter recorded 24% and 16% respectively.

Farmers' plans to combat flooding

To cope with the increasingly frequent flooding, the respondents proceed in two ways: the case that concerns themselves and the case of crops.

Figure 4 illustrates the different farmers' flood control plans in the Yanonge region.

❖ Percentage calculation for flood control plans

a) Peasant plan: The water pipe

$$\% = \frac{n \times 100}{\text{nt}} = \frac{16 \times 100}{175} = 9\ \%$$

b) No plan

$$\% = \frac{n \times 100}{\text{nt}} = \frac{159 \times 100}{175} = 91\%$$

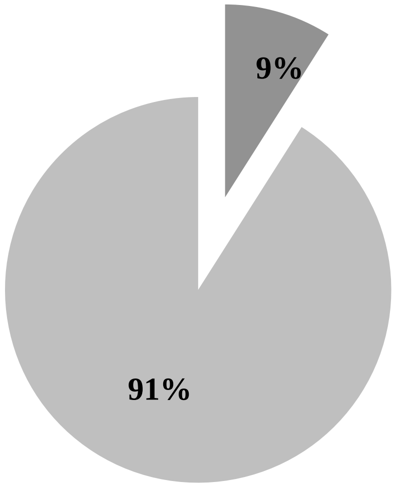

Figure 4: Farmers' flood control plans in the Yanonge area

The results of this figure show that a large majority of the population (91%) residing in this area of Yanonge does not have any flood control action plan. On the other hand, an extremely small proportion (9%) resort to water channelling, i.e., digging up a large part of the soil to facilitate the passage of water, and this is considered the only flood control plan used by the population of this area.

Farmers' flood control plans for crops

Table 2 provides information on the different farmers' flood control plans in the Yanonge region, specifically the case of crops.

- ❖ Percentage calculation for farmers' flood control plans: case of crops

a) Farmers' plan: identification of areas of increasing flooding

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{37 \times 100}{175} = 21\%$$

b) No plan

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{138 \times 100}{175} = 79\%$$

Table 2: Farmers' flood control plans for crops

Plans	**Surveyed**	**%**
Identification of areas of increasing flooding	37	21
No plan	79	79
TOTAL	**175**	**100**

Table 2 shows that a large proportion of the population living in the Yanonge region (79%) does not adopt any farmer's plan for flood control in the case of crops. In addition, a small proportion of respondents (21%) identified flood-prone areas as their main flood control plan to avoid flooding.

Farmers' plans for erosion control

Figure 5 shows the different peasant plans for erosion control in the Yanonge region.

- ❖ Percentage calculation for farmers' erosion control plans

a) Peasant plan: planting of bamboo and establishment of sandbags

$$\% = \frac{n \times 100}{\mathrm{nt}} = \frac{70 \times 100}{175} = 40\%$$

b) Peasant plan: planting of *Paspalum notatum*

$$\% = \frac{n \times 100}{\text{nt}} = \frac{26 \times 100}{175} = 15\%$$

c) No plan

$$\% = \frac{n \times 100}{\text{nt}} = \frac{79 \times 100}{175} = 45\%$$

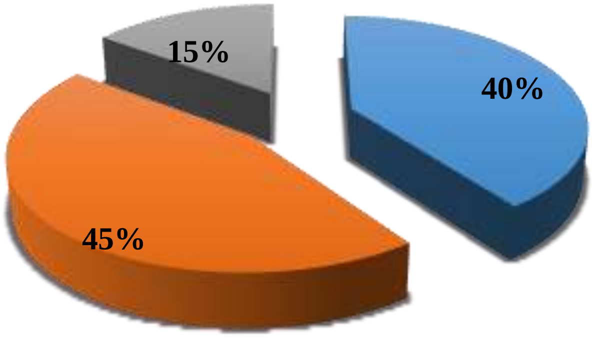

Figure 5: Main farmer strategies for erosion control in the Yanonge region

The results presented in Figure 5 indicate that the majority of the population of the Yanonge region has no notion of the peasant plan for erosion control as shown in the red portion of this figure (45%). However, almost half of the population (40%) uses bamboo planting and sandbagging as their main erosion control plan. In addition, *Paspalum notatum* is planted. However, the proportion of *Paspalum notatum* planted in all plans is very small (15%).

Farmers' plans for erosion control: the case of crops

Figure 6 illustrates the farmers' plans for erosion control in the Yanonge region in crop fields.

❖ Percentage calculation for farmers' erosion control plans: case of crops

a) Peasant plan: bamboo planting and sandbagging

$$\% = \frac{n \times 100}{\text{nt}} = \frac{12 \times 100}{175} = 7\%$$

b) No plan

$$\% = \frac{n \times 100}{\text{nt}} = \frac{163 \times 100}{175} = 93\%$$

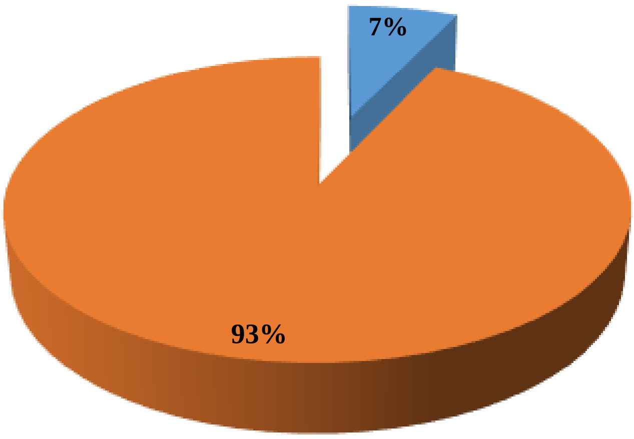

Figure 6: Farmers' erosion control plans in the Yanonge region, for crops

This figure shows that a large part of the population in the Yanonge region does not have a farmers' erosion control plan for crops. As a result, they are too exposed. But we note a very small share of those who proceed by planting bamboo and the establishment of sandbags as the only peasant plan of adaptation against erosion for the case of crops, that is 7%.

Discussion

This chapter is of the utmost importance in all scientific work. It consists in establishing the discussions on all the essential points of the present study. These discussions will focus on two main points:

1. the methodological approaches adopted; and
2. the main results obtained.

Methodological Approaches

This first section discusses the different methodological approaches used to achieve the different objectives pursued throughout this study.

Use of the Survey Method

In this phase of the various population surveys in the Yanonge area, we used the "systematic random sampling" method. This method is the one that is carried out in the field using the sampling step (or drawing step), which was chosen among many others because it reduces, through its sampling step procedure, the cost of investing in the survey and remains the most efficient in terms of time.

Results of the Study

We were interested in studying the main impacts and farmers' plans for managing the risks associated with climate change in the Yanonge region. This discussion of the results focuses on:

1. The main impacts of climate change experienced by farmers in the Yanonge region; and
2. The different farmers' plans for managing the risks associated with climate change in the Yanonge area;

Main Impacts of Climate Change in the Study Area

The typical impacts of climate change are not as easy to measure, especially in equatorial zones. Certainly, the perception made by forest communities in the Yanonge area is summarized by drought, erosion and flooding, etc.

Excessive heat (drought) is recorded as the most major impact of climate change in this Yanonge region. This is justified by two reasons: first, the geographical location. Indeed, the Yanonge area is located in the equatorial zone where it is naturally hot with an average temperature level oscillating around 25°C. Secondly, the practice of slash and burn, the main agricultural technique, contributes to the increase of temperature through the emission of GHG (Greenhouse Gases) in the atmosphere. Forest burning now accounts for 35.7% of greenhouse gas emissions, compared to 64.3% for industrial production (Newman, 1990).

These assertions by farmers are consistent with the results found by Kasongo (2012). Indeed, the latter observes, an increase of 0.051°C, or 0.17% in maximum temperature between 1981 to 1990 and 1991 to 2000; of 0.504°C, or 1.51% between 1991 to 2000 and 2001 to 2010.

Erosion is noted as the second impact of climate change in this Yanonge area and is marked by a fairly low percentage. The Yanonge area, being located in a plateau environment and purely forested, this kind of ecosystem contributes strongly in the maintenance of the soil through its stands of trees and shrubs that constitute real barriers limiting the spread of erosion in this Yanonge area.

However, the 17% of respondents mention erosion in the Yanonge region as one of the impacts of climate change. This is justified by the fact that beyond the plateaus, the environment also includes areas with steep slopes where the soil is exposed by the road layout and is easily eroded by runoff. Thus, most of the erosion in the Yanonge region is located along roads compared to the results found by CFSI (2018) show that emissions from the agricultural sector account for 11% of total global GHG emissions.

Since soil erosion is directly related to the intensity of rainfall (degradation of soil particles, runoff carrying soil particles favored by the phenomenon of soil compaction and saturation, erosive power of the water net on areas with steep slopes (Bastone and De la Torre, 2011), most of the sloping areas and those exposed in the Yanonge region, are exposed to the erosion phenomenon.

Flooding occupies a small proportion in terms of percentage (i.e. 15%) compared to all other climate change impacts recorded in this study in the Yanonge region. This low proportion is explained by the fact that only the village of Lokomba is subject to this scourge.

Thus, considering the methodological guide for the elaboration of the PPR (Mate & Metl, 1999), the floods localized in the Yanonge area, are found in the typology of floods due to the submergence of coastal areas. This being the case, Lokomba, being located on the banks of the Congo River, suffers from flooding every year when the water level rises. Indeed, this increase in water level would be linked to climatic disturbances; in particular intense rains, one of the consequences of climate change in the tropical environment.

These results, together with our own, confirm our first hypothesis, which states that drought, erosion and flooding are the main impacts of climate change on the forest community in the Yanonge region.

Different Farmers' Plans in the Yanonge Region

For this phase, the analysis focuses on the mechanisms or plans that the populations of the Yanonge region have in place to deal with the climate change impacts studied. These mechanisms are therefore, the set of strategies or capacities that the populations of this area develop to implement all the possibilities that are offered to adapt to the main impacts of climate change encountered in their daily lives.

Overall, the farmers' plans for managing the risks associated with climate change in the Yanonge zone, however, have recorded low percentages. However, during drought, the main plans adopted by the population living in this study area are to wash and sleep late, and to stay under the trees and sleep with the windows open.

These peasant plans allow the population to resist the high temperatures by reducing their impacts. Thus, sleeping late allows the population to benefit from the coolness of the night in order to have a peaceful sleep. For crops, we found that the majority of respondents have too few appropriate mechanisms. Moreover, only 16% of respondents use the cultivation technique of sowing deeper (10 cm from the ground) as a plan to combat drought in order to reach a moisture level that is favorable to the development of bio-agents that allow crops to grow well.

The depth of seeding is essential for optimal germination and emergence. In this, it is to be retained two great rules, following:

A seed must be sown at a depth approximately equivalent to 3 or 4 times its thickness;

In sandy soil and in dry periods, we sow a little deeper, as the surface layer dries out more quickly in this condition (Gilles le Jardinier Bio, 2013).

Only twenty-four percent (24%) of our respondents practice indirect sowing by passing the seeds through germinators in order to preserve the germinative power of the seeds and avoid their destruction by excessive heat.

With regard to flooding, one hundred percent (91%) of the population surveyed stated that they had no farmers' flood control plan. On the other hand, an extremely small proportion (9%) of the population is inclined towards water channelling, i.e., digging up a large part of the soil to facilitate the passage of water, and this is considered the only flood control strategy used by the population in this region.

From the agricultural point of view, we note that 21% of the population proceed by the identification of the places which are increasingly flooded as the principal strategy of fight against the floods against 79% of the population not having any agricultural strategy of fight against the floods in the forest zone of Yanonge.

Finally, considering erosion, the second impact of climate change threatening the population in the Yanonge area, planting bamboo and filling bags with sand (40%) are considered as the main farmer strategy for erosion control in the Yanonge area. In addition, the planting of *Paspalum notatum* (15%) is also considered.

For crops, the planting of bamboo and the filling of bags with sand remain a very effective peasant strategy to fight against erosion. However, it should be noted that this strategy is applied in fields covering smaller areas, since its implementation causes enormous difficulties in terms of cost (labor), which justifies its low proportion among our respondents (7%).

These results are consistent with those of Ngabaka-koubango (2003) and confirm our second hypothesis, which states that planting bamboo, filling bags with sand, planting *Paspalum notatum*, etc. are among the biological actions for erosion control. These biological actions consist in the use of certain plant species to fight against them. These are a very effective way in reducing the effects of splash and by the fasciculated and dense root system that these plants develop in the soil, effectively retaining it against the runoff of water so will be difficult the development of erosion.

Conclusion

In sum, this research has used a number of themes (forestry, climate change, etc.). The objective of the latter was to study the main impacts and farmers' plans for managing the risks associated with climate change. This overall objective was broken down into three specific objectives. This study was conducted in the Yanonge forest area of the Democratic Republic of Congo. This region is one of the vast areas of tropical forests subject to the various impacts of climate change.

The results obtained during this study allowed to determine the main impacts and the farmers' plans to manage the risks related to climate change in the Yanonge region.

These results revealed that drought, flooding and erosion are the main impacts of climate change in the Yanonge region with the respective proportions of 68%, 17% and 15%.

Based on the different farmers' strategies for managing the risks due to climate change in the Yanonge region, we recorded very low proportions of the surveyed population, both in terms of human beings and the different crops practiced in the study area. During dry periods, farmers opt for: washing, sleeping late; staying under the trees and sleeping while leaving the windows open as the main strategies to fight against excessive heat by their largest proportion recorded. For crops, as far as farmers' strategies for combating drought are concerned, it was noted that the population uses the technique of sowing deeper (10 cm), but also the technique of indirect sowing by passing the seeds through the germarium. These farmers' strategies for combating drought recorded 16% and 17% respectively. The planting of bamboo, the filling of bags with sand corresponded to 40% of the population surveyed and add to that, the planting of *Paspalum notatum* which noted 15%, remain the main farmers' strategies to fight against erosion in the Yanonge region.

In order to enrich this research and to limit the probable harmful effects of climate change, the present study suggests the following alternatives:

- ✓ To deepen the study of the main impacts and farmers' strategies for managing the risks of climate change in the Yanonge region by broadening the scope of the study;
- ✓ To deepen this study by analyzing other climate variables or parameters complementary to temperature and precipitation in order to identify the different climatic characteristics of the seasons in this same study area or elsewhere.

References

Bastone V. & De le Torre Y. (2011). Preliminary study of the impact of climate change on natural hazards in Reunion, 135p.

Bele Y., Mulotwa E., Bokoto de Semboli B., Sonwa D., & Tiani A-M. (2010). Climate change impacts in the Congo Basin: the need to support local adaptive capacities. Adaptation Overview. Supporting climate change adaptation in Africa through participatory action research. November A2010 -No. 3. p 1.

Beucher & Bazin A. (2012). Agriculture in Africa Face the Challenge of Climate Change-SYNTHESIS, 77 p.

Bullot M. (1977). Diasporisations sociolinguistiques et précarités. Discriminations et mobilités, 153p.

Cahen L. (1954). Géologie du Congo Belge. Liège: Vaillant-Carmanne SA, 1954, 575p.

UNFCCC (1992). Awareness of the impacts of climate change on the entire planet and their adverse effects: a concern for humanity, 44 p.

UNFCCC (2009). Copenhagen Climate Change Conference 2009, 46p.

CED (2010). Assessment of projected climate change signals over central Africa based on a multitude of global and regional climate projections. In Haensler A., Jacob D., Kabat P. & Ludwig F. (Eds.), *Climate Change Scenarios for the Congo Basin* [Climate Service Centre Report No. 11, Hamburg, Germany.

CFSI (2018). Agriculture and forestry facing the challenge of Climate Change, ALIMENTERRE, Fiche thématique, 13 p.

Coté, G., & Gagnon, C. (2005). Gouvernance environnementale et participation: pratique ou utopie? Le cas de l'implantation du mégaprojet industriel Alcan (Alma). *Nouvelles pratiques sociales, 18*(1), 57-72.

De Perthuis C., Daze A., & Ehrhart C. (2010). Analysis of vulnerability and adaptive capacity to climate change. Care: Pari; 8-9.

Fahem A.K. (1978). Geology, soils and vegetation in the Republic of Zaire. Atlas de la République du Zaïre. Paris: ed. J.a. (IGN), 12-13, 20-21 and 22-23.

IPCC (2007). Climate Change 2007. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Lead writing team: Switzerland. 103 p.

Gilles the Organic Gardener (2013). https://www.un-jardin-bio.com/category/agenda-jardinier/les-periodes-de-travaux.

International Food Policy Research Institute (IFPRI) (2009). Climate Change: Impact on Agriculture and Costs of Adaptation. Washington, D.C. Updated October 2009, Food Policy Report, 30P.

Kasongo Y. (2012). Analyse de la vulnérabilité et des stratégies d'adaptation au changement climatique des communautés forestières de la République Démocratique du Congo: cas de la région de Yangambi, Master's thesis, 55 p.

Mampeta S. (2012). Populations, pouvoir et conflits autour des concessions forestières. Quelle gouvernance pour une exploitation durable des forêts à Isangi, République Démocratique du Congo. PhD thesis. FSSAP-UNIKIS, 342p.

United Nations (2010). Resolutions adopted by the Security Council in 2010.

Newman A. (1990). Tropical forests, how to save them? Éd. La rousse. Paris, 248 p.

Ngabaka-Koubango A. (2004). La dynamique actuelle de l'érosion du sol dans bassin versant de la M'filou à Massina (Brazzaville, Congo), Université Marien Ngouabi, 70p.

Ngongo R., Kasongo G., & Verdoot A. (2009). Guide des sols en République Démocratique du Congo, tome I: étude et gestion, 152p.

OECD (2008). Climate Change Mitigation. WHAT TO DO. Www.oecd.org/eco/working.

Somorine, O.A., Brown, H.C.P., Visseren-Hamakers, I.J., Sonwa, D., Arts, B. & Nkem, J.N. (2011). The Congo Basin forests in a changing climate: policy discourses on adaptation and migration (REDD+), Global Environmental Change 22, 288-98.

Tiani, Bele M., & Sonwa Y. (2014). Local communities vulnerability to climate change and adaptation strategies in Bukavu in DR. Congo, 117p.

Toirambe B., Mukinzi J.C., Solia S. & Onotamba K.P. (2010). Conducting a baseline assessment of the biodiversity status, impacts of anthropogenic pressures on natural resources and environmental governance issues of the Yangambi Biosphere Reserve. Consultation report. DMP/WWF Project. 165p.

Vandenput (1981). Impact du changement du mode d'occupation des sols sur le fonctionnement hydrogéochimique des grands bassins versants : cas du bassin versant de l'Ain, 144 p.

Van Wambeke & Evrard JP. (1954). La végétation de l'Afrique centrale. Https://books.google.cd

Vandenput, R. (1981). The main crops in Central Africa. Tournai: ed. Lesaffre, 458 p.

White F. (1986). The vegetation of Africa. Memorandum accompanying the vegetation map of Africa. UNESCO/AETFAT/UNSO. ORSTOM & UNESCO, Paris, France, 384 p.