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Perception and adaptation strategies to climate change by market gardeners in the Funa river valley in the city of Kinshasa

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ABSTRACT: The study concerns the adverse effects of climate change on peri-urban agriculture in Kinshasa, Democratic Republic of Congo (DRC). The overall objective of this research is to contribute to a better understanding of the endogenous strategies put in place by market gardeners to adapt to the adverse effects of climate change. To this end, a questionnaire survey was carried out on a sample of 100 randomly selected market gardeners in the Funa valley, on the outskirts of the Monastery of the Our Lady of the Assumption. This was complemented by field observations. Meteorological data covering a period of 30 years (1990-2020) made it possible to assess the evolution of precipitation and temperature. The results indicate that the respondents are informed about climate change and perceive its effects through the increase in temperature (93%) and rainfall (86%). Market gardeners reported that climate change induces water stress, stunting and low crop germination rate. The intensification of the use of fertilizers, the gradual abandonment of the empirical agricultural calendar, the supply of water for the fight against drought and the construction of dykes and drainage canals are the adaptation strategies developed by market gardeners in order to limit the harmful consequences of climate change on agricultural production.

KEYWORDS: Market gardener, climate change, temperature, precipitation, Funa River, Kinshasa.

1 INTRODUCTION

Climate change and its impacts are a major challenge that requires a global response [1, 2]. It induces a slow and continuous increase in the average global temperature of the earth's surface and is already upsetting the rhythm of precipitation [3, 4]. These upheavals are accompanied by an increase in the frequency and intensity of extreme climatic events (droughts, floods, heat waves, heavy and abundant rains, tornadoes, etc.), often the cause of natural disasters [4, 5].

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Therefore, health, terrestrial and aquatic ecosystems as well as socio-economic systems such as agriculture, forestry, fisheries and water resources, essential elements for human development and well-being, are already experiencing the induced effects of climate change [6].

Given the current magnitude of these changes, sub-Saharan Africa appears to be one of the most vulnerable regions of our planet [7, 8]. Indeed, sub-Saharan Africa's great vulnerability to climate change is due to its strong dependence on natural resources, the basis of livelihoods and food security (fisheries and agriculture), and its limited adaptive capacity which is due to the lack of resources and technologies [9].

The Congo Basin, like other sub-regions of Africa, has been subjected for several decades to the harmful effects of climatic hazards. The vulnerability of this area to climate change is all the greater as more than 80% of its populations live exclusively from agriculture, fishing, livestock and gathering, which are activities largely dependent on the climate [10]. The threat to African countries is all the more serious as they do not have the technical means to measure the impact of this climate change in order to consider effective control strategies.

Much of the Congo Basin could suffer by 2050 from a sharp increase in the frequency of intense rainfall [2]. In addition, average and extreme temperatures will increase in the future. These changes in temperature and rainfall will lead to more floods and droughts, damaging crops and potentially causing increased food insecurity among poor families, especially in rural and peri-urban settings [2, 11].

The Democratic Republic of Congo is a typical case of African countries where the rural exodus linked to conflicts and the deterioration of living conditions in rural areas has led to vertiginous and unprecedented demographic growth in the capital, over the course of three last decades [12]. With about 14 million inhabitants in 2020, the population of Kinshasa has quadrupled in the last thirty years. This galloping demography is also due to the concentration of economic, school, university and health infrastructures as well as administrative and political institutions [12].

The development of peri-urban agriculture in general and market gardening in particular are proving to be opportune to meet the growing demand for foodstuffs from urban households. In addition, the market gardening sector is now proving to be one of the best strategies allowing a large number of unemployed city dwellers to face several problems of their survival [13].

However, the vagaries of the weather, which result in long periods of drought, increased temperatures, heavy rainfall and flooding of market gardening sites, limit the development of this activity.

A study recently carried out in the municipality of Masina, in the eastern part of the city-province of Kinshasa, indicates that due to lack of knowledge, nearly half of the market gardeners questioned cannot correctly perceive the harmful effects of climate change on market gardening [14]: which makes the fight against this phenomenon difficult.

In this context, there is reason to wonder if the market gardeners of the Funa river valley, in Kindele quarter, municipality of Mont-Ngafula to the west of the city of Kinshasa are aware of the effects of climate change on their activity.

The general objective pursued in this study is to improve knowledge on the endogenous strategies put in place by the market gardeners of the city of Kinshasa in order to adapt to the adverse effects induced by climate change over the past three decades.

2 METHODS

2.1 STUDY SITE

The study took place in Kinshasa, in the valley of the Funa River, located in the Kindele quarter in the municipality of Mont-Ngafula. The natural vegetation of the study site consists of a forest island, relatively preserved around the Priory of Our Lady of the Assumption monastery and the savannah (Figure 1). The landscape of the whole quarter remains dominated by a cover of mostly fruit trees. However, the demographic pressure which translates into increasing demand for land, with a view to installing new housing, often leads to the felling of these trees, thus jeopardizing the environmental balance of the city.

Located in the city-province of Kinshasa, the climate of the Kindele quarter is of the Aw4 type, according to the Köppen classification [15]. It is a hot and humid tropical climate, which originates from the hill breezes which at a certain time of the day blow from the bottom of the valley to the top bringing a certain freshness [16, 17]. This climate has two seasons, a four-month dry season that runs from mid-May to mid-September and an eight-month rainy season that runs from mid-September to mid-May. The rainy season is interspersed with a short dry season between mid-January and mid-February [18]. The average annual temperature is 24.5°C [14].

The average annual precipitation is around 1400 mm. However, the rains decrease around January-February (the small dry season). [16, 19]. The relief of the Kindele quarter is dominated by hills separated by very deep valleys, through which flow certain streams, sometimes cut by erosion. Two types of soil predominate in this environment, hill soils (erosive) and valley soils (fertile and suitable for agriculture) [20].

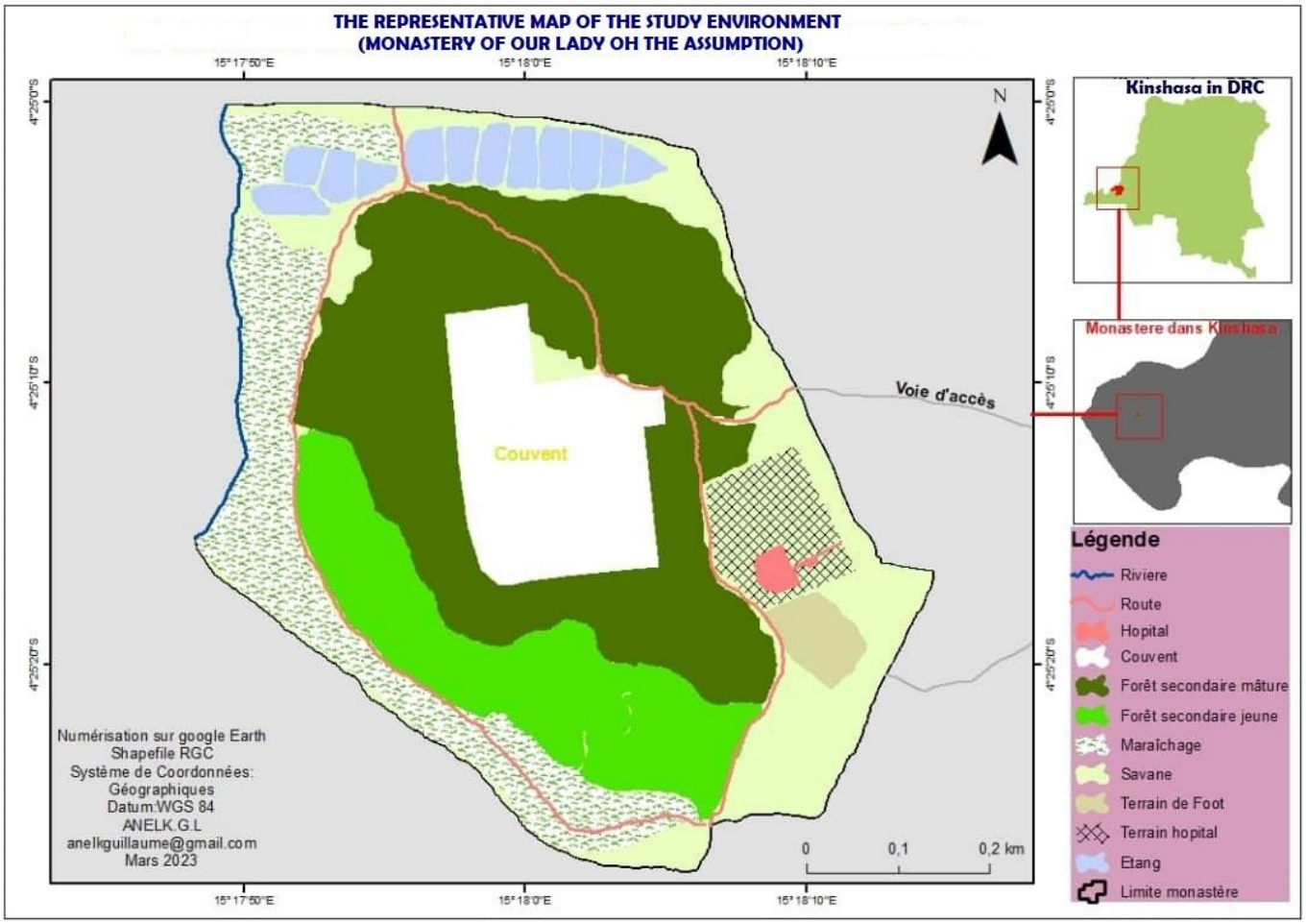

Fig. 1. Land use map of the study area

2.2 DATA COLLECTION AND ANALYSIS

Data collection was carried out on a sample of 100 market gardeners according to a reasoned sampling plan. The semi-structured interview allowed market gardeners to freely express their opinions, which allowed us to collect their perceptions on the effects of climate change on their activities. Such a technique is all the more interesting in that it avoids the biases that could have been recorded during group interviews [21, 22]. The content analysis of the interviews was done manually as described by Wanlin [23].

Non-participant observation allowed us to realize the realities of our study site without directly participating in the activities of market gardeners who are observed subjects [24, 25].

Meteorological data was obtained from the National Meteorological Agency of the DRC (METTELSAT). These cover a period of 30 years (1990-2020). They were then analyzed and processed using Microsoft Excel 2016 software to obtain the trend curves respectively for temperature and precipitation in the study area for a period of three decades. The information obtained was compared with the opinions of market gardeners on the evolution of these two climatic parameters during the same period.

3 RESULTS

3.1 SENIORITY IN THE MARKET GARDENING ACTIVITY

The market gardeners randomly selected in the Kindele district responded favorably to the various questions asked during the survey. These were grouped into a sample of 100 farmers including 71% of men and 29% of women (Figure 2). Regarding their seniority in the exercise of the activity, 85% of the subjects surveyed have embarked on market gardening over the past 11 years. Indeed, in a context of unemployment and impoverishment that characterizes the populations of the peri-urban districts of Kinshasa, market gardening remains one of the main income-generating activities that supports the household economy of these areas.

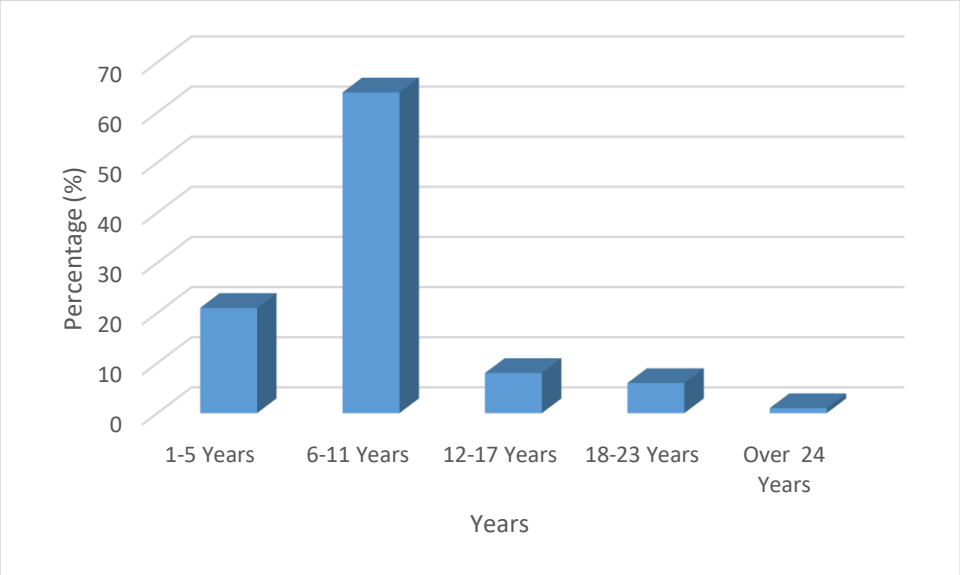

Fig. 2. Time in business in terms of years

3.2 DISTRIBUTION OF CROPS GROWN ON THE SITE

Amaranth (Amarantus sp) and sweet potato (Ipomea batatas) are the two crops most grown by market gardeners in our study area, i.e. 62 % of our subjects; then comes spinach (Basella sp) and sweet potato (Ipomea batatas) 14 % and finally amaranth (Amarantus sp), potato (Ipomea batatas) and eggplant (Solanum melongena) 11 %. The rest of the crops practiced occupy only 13% overall. The low diversity of vegetables cited is explained by the fact that the survey took place during the dry season. These crops adapt easily during the dry season.

Table 1. Distribution of the main crops grown in the Funa Valley

Crop	%
Amarantus sp + *Ipomea batatas* (L.) Lam.	62
Basella sp + *Ipomea batatas* (L.) Lam.	14
Solanum melongena L. + *Amarantus sp* + *Ipomea batatas* (L.) Lam.	11
Solanum lycopersicum L. + *Amarantus sp* + *Ipomea batatas* (L.) Lam.	7
Amarantus sp + *Basella sp* + *Ipomea batatas* (L.) Lam.	2
Solanum lycopersicum + *Solanum melongena* L. + *Amarantus sp* + *Ipomea batatas* (L.) Lam.	2
Ipomea batatas (L.) Lam.	1
Amarantus sp + *Basella sp*	1
Total	**100**

3.3 PERCEPTIONS OF CLIMATE CHANGE

Perceptions of climate change were reported using indicators of change observed among market gardeners in the Funa Valley. These indicators have been classified according to the nature of the climatic parameter taken into account. On the rainfall side, the indicators were perceived at 86% by the producers surveyed while they appear at 93% among the producers concerning the temperature (Table 2).

Table 2. Market gardeners' perceptions of climate change indicators

Climatic parameters	Indicators of change	Percentage of market gardeners on perception
Rainfall	Increase in the amount of rainfall Delayed onset of rains Increase in the length of the rainy season Frequent flooding	86%
Temperature	Increased heat Longer warm period	93%

Climate change is a phenomenon recognized by market gardeners in the Funa Valley, but the causes attributed to them vary. For 72% of the producers surveyed, the climate change observed in recent years is only the result of human actions through deforestation and/or deforestation; 26% of market gardeners attribute it to bush fires and air pollution caused by factories and 2% of producers blame road traffic and slash and burn agriculture (Figure 3).

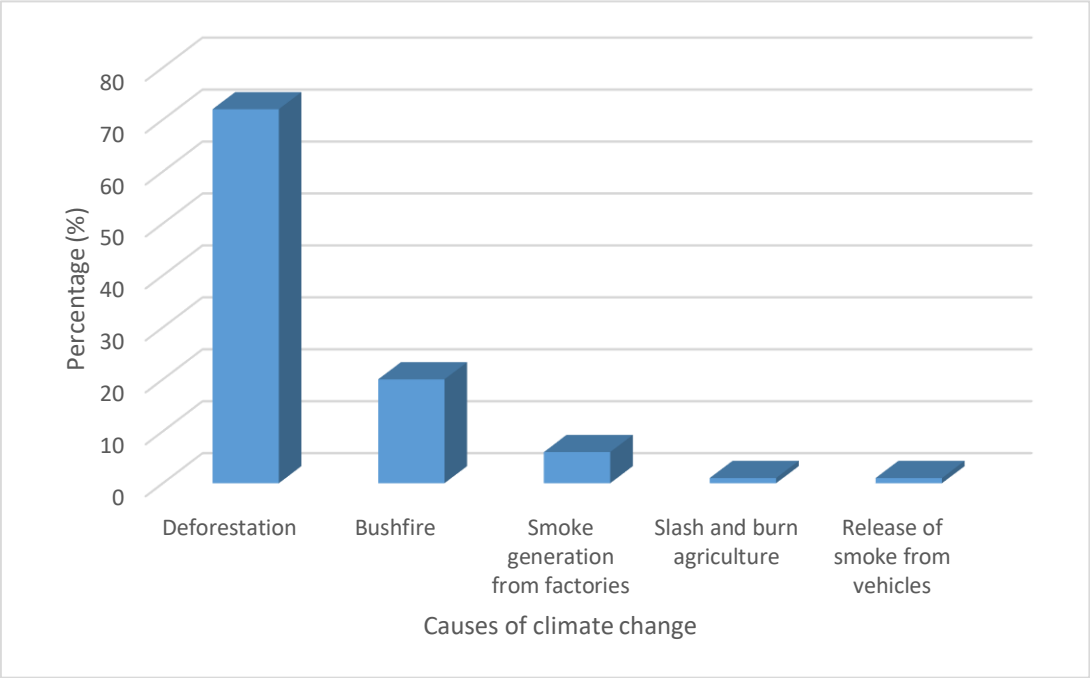

Fig. 3. Causes of climate change

Regarding information on climate change, 46% received it through their friends and relatives, 44% through television and 7% through a conference (Figure 4).

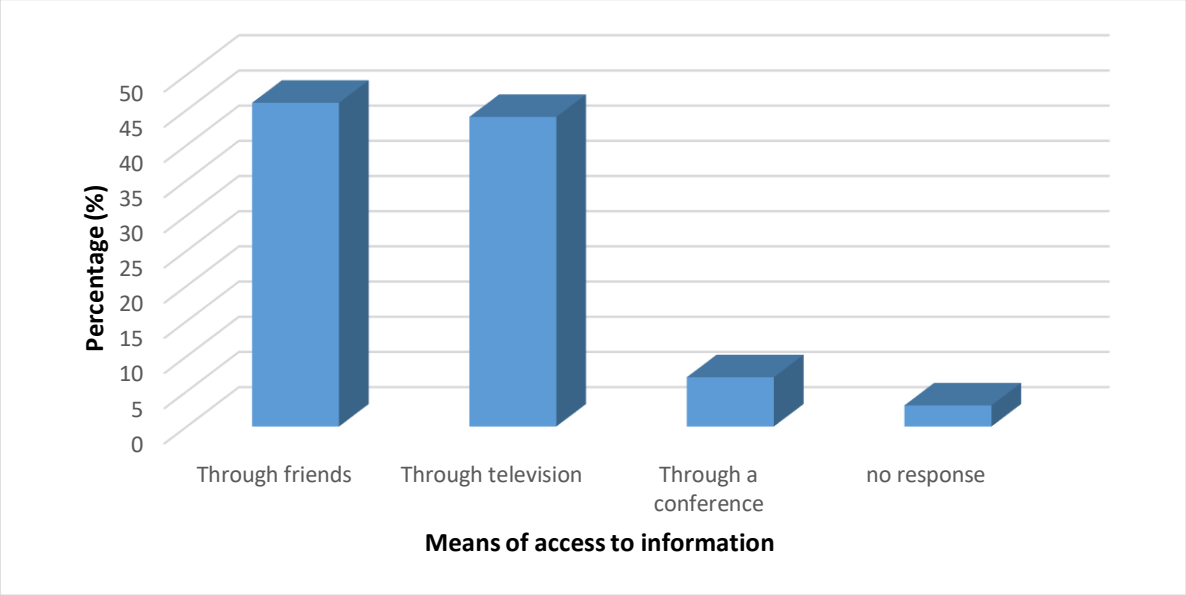

Fig. 4. Means of access to information on climate change by market gardeners

3.4 Analysis Of Climate Trends

3.4.1 Analysis Of Temperature Trends In The Study Area

According to market gardeners' opinions, temperatures have increased over the past thirty (30) years. This temperature trend is confirmed by 93% of respondents. However, 5% mention temperature stability and 2% say that temperatures are getting lower and lower (Figure 5).

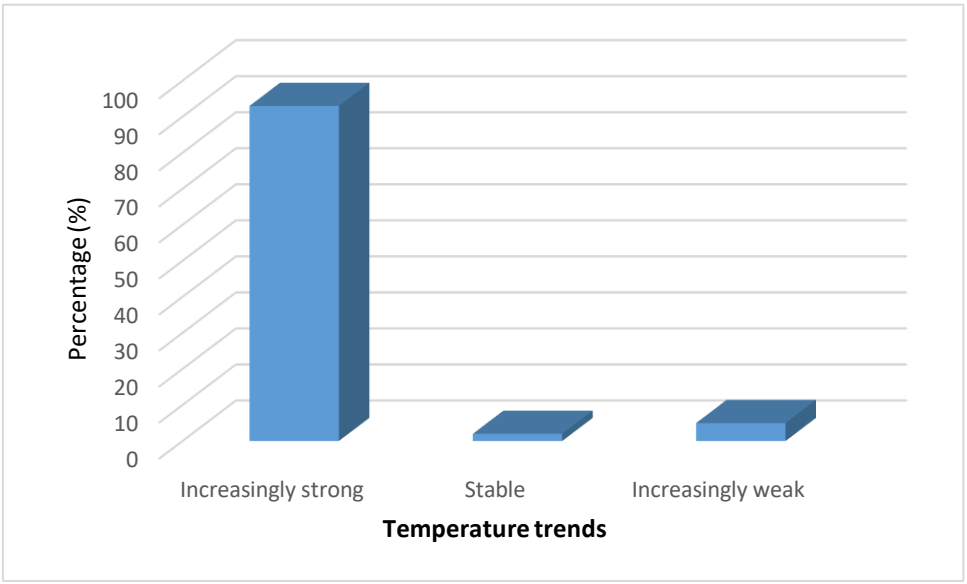

Fig. 5. Observed temperature trends

The information obtained from market gardeners was not sufficient to identify the changing trends in temperatures. Hence the need to compare them with meteorological data.

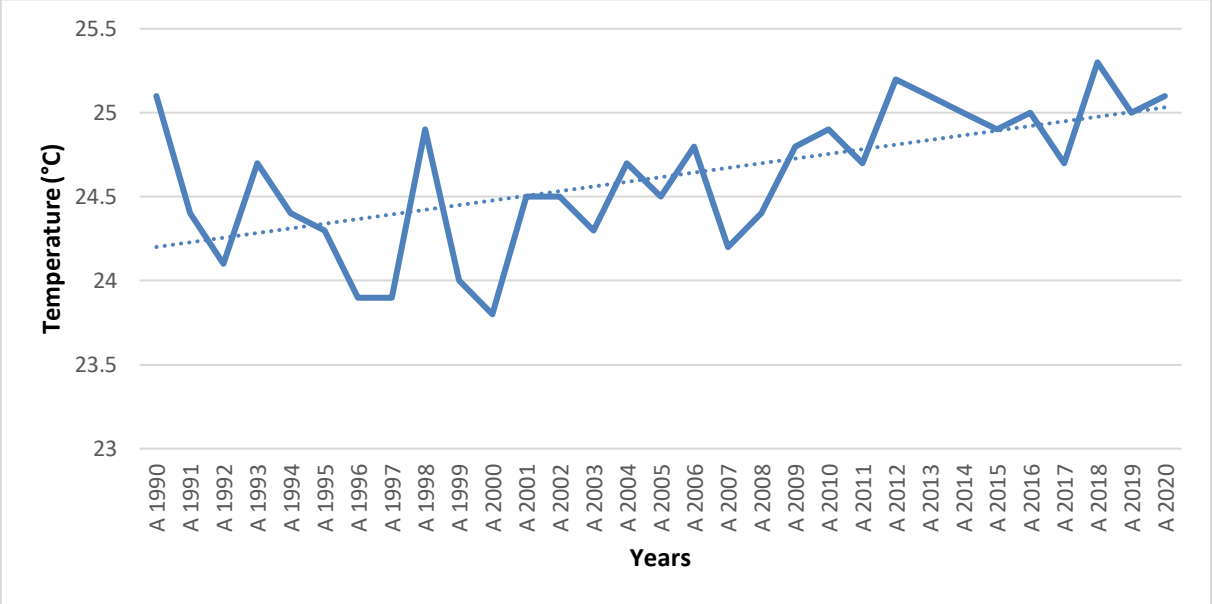

Fig. 6. Evolution of annual average temperatures according to Kinshasa station (1990-2020)

The analysis of the meteorological data shows that the annual mean temperatures have developed in a sawtooth pattern, i.e. large deviations from the mean values have been reported over three decades. The trend curve showed a strong upward trend in temperatures over this period (Figure 6).

3.4.2 Analysis Of Rainfall Trends

The interest of the study of rainfall parameters is the comparison of theoretical results with the perceptions of market gardeners. In order to better examine the trend of evolution of theoretical data of the last thirty (30) years, the graph showing the opinions of market gardeners on the evolution of rainfall data is presented in Figure 7.

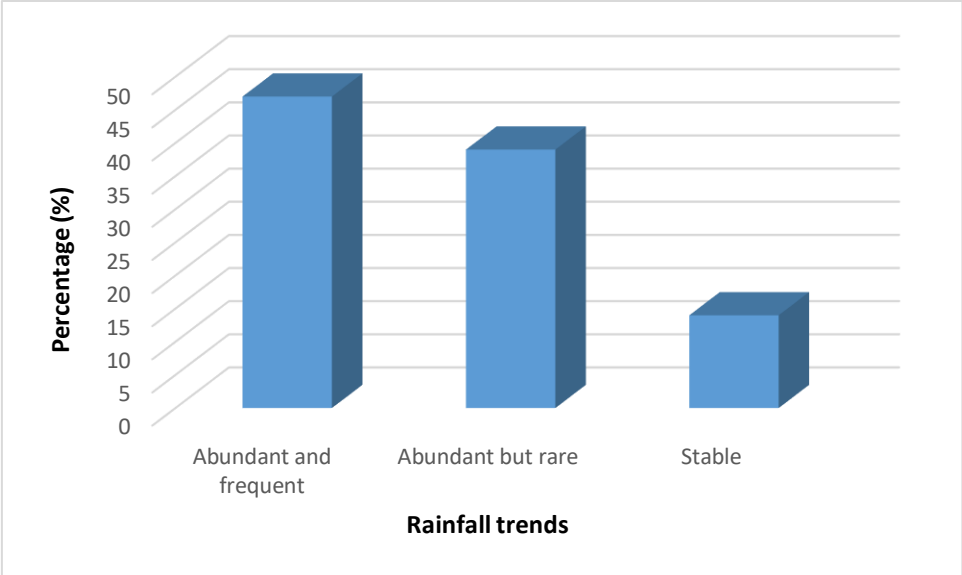

Fig. 7. Rainfall trends

The analysis of Figure 7 shows that overall there is an upward trend in annual rainfall and the number of annual days of rain during the last thirty (30) years in our study area, i.e. 47%. However, 39% said that they are abundant but rare and only 14% of the subjects said that the evolution of the rains is stable.

As for temperatures, rainfall data collected at the Kinshasa meteorological station were also analyzed. These are shown in Figure 8.

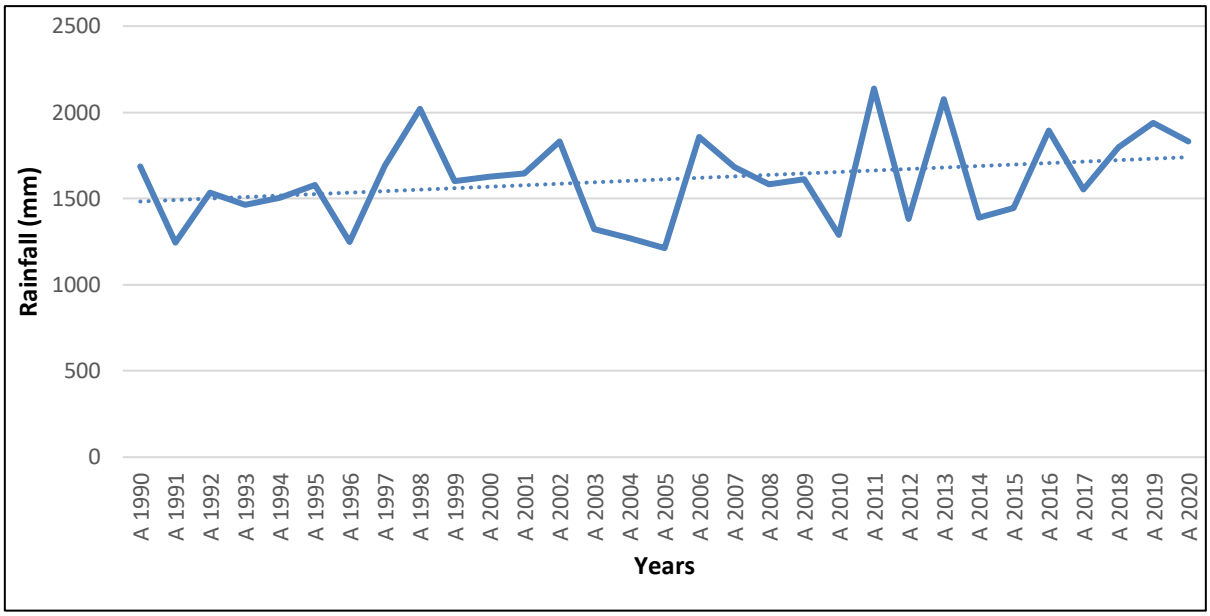

Fig. 8. Rainfall evolution according to Kinshasa station (1990-2020)

It emerges from the analysis of Figure 8 that the precipitation values recorded over the last thirty years have experienced large interannual variations. However, the trend curve generated has a relatively weaker curve than that of the temperature.

3.5 Consequences Of Climate Change On Crops

According to 44% of the producers surveyed, changes in rainfall and temperature have negative consequences on crops through reduced yields and crop loss (low germination rate).

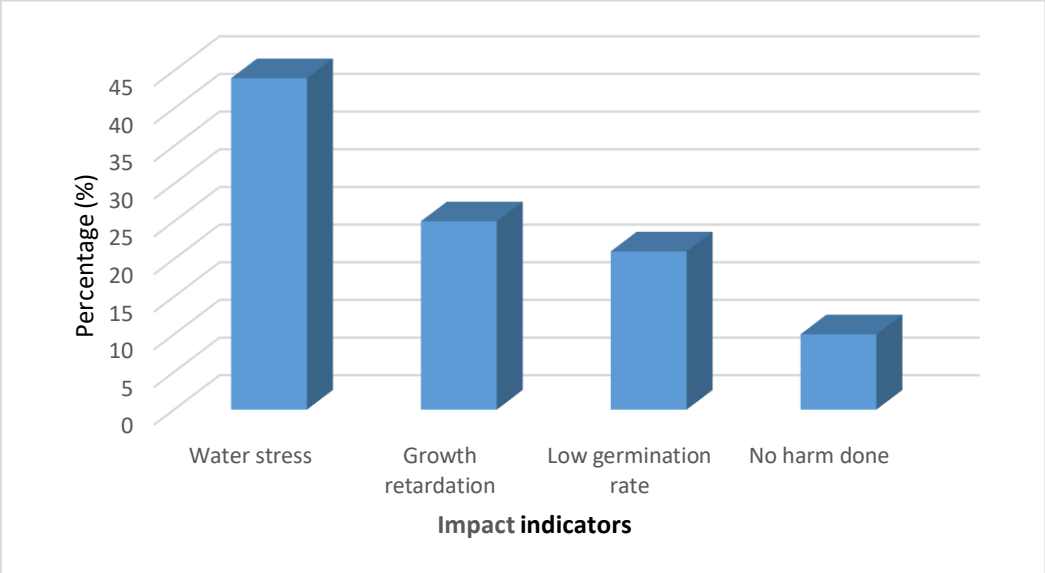

Fig. 9. Impacts of climate change on crops

3.6 CLIMATE CHANGE ADAPTATION STRATEGIES

The adaptation strategies developed by the market gardeners of the Funa Valley allow them to limit the harmful consequences of climate change likely to affect their activities. These are the intensification of the use of fertilizers, the gradual abandonment of the empirical agricultural calendar, the supply of water for the fight against drought and the construction of dykes and canals for the fight against floods.

3.6.1 INTENSIFICATION OF FERTILIZER USE

Climate change and particularly rainfall deterioration constitute an additive effect to the problems of fertility decline that arise in our study area. And to allow plants to complete their vegetative cycle before the rains stop, market gardeners apply urea. Urea is used for the fertilization of the plants in order to facilitate its growth and to obtain an acceptable harvest before the interruption of the rains. This intensive use of inputs has repercussions on the environment in the medium and long term, even if they make it possible to improve production and/or limit the efforts made for weeding activities.

3.6.2 GRADUAL ABANDONMENT OF THE EMPIRICAL AGRICULTURAL CALENDAR

One of the legacies of the market gardening world of our study environment is the agricultural calendar. This calendar resulted from the perception and climatic conditions enjoyed by previous generations. It was respected and rigorously followed for several years. But the pockets of repeated droughts, the early cessation of the rains and the frequent bad distribution of the rains made it difficult to respect the calendar. According to the producers surveyed, this agricultural calendar is no longer in line with current climatic realities.

3.6.3 SUPPLY OF WATER FOR THE FIGHT AGAINST DROUGHT

In order to fight against the drought, the market gardeners proceed by bringing water to the crops by watering, a preponderant factor, says the market gardeners. However, the growers proceed with the watering including twice a day in an abundant way, but it is not an easy task to do. Sometimes faced with the difficulty of the availability of water, in times of shortage, market gardeners are especially unable to cope.

3.6.4 CONSTRUCTION OF DYKES AND CANALS FOR FLOOD CONTROL

The market gardeners proceed with the construction of the dikes and the installation of the water evacuation channels in all the directions where the water enters. This technique allows them to channel and make the water flow.

3.7 REDUCTION MEASURES

When it comes to measures to mitigate the effects of climate change, reforestation comes first (66%), followed by banning bushfires (22%). 12% of market gardeners wanted the joint application of these two measures.

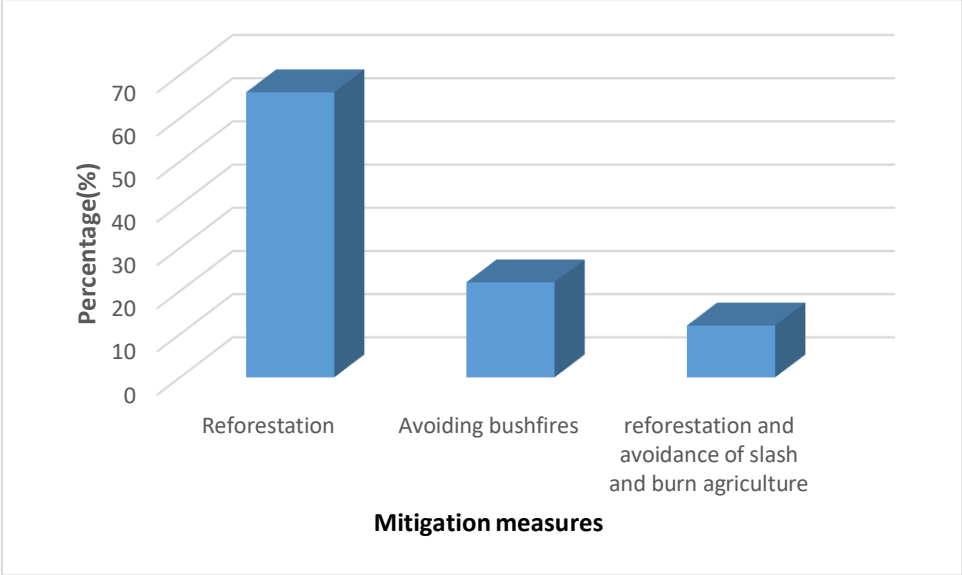

Fig. 10. Measure of mitigations to the effects of change

4 DISCUSSION

This study revealed the perception of market gardeners on climate change in the Funa Valley, in the peri-urban municipality of Mont-Ngafula, in the city of Kinshasa. The results of this study showed that nearly three quarters of market gardeners surveyed (72%) incriminate deforestation as the main cause of climate change. This result is more or less consistent with a study carried out in Benin by Dimon [26]. Indeed, producers surveyed in his study area conclude that the climate change observed in recent years is the result of human actions through deforestation. Bellassen et al. [27] claim that deforestation is one of the causes of climatic disturbances in tropical regions. In the context of the municipality of Mont-Ngafula in general and that of the Kindele quarter in particular, the effects of deforestation are visible. The natural vegetation, once lush as evidenced by the forest island of the monastery, has visibly deteriorated over the years due to demographic and land pressure [15]. Disappeared, it was replaced by an artificial cover of mostly fruit trees. Thus, due to a lack of sufficient vegetation cover on the slopes, the Funa River valley is occasionally flooded during the rainy season, thus making it difficult to practice market gardening.

From the point of view of the assessment of the consequences of climate change on market gardening, 44% of the surveys confirmed that climate change induces a low germination rate of their crops, water stress, and a delay in the growth of crops. Similar results have been found by the work of the Ministry in charge of the Environment and Nature Protection of Benin [28] which demonstrated during the development of the National Action Program for Adaptation to Changes that these disturbances induce impacts on agriculture. These relate to crop behavior, soil modification and declines in crop yield. Phenomena of shortening of the vegetative cycles and early deflowering are also observed, due to the rise in temperature. Houndénou [29] and Ogouwale [30] confirm that seasonal rainfall disruption and defiance disrupt crops, upset the peasant agricultural calendar and render the empirical cultural norms in force non-functional. Producers also report a drop in production or yield, crop yellowing, crop attack by insects, wilting. The same observation was made by Aho et al. [31] in their study; They found that climate change leads to a decrease in agricultural production. In Benin, the studies carried out respectively by Issa [32] and in Ogouwale [33] Ogouwale [30] concluded that additional thermal stress induces the reduction of yields in the different agro-ecological regions. In addition, the multiplications and expansion of crop pests due to climate change tend to aggravate the risk of post-harvest losses amplifying the vulnerability of farmers, the rural and urban poor, etc. [33; 34; 35]. With regard to adaptation measures to deal with the effects induced by climate change, market gardeners are developing various strategies, namely: Intensification of the use of inputs, gradual abandonment of the empirical agricultural calendar, supply of water for the fight against drought, construction of dykes and canals for the fight against floods. This finding is consistent with that noted by Dimon [26], which states that in Benin producers resort to the application of urea and inputs to cope with the adverse effects of climate change on crops. From the analysis of meteorological data, it reveals a consistency between them and the opinions of market gardeners. There is an upward trend for the two climatic parameters studied (temperature and precipitation). However, based on these two lines of information, the upward trend of annual temperatures over the three decades of study appears to be relatively greater than that of precipitation recorded over the same period.

5 CONCLUSION

The study on the perceptions of climate change by market gardeners in the Funa Valley in the municipality of Mont-Ngafula seems relevant to combat the harmful consequences of this phenomenon in the agricultural sector. Deforestation is attributed by 72% of market gardeners surveyed as the main cause of climate change. This is also recognized by numerous studies as being one of the main causes of this scourge in the tropics.

Almost all of the respondents clearly perceive the effects of climate change on market gardening in the Funa valley. The consequences of climate change on the activities of producers are reflected, among other things, in lower yields and crop losses. In addition, climate change induces a low crop germination rate according to 44% of market gardeners and water stress according to 25% of producers and a delay in crop growth according to 21% of them.

The adaptation measures developed in the study area to cope with the effects induced by climate change are: intensification of the use of inputs, the gradual abandonment of the empirical agricultural calendar, the contribution of water to fight against drought, the construction of dykes and canals to fight against floods.

In view of the results of this study, it is necessary to conduct similar studies at other sites throughout the Democratic Republic of Congo in order to put in place a national strategy for mitigation and adaptation and climate change. This will have made it possible to manage the harmful effects of climatic disturbances on agriculture in general and market gardening in particular.

Given the low female participation during this study, the gender aspect should be taken into account in future studies.

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