

# Diversification of Livelihoods as an Adaptive Response to Climate Change Impacts in Mali's Sahel Region: Case of Diéma Circle

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**Abstract:** *This article delves into the pressing concern of climate changes escalating impact on the Sahel region, with a specific focus on Mali. The transformative effects of climate change on agricultural systems have prompted communities to devise adaptive strategies. This study centers on the analysis of livelihood diversification within the context of climate change in Diéma Circle. Employing a mixed - method approach involving both quantitative and qualitative data collection techniques, the research unveils the role of diversifying livelihoods as a crucial adaptation tactic by the inhabitants of Diéma Circle to counteract the detrimental effects of climate change on agriculture. The diversification strategy encompasses two key categories: activities reliant on natural resources and those based on non - natural resources. Noteworthy among the former are practices like market gardening, agricultural services provisioning, wood exploitation, and livestock trading, each serving as essential sources of income for surveyed households. The latter category encompasses trade, crafts, and transport - related activities. Overall, this article elucidates how the diversification of income sources has emerged as a vital means of both survival and prosperity for the local populations grappling with the challenges posed by climate change in the Sahel region.*

**Keywords:** Livelihoods, Climate Change, Adaptation, circle of Diéma, Mali.

## 1. Introduction

The lives and livelihoods of the world's most vulnerable populations are constantly threatened by disasters including climate change. First, the existence of this phenomenon is not the shadow of a doubt. Indeed, according to [1], the scientific community now agrees in recognizing that climate change is already a reality and that the intensity and duration of the warming observed in the 20th century are unprecedented for a thousand years.

Worse, the prospects are worrying according to [2] which concludes that the projections made on the basis of all the emission scenarios considered indicate an increase in surface temperature during the 21st century. It is very likely that the frequency and duration of heat waves will increase, and that extreme precipitation events will become more intense and more frequent in many regions. The oceans will continue to warm and acidify and the average sea level to rise.

Africa, although less responsible for climate change, is one of the regions of the world that suffers the worst devastating effects caused by this scourge. Indeed, for [3], Africa has already felt the impact of climate change and we can expect even more marked effects. Thus, in general, areas that have had precipitation, such as the equatorial and subpolar rainfall belts, will have even more, while dry areas, such as subtropical arid areas, will have even less. In addition, according to [4], the increase in average temperature between 1980/1999 and 2080/2099 could reach between 3°C and 4°C on the whole continent, 1.5 times more than at the global level. . This increase will be less strong within the coastal and equatorial areas (+3°C) and higher in the western part of the Sahara up to +4°C.

As far as Mali is concerned, the economy is highly dependent on the agro - pastoral sector which contributes 33% to GDP, employs 79% of the active population and provides 20% of the country's export earnings [5]. In view of this importance, Mali's agricultural development policy aims to promote sustainable, modern and competitive agriculture [6]. Malian agriculture aims to guarantee food sovereignty and to make the agricultural sector the engine of the national economy in order to ensure the well - being of the populations [7]. However, the country's agricultural production systems are impacted by climate change. Moreover, agriculture and livestock have been retained in the National Action Program for Adaptation to Climate Change in Mali (PANA) drawn up by the Ministry of Equipment and Transport (MET) [8], as sectors highly vulnerable to climate change.

Like other localities in Mali, the circle of Diéma is not spared by the phenomenon of climate change. The area has a predominantly agricultural economy. Agriculture is based on the production of rainfed crops. Being a Sahelian zone, the circle of Diéma has known for several decades according to [9], the impacts of climate change which exacerbate the already difficult conditions.

Thus, this work focuses on strategies for adapting to climate change. Therefore, the objective of this article is to analyze the diversification of livelihoods operated by the populations as a measure of adaptation to climate change in the circle of Diéma.

## 2. Method and materials

The methodology adopted for this article is composed of the location of the field of study and the methodological approach.

## 2.1 Location of the study area

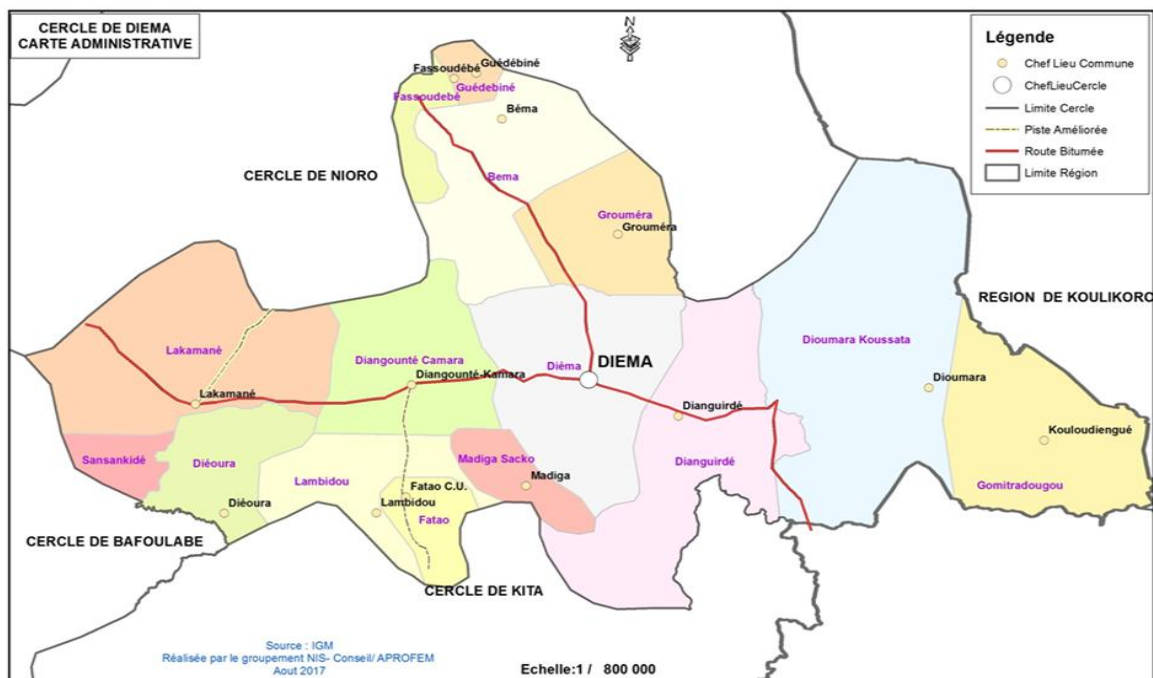


Figure 1: Map of the circle of Diéma

The circle of Diéma occupies the eastern part of the Kayes region in Mali. It is bordered to the west by the circle of Bafoulabé, to the east by the circles of Kolokani and Nara (Koulikoro region), to the north by the circle of Nioro du Sahel and to the south by the circle of Kita (figure 1). The geographical coordinates of Diéma are: Latitude ( $14^{\circ} 34' 59''$ ) and longitude ( $9^{\circ} 15' 0''$ ).

With an area of 12, 440 km<sup>2</sup>, the circle of Diéma has 15 communes including 14 rural communes and one urban commune: Diéma, Madiga - Sacko, Diangouirde, Dioumara - Koussata, Gomitradouyou, Grouméra, Béma, Fassou - Débé, Guédébiné, Diangouité - Camara, Lambidou, Lakamané, Diéoura and Sansankidé and the urban commune of Fatao.

The capital of the circle (Diéma) is located 276 km from Kayes via Lakamané, 350 km from Bamako via Kolokani, 105 km from Nioro du Sahel and 200 km from Kita.

## 2.2 Method

The methodological approach used is mixed. Upstream, the consultation of documents in several documentation centers and libraries was very useful. Indeed, it allowed the structuring of ideas for the development of this article.

### 2.2.1 Data collection

Data was collected from field surveys to learn about the diversification of livelihoods in response to the effects of climate change.

For the collection of quantitative data, the questionnaire was used as an instrument. To this end, the quantitative sample was constituted at three levels:

- **Communes level:** With a representativeness rate of 33%, the sample is fixed at 5 communes out of the 15 that make up the circle of Diéma. The geographical criterion is retained for the selection of the 5 communes: (Béma in the North, Diéma, Gomitradouyou and Lakamané in the center and the commune of Diangouirde in the South).
- **Village level:** For the choice of survey villages, we opted for systematic random sampling. The 5 communes surveyed are made up of 78 villages which constitute our sampling base. Based on a representativeness rate of 32%, we obtained 25 survey villages. The selection of these villages by survey commune was made in proportion to the size of the communes surveyed, i. e. 32% of the villages in each commune were selected.

Thus, for the commune of Béma, which has 24 villages, our sample corresponds to 8 villages. The selection was made from the list of villages arranged in alphabetical order. To do this, we first calculated the probing step K.

$$K = N/n$$

K= no sampling; N= total number of villages; n= number of survey villages

$$K = 24/8 = 3$$

Given that K=3, the first village to be surveyed was drawn between the numbers 1 to 3. To this end, we wrote the names of the first 3 villages in our sampling base on slips of paper which were put a box. The box was then vigorously shaken, then the scraps of paper were dumped out. A random choice fell on the third village on the list which is Badiané. To draw the second survey village, we calculated  $3+3=6$ , so the 6th village on the list is chosen, the village of Diarra Madina. Then to draw the third village to investigate, we asked the operation  $6+3=9$ , so the 9th village on the list

is taken, the village of Fadou. So on, we drew the 8 survey villages of the commune of Béma. The survey villages selected are: Badiané, Diarra Madina, Fadou, Kakanou, Kamidala, Koungo, N'tomikoro and Torgomé.

This procedure for selecting survey villages was used for the other survey communes.

**Level of Agricultural Production Units (UPA):** with a sample of 420 UPA out of 1288 of the 25 survey villages, the representativeness rate is 32.6%. The UPA Draw is made according to a survey step and a random starting point. The lists of UPA chiefs available from village chiefs were used as a sampling frame.

Table 1 shows all the communes, villages and Agricultural Production Units (UPA) selected for the quantitative survey.

**Table 1:** Communes, villages and agricultural production units retained for the quantitative survey

Communes	villages	UPA
Béma	Badiané	25
	Diarra Madina	19
	Fadou	28
	Kakanou	08
	Kamidala	07
	Koungo	15

Dianguirédé	N'tomikoro	10
	Torgomé	08
	Beïdy	12
	Foulabougou	12
	Nacoumana	06
Diéma	Torodo	12
	Bougoudéré Mahomet	24
	Diéma	19
	Fangouné Bambara	95
	Kana	19
Gomitradougou	Mambrouké	07
	Bassibougou	8
	Missira	06
Lakamané	Sébabougou	21
	Dalibera	13
	Foutougou	09
	Kabakoro	05
	Kobokoto	14
Total	Lattakaf	18
	25	420

Concerning the qualitative data, an interview guide was developed and the interviews were carried out with municipal elected officials, technical service agents, circle council agents, NGO agents and members of associations (Table 2). The interview was carried out with associations or groups of men and women in the form of a focus group.

**Table 2:** Number of resource persons interviewed per municipality and per village

Communes	Villages	Nombre de personnes interviewées					
		Men's focus group	Women's focus group	Municipal elected officials	Technical services	NGO	circle board
Béma	Badiané	06		01	02		
	Diarra Madina	09					
	Fadou						
	Kakanou	08					
	Kamidala						
	Koungo	06	11				
	N'tomikoro						
Dianguirédé	Torgomé	07		01			
	Beïdy						
	Foulabougou		06				
	Nacoumana	05					
Diéma	Torodo			01	04	04	01
	Bougoudéré Mahomet						
	Diéma						
	Fangouné Bambara	12	08				
	Kana						
Gomitra - dougou	Mambrouké	06		01	01		
	Bassibougou		13				
	Missira						
Lakamané	Sébabougou	10		01	01		
	Dalibera		06				
	Foutougou	04					
	Kabakoro						
	Kobokoto						
Total	Lattakaf.	06		05	08	04	01
	25	79	44				

**2.2.2 Data processing**

The processing of the data consisted in the exploitation of the data collected in the field concerning the diversification of the means of existence of the populations to adapt to the climate changes which impact agricultural production. These

data were processed with tools including SPSS and Excel for statistical analysis and Microsoft Word for word processing.

**3. Results**

Agriculture is the main activity of the populations in the circle of Diéma. However, food insecurity and poverty, reinforced by the negative impacts of climate change, have led to the implementation of strategies allowing the population to survive. Among these strategies is the diversification of livelihoods, which is a factor in adapting to climatic hazards and ultimately in the resilience of the population. The diversification of the means of existence developed by the populations in the circle of Diéma is divided into two main activities: activities based on natural resources and those based on non - natural resources.

### 3.1 Activities based on natural resources

Activities based on natural resources are the main sources of income for the populations in the circle of Diéma. They include agricultural production, market gardening, the provision of agricultural services, logging and the sale of livestock.

#### 3.1.1 Agricultural production

Agricultural production is a very important means of existence for the Agricultural Production Units (UPA) in the circle of Diéma. It concerns the cultivation of cereals such as *Sorghum vulgare* (sorghum), *Pennisetum typhoides* (millet), *Zea mays* (maize) and *Oryza glaberrima* (rice) and that of legumes such as *Vigna unguiculata* (cowpea) and *Arachis*

hypogaea (the 'peanut). If initially, these products constitute income in kind for agricultural holdings, they are often transformed into monetary income to meet certain needs, in particular non - food. This is done by selling mainly groundnuts and cowpeas. But, it happens that the peasants sell part of their cereals for the family expenses which corner them.

The income of UPAs through agricultural production has evolved from 1960 to 2018 (Figure 2). In fact, 64.3% of the heads of UPAs surveyed say that their income from agricultural production has decreased, a phenomenon whose onset is essentially located during the 1980s. This period is generally considered to be dry, marked above all by the drought of 1984. This rainfall deficit contributed to the drop in agricultural production. Despite the absence of food self - sufficiency for almost all farms, a large number of farmers surveyed (30.2%) are experiencing an increase in income generated by agricultural production. This began in the 1990s and intensified in the 2010s. This slight upturn in production, identified with a sign of resilience, is explained by a certain number of factors which are, among others, the improvement in rainfall amounts at from the 1990s, the reinforcement and / or the introduction of appropriate soil and water conservation techniques and the adoption of certain early varieties.

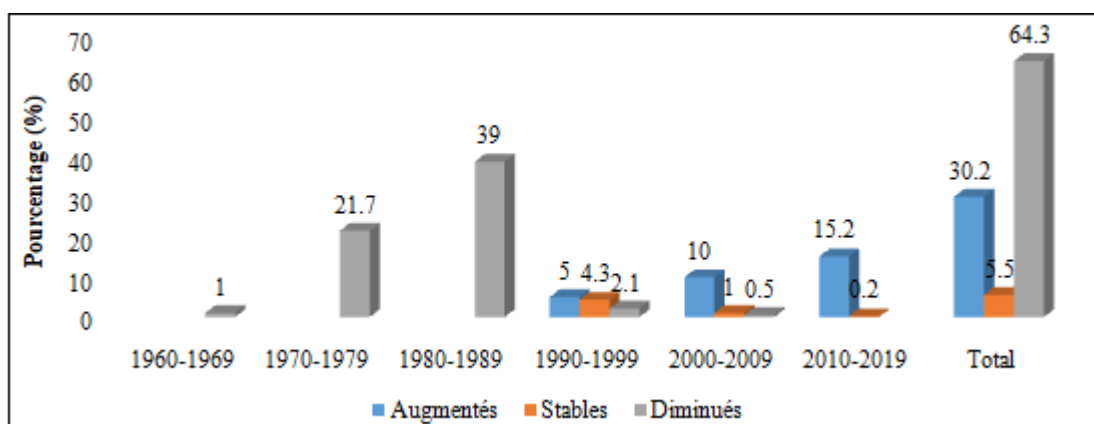


Figure 2: Evolution of income related to agricultural production between 1960 and 2019.

In general, agricultural production has declined under the effect of climate change, a reason for farmers to multiply subsidiary activities to overcome food insecurity.

#### 3.1.2 Market gardening

Market gardening is an income - generating activity and an element of the diversification of agricultural production and livelihoods. He is currently experiencing a resurgence of attention in the circle of Diéma. The market gardening activity is practiced in all the communes of the circle and in particular during the off - season period from October to June. Women, generally organized in groups, are very present in this activity. They are supported by NGOs in the context of women's empowerment and the fight against food insecurity. The gardens are located on the banks of ponds and rivers but also on other types of suitable spaces. For safety, in particular to prevent the wandering of animals, market garden sites are fenced with dead or live hedges and wire netting.

The main market garden products are tomato, pepper, cabbage, carrot, cucumber, eggplant/jaxatu, shallot and lettuce. Market gardening is considered very useful by women. Indeed, part of these products is used for family consumption, which induces a nutritional improvement and part is sold to obtain monetary income helping to meet certain expenses related to the education of children, the health of the family and the purchase of food. It is in this context that the president of a women's association with a market gardening perimeter at BEMA said: "Initially, many men were against their wives joining our association to carry out market gardening activities. But today, the perception has changed given the income generated by our activities, which has improved the living conditions of households". Therefore, market gardening is a factor in food security and the resilience of populations.

#### 3.1.3 Provision of agricultural services

To overcome the negative impacts of climate change, particularly food insecurity, one of the strategies developed by the UPAs is the provision of agricultural services. These services are divided into labor and the rental and sale of agricultural tools.

Labor is a source of income for some farmers insofar as members of an Agricultural Production Unit (UPA), on their own or family initiative, carry out work for other Agricultural Production Units in return for income in cash or in kind (cereals). Our surveys show that 65% of the heads of UPAs surveyed say that their UPAs provide agricultural labor (Table 3).

**Table 3:** Proportion of UPAs providing agricultural labor

UPA providers of agricultural labor	Number	Percentage (%)
NO	147	35
YES	273	65
Total	420	100

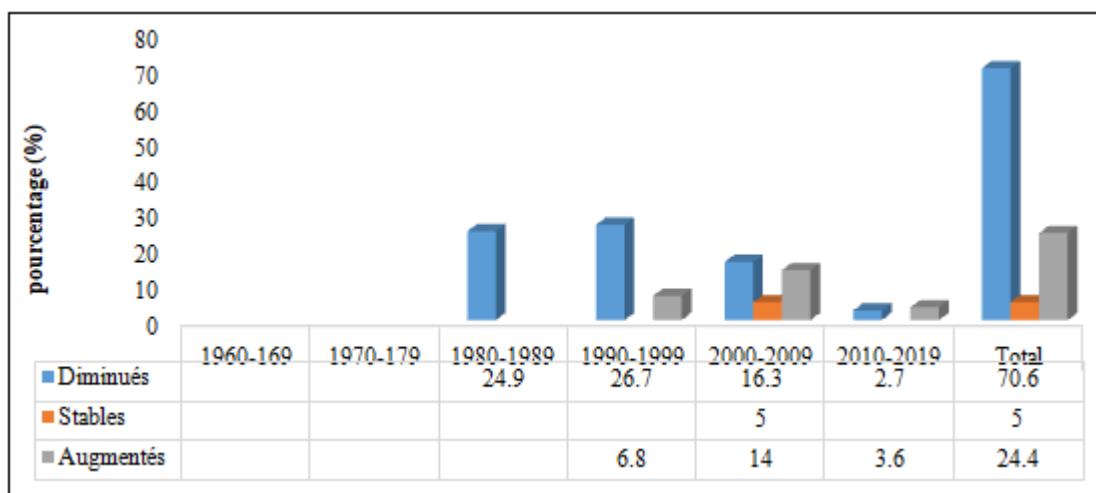
Labor is individual and collective. In fact, in addition to individual contracts (2000 CFA francs/day as the average price), associations carry out paid agricultural work. These associations are those of women, men and young people who allow their members who are very often dependent members of farms to obtain an individual income.

As for the rental and sale of agricultural tools, they also bring income to some UPAs. Indeed, tractors (15, 000 FCFA/hour), draft animals (4, 000 to 7, 500 FCFA/day) and carts are rented for operations such as plowing, harvest threshing and their transport to granaries. . Also, the sale of certain tools made in the area such as dabs, hoes, sickles, plows and carts generates income for certain UPAs. These agricultural services (rental and sale of agricultural tools) are paid for in cash or in kind.

**3.1.4 Logging**

The circle of Diéma is not a logging area par excellence because it is a Sahelian zone. Nevertheless, the populations generate income by exploiting plant resources, in particular wood, fruits and leaves.

Wood is a resource highly sought after by the UPAs who use it mainly for heating in the context of cooking and building houses. That said, all UPAs use wood or its derivatives such as coal. However, wood is a source of income for 221 out of 420 UPAs surveyed, i. e.52.6 %. Among these UPAs, those whose income from logging fell from the 1980s represent 70.6%. Income can be, within each of these UPAs, individual or collective. On the other hand, 24.4% of UPAs surveyed see their income from logging increased.



**Figure 3:** Evolution of UPA income related to logging between 1960 and 2019.

While this increase in income, boosted by the intensification of charcoal production, allows some farmers to diversify their livelihoods, it also has negative repercussions on the environment, especially since the extraction of wood does not very often respect the legality. In addition to wood, grasses are also exploited and sold as fodder, thus providing income.

As far as picking is concerned, it is an income - generating activity. These revenues, which are difficult to assess, are mainly derived from the sale of fruits, leaves and gum arabic. Baobab, jujube, date palm and tamarind fruits are the main fruits picked and sold mainly by women. In addition, baobab leaves are sold dry or fresh for human consumption.

In addition, *Acacia nilotica*, exploited for the tannery, generates significant income in the area. Also, gum arabic is

a resource exploited in the circle of Diéma whose income is not negligible for the operators.

The transformation of plant resources is done in negligible proportions and using artisanal means. For example, baobab fruit is processed into juice by women.

**3.1.5 Sale of cattle**

Given that the circle of Diéma is a breeding area par excellence, the sale of livestock is an alternative widely used by the UPAs to compensate for the decline in agricultural production. As such, breeding is an important support for the family economy. If each UPA has livestock in the circle, whatever its nature, the sale of livestock constitutes income for 385 out of 420 UPAs surveyed, i. e.92 %. Among these UPAs, 66 % have seen their income from the sale of livestock increased since the 1990s. This result is made possible thanks to a certain number of factors, including the

absence of major droughts since the end of the 1980s, livestock development strategies and access to local, regional, national and international livestock markets. Figure

4 only concerns UPAs with income related to the sale of livestock.

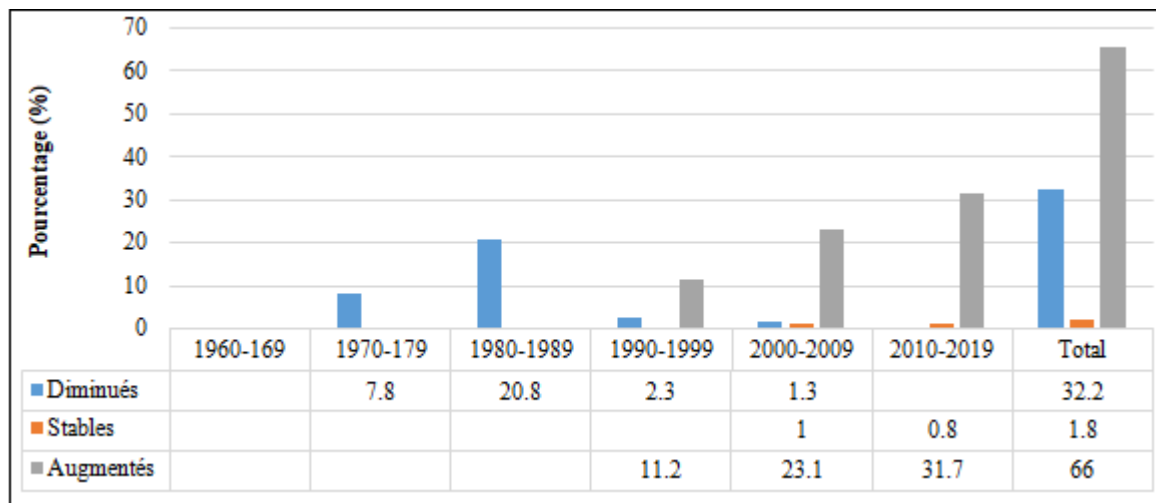


Figure 4: Evolution of UPA income related to livestock sales between 1960 and 2019

On the other hand, 32.2 % of the heads of UPAs surveyed say that their earnings from the sale of animals have decreased since the 1970s and 1980s. To adapt to these constraints, the UPAs decapitalize by selling animals during years of bad harvests and buying cattle during years of good harvests.

### 3.2 Activities based on non - natural resources

The livelihoods of farms are diversified in the circle of Diéma thanks also to activities based on non - natural resources including trade, crafts and transport.

The trade relates in particular to basic foodstuffs which are transported to the weekly markets or sold on the spot. As for crafts, it generates income mainly from the sale of jewelry. As far as transport is concerned, members of certain UPAs work in this field as drivers, counter clerks or couriers.

Income from these activities does not necessarily belong to the entire Agricultural Production Unit. They are very often owned and managed by dependent households who pay, as they see fit, a contribution in cash or in kind to the head of the UPA to meet certain needs, particularly food and social needs, of the whole group.

## 4. Discussion

The results of this research show that the diversification of livelihoods is one of the strategies put in place by the populations in the circle of Diéma to adapt to climate change. Other studies have emphasized the importance of livelihood diversification such as that of [10] which considers livelihood diversification as a tool for sustainable agriculture.

Our results substantiate the conclusions of [11] who asserted that livelihood diversification is complex and can help families to protect themselves from economic and environmental shocks, thus managing to be less vulnerable.

The diversification of livelihoods in the circle of Diéma is based on two main types of activities: activities based on natural resources and those based on non - natural resources.

Activities based on natural resources in the circle of Diéma are numerous. Income (money or nature) related to these activities has evolved. Indeed, our surveys show that 30.2% of UPA heads surveyed are experiencing an increase in income generated by agricultural production, market gardening is currently experiencing renewed attention, 65 % of UPA surveyed are labor providers agricultural work. Within the framework of the provision of agricultural services, wood (by - products included) constitutes a source of income for 52.6 % of surveyed UPAs. These results corroborate those obtained by [12] which indicates that the diversification of livelihoods, a key response to environmental changes that have affected the viability of traditional livelihoods. In addition, the sale of livestock constitutes an income for 92 % of the UPAs surveyed in the circle of Diéma. This goes in the direction of the results obtained by [13] who affirmed that the populations practice livestock breeding in addition to their main activity in Madagascar.

However, contrary to our results, according to some authors, the development of activities based on non - natural resources can negatively affect activities based on natural resources in the context of the diversification of livelihoods. Thus, for [14], the diversification of livelihoods could lead to marginalization or even abandonment of agricultural activity by households.

## 5. Conclusion

This research aims to analyze the diversification of livelihoods as a measure of adaptation to climate change in the circle of Diéma. To do this, a mixed methodology was used. Thus, the questionnaire was administered to collect quantitative data and the interview guide for qualitative data.

Thus, this study shows that the diversification of activities and sources of income is a reality in the circle of Diéma to overcome the harmful impacts of climate change, particularly food insecurity. It is based on two main types of activities: activities based on natural resources and those based on non - natural resources.

However, if many Agricultural Production Units diversify their sources of income, it must be recognized that the values of these incomes are experiencing a regressive evolution. This means that the diversification of livelihoods is, for the moment, a means of survival rather than wealth for the populations.

Moreover, it is relevant to extend the research on other measures of adaptation to climate change in the circle of Diéma and in general in the Sahel to have a broad information. This makes it possible to put in place corrective measures in the execution of programs and projects on climate change.

## References

- [1] IPCC (2007).2007 assessment of climate change. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R. K. and Reisinger, A. (edited by~) ]. IPCC, Geneva, Switzerland, 103 pages.
- [2] IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edited by the main writing team, R. K. Pachauri and L. A. Meyer]. IPCC, Geneva, Switzerland, 161 p.
- [3] Terdiman M. (2007). Environmental security, climate change and conflicts: the case of Darfur. *Outre - Terre*, no.20, p.141 - 150.
- [4] ECOWAS and SWAC (2008). The climate and climate change. Atlas of Regional Integration in West Africa, Environment Series, 24 p.
- [5] MAAF (2014). Agricultural policies around the world: some examples. Collection of country sheets, Ministry of Agriculture, Food and Forestry (France), 6 p.
- [6] PDA (2013). Agricultural Development Policy of Mali (). Provisional document, Republic of Mali, 39 p.
- [7] LAW N°06 - 40/AN - RM of August 16, 2006 on the Agricultural Orientation Law (LOA). Mali, 24 p.
- [8] MET (2007). National Action Program for Adaptation to Climate Change. Bamako (Mali), 100 p.
- [9] PDESC (2009). Economic, Social and Cultural Development Program of the Circle of Diéma 2010 – 2014. Region of Kayes (Mali), 28 p.
- [10] Nahal I. (1998). Principles of sustainable agriculture. Editions ESTEM, ISBN 284371 0286, 121 p.
- [11] Neely C., Sutherland K. and Johnson J. (2004). Do sustainable livelihoods approaches have a positive effect on rural poverty? Livelihoods Support Program Working Paper 16, FAO, 65 p.
- [12] UNDP (2019). Beyond incomes, averages and the present: inequalities in human development in the 21st century. Human Development Report 2019, New York, NY 1007 United States: UNDP, 29 p.
- [13] Ranaivomanana L. (2013), Livelihood Diversification Study in Madagascar 2013. Report/Rapport: SF - FAO/2013/26. FAO - SmartFish Program of the Indian Ocean Commission, Ebene, Mauritius.
- [14] Rigg J. (2005). Land, farming, livelihoods and poverty: rethinking the links in the rural south. *World Development*, p.180 - 202.