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Climatic disasters in Burkina Faso from 1960 to 2020: Occurrence, Spatio-temporal dynamics and Socio-environmental consequences

[1]YAMÉOGO Joseph, [2]ROUAMBA Songanaba

[1]Norbert ZONGO University, Department of Geography, Koudougou, Burkina Faso
josephyameogo10@gmail.com

[2]Norbert ZONGO University, Department of Geography, Koudougou, Burkina Faso
songanaba@gmail.com

ABSTRACT

Context and background

Climate variability is a reality in Burkina Faso, and climatic disasters are the visible effects. This poses huge challenges for governments and local populations alike. However, it is difficult to implement any real policy without understanding the phenomenon and its social and environmental consequences. Consequently, the main hypothesis of the study is that natural disasters are dynamic and therefore cause socio-environmental problems in the country.

Goal and Objectives:

The main objective of the study is to analyze climate-related disasters in Burkina Faso between 1960 and 2020 and their socio-environmental impacts. This involves analyzing the dynamics of climatic disasters between 1960 and 2020, identifying the areas affected by climatic disasters and analyzing the socio-environmental impacts of climatic disasters.

Methodology:

The study is based on combining quantitative and qualitative methods.

Results:

The results show that droughts and floods are the main climatic disasters in Burkina Faso over the period 1960-2020, although a succession of droughts (57.14%) and floods (42.86%) was observed over the period 1960-1999. Conversely, there were more floods than droughts over the period 2001-2020. Furthermore, the socio-environmental and territorial impact of climatic disasters varies according to Burkina Faso's climatic zones. In addition, many waterworks have been destroyed, with negative external effects on the environment. In view of these results, the government of Burkina Faso would be well advised to review the specifications for the country's waterworks in order to adapt them to the new conditions. In addition, the agricultural seeds promoted by Burkina Faso's agronomic research institutes should be geared towards seeds that can adapt to water. This will reduce the impact of climate disasters in the years to come.

Keywords:

Climatic disasters, spatial dynamics, socio-environmental consequences, Burkina Faso

1. INTRODUCTION

The number of climate-related disasters, including floods, storms, droughts and heatwaves, is increasing worldwide (Thomas & López, 2015). Floods and storms were the most frequent disasters worldwide between 1998 and 2017 (Koubi, 2019). In Africa, disasters depend on hydrological (floods), meteorological (extreme temperatures) and climatological (drought) phenomena (Osman-Elasha, 2012). According to Tramblay et al. (2020), floods are a major natural hazard in Africa, causing more than 27,000 deaths between 1950 and 2019.

In West Africa, changes in rainfall behaviour brought about by climate change are leading to more extreme rainfall events, which in turn are leading to more climatic disasters, particularly floods (Tabari, 2020; Engel et al., 2017; Sylla et al, 2016; Nka et al, 2015; Panthou et al, 2014; Ly et al, 2013). Benin, Burkina Faso, Niger and Senegal all experienced major floods in 2009 (Salack et al., 2018). Sahelian West Africa also experienced droughts between 1950 and 2000 (Lu & Delworth, 2005). In addition, simulation models predict that droughts will occur in the coming years (Held et al., 2005).

The prevention and reduction of loss and damage caused by climate-related disasters is an urgent issue for the international community, particularly in the context of negotiations on disaster risk reduction (Birkmann & Welle, 2015). This is why it is important for governments in developing countries to understand the types of climate-related disasters that occur in their countries and their spatial, social and environmental scale. This could lead them to take action in their respective countries. The study focused on Burkina Faso; a developing country located in West Africa. The aim of the study is to analyze climatic disasters and their socio-environmental consequences in Burkina Faso.

2. DATA AND METHOD

2.1 Geographical location

Burkina Faso is located in Sudano-Sahelian West Africa. The country is subdivided into regions (Figure 1).

The country is crossed by three (03) climatic zones: the Sudanian zone, the Sudano-Sahelian zone and the Sahelian zone (Figure 2). The country's population was 20,505,155 in 2019, according to the Recensement Général de la Population et de l'Habitation du Burkina Faso, 2019.

2.2 Data

- Secondary data

They come from EM-DAT, which contains data on the occurrence and impact of more than 26,000 disasters worldwide, from 1900 to the present day. Sources include United Nations agencies, non-governmental organisations, reinsurance companies, research institutes and news agencies. The data is made available free of charge by the Centre for Research on the Epidemiology of Disasters (CRED).

To access the data, you need to go to their website: https://public.emdat.be/, then register before accessing the data. The data are classified according to two (02) groups of disasters: natural (climatic) and technological. Each type of disaster is associated with sub-groups and types of disaster.

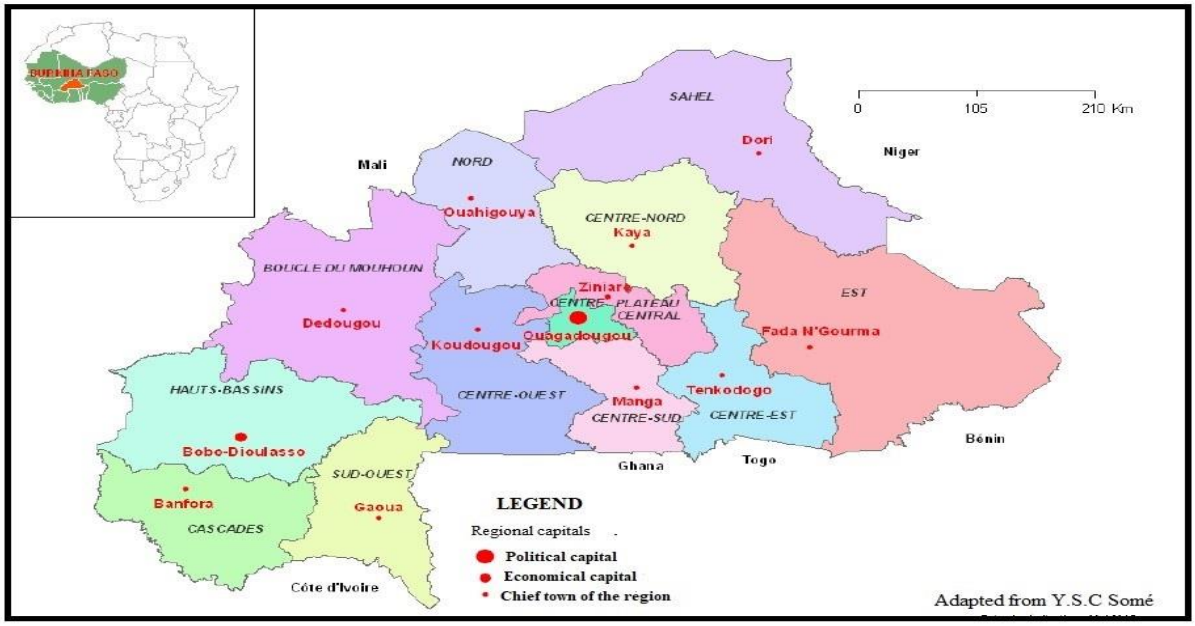

Fig. 1: Location of the study area

For this study, the natural (climatic) group and the climatology and hydrology subgroup were recommended. Consequently, the types of disaster listed are drought (climatology subgroup) and flooding (hydrology subgroup) (table 2).

Table 2: Groups, sub-groups and types of disasters

Group	Sub-Group	Type	Sub-Type
Natural	Hydrological	Flood	Coastal flood
			Riverine flood
			Flash flood
	Climatological	Drought	Drought

Source : https://public.emdat.be/about

The data period extends from 1960 to 2020, which is justified by the fact that Burkina Faso has experienced several climatic trends during this period. This makes it possible to assess the occurrence of different types of disasters in the country.

- Primary data

This is survey data. Three localities (Villy-centre, Poni, Dassa) (central-western Burkina Faso) were selected whose dams had collapsed following flooding. A total of 100 households (or 40%) living near the dams were interviewed during the period 2021-2023. The surveys focused on the socio-environmental consequences of disasters (floods). The focus was on climatic disasters such as floods, as their frequency has increased in recent decades. The choice of three locations in the Centre-West region can be explained by the fact that it is difficult to travel to other parts of Burkina Faso due to terrorism, and we therefore chose this region for its relative safety. The surveys were supplemented

by interviews with non-governmental organisations such as Action Micro-Barrage (AMB), which has built around 30 dams in the central-western and northern regions of Burkina Faso. Observation was also used to get a feel for the realities on the ground.

2.3. Data processing method

This is based on descriptive statistics and spatial analysis. Two software packages were used, Excel spreadsheet and QGIS.

3. RESULTS

3.1. Typology and frequency of climate-related disasters from 1960 to 2020

There are two types of climate-related disasters: droughts and floods. The occurrence of these climate-related disasters varies over the period 1960-2020. In fact, climate-related disasters are characterized by two periods: 1960-1999 and 2001-2020. The assessment of the dynamics of climate-related disasters during these two periods is based on the predominance of the type of climatic disaster and on the frequency of disasters.

- The period 1960-1999: Burkina Faso's drought-flood binomial period

During this period, droughts and floods alternated with an increase in the frequency of droughts (Table 3).

Table 3: Alternation of droughts and floods in the period 1960-1999

Year of occurrence of the climatic disaster	Disaster Group	Disaster Subgroup	Disaster Type	Disaster Sub-type
1966	Natural	Climatological	Drought	Drought
1969	Natural	Climatological	Drought	Drought
1976	Natural	Climatological	Drought	Drought
1977	Natural	Hydrological	Flood	-
1980	Natural	Climatological	Drought	Drought
1984	Natural	Climatological	Drought	Drought
1985	Natural	Hydrological	Flood	-
1988	Natural	Hydrological	Flood	-
1988	Natural	Climatological	Drought	Drought
1990	Natural	Climatological	Drought	Drought
1994	Natural	Hydrological	Flood	-
1995	Natural	Climatological	Drought	Drought
1998	Natural	Hydrological	Flood	Riverine flood
1999	Natural	Hydrological	Flood	Flash flood

Source: ED-MAT, Burkina Faso, 1966-1999; :-: no information

Fourteen (14) climatic disasters (droughts, floods) were reported during the period 1960-1999, with droughts being the dominant climatic disaster with 57.14% against 42.86% for floods. Moreover, the dynamics of disasters are low, with only fourteen (14) disasters recorded over 39 years (1960-1999). However, it was high in the 1980s and 1990s, when the frequency of disasters ranged from one or two years to four years. This means that people suffered more from climatic disasters during this period.

- The period 2001-2020: a time of floods in Burkina Faso

In contrast to the period 1960-1999, the current period (2001-2020) shows a higher occurrence of flooding in the country (table 4).

Table 4: Continuing rise in the occurrence of floods in Burkina Faso between 2001 and 2020

Year of occurrence of the climatic disaster	Disaster Group	Disaster Subgroup	Disaster Type	Disaster Subtype
2001	Natural	Climatological	Drought	Drought
2003	Natural	Hydrological	Flood	Riverine flood
2006	Natural	Hydrological	Flood	Flash flood
2006	Natural	Hydrological	Flood	Riverine flood
2007	Natural	Hydrological	Flood	Riverine flood
2008	Natural	Hydrological	Flood	Flash flood
2008	Natural	Hydrological	Flood	Riverine flood
2009	Natural	Hydrological	Flood	Riverine flood
2009	Natural	Hydrological	Flood	Riverine flood
2010	Natural	Hydrological	Flood	Riverine flood
2011	Natural	Climatological	Drought	Drought
2012	Natural	Hydrological	Flood	Riverine flood
2013	Natural	Hydrological	Flood	Riverine flood
2014	Natural	Climatological	Drought	Drought
2015	Natural	Hydrological	Flood	Riverine flood
2016	Natural	Hydrological	Flood	Riverine flood
2017	Natural	Hydrological	Flood	-
2020	Natural	Climatological	Drought	Drought
2020	Natural	Hydrological	Flood	-
2020	Natural	Hydrological	Flood	-
2020	Natural	Hydrological	Flood	-

Source: ED-MAT, Burkina Faso, 2001-2020; -: no information

The table shows the overwhelming dominance of floods. In fact, floods account for 80.95% of compared to 19.05% for droughts. However, riverine floods (80%) are more frequent than flash floods (20%). Moreover, the frequency of climatic disasters is very high, as they occur every year (Table 4). As a result, people are constantly suffering the horrors of climatic disasters (especially rain floods).

3.2. Spatio-temporal dynamics of areas affected by climatic disasters in Burkina Faso

Over the period 1960-2020, the country experienced 35 climatic disasters (drought, flooding). The occurrence of these disasters has had a differentiated spatial footprint across the country. The period 1960-1999 showed that the northern and Sahel regions, and to a lesser extent the central region, were more affected by drought, while the Boucle du Mouhoun and Cascades regions were affected by flooding (fig.2, fig.3, fig.4, fig.5). The years 1994 and 1995 did not provide any information on the regions affected by disasters, hence their absence from the spatialization of the areas affected during those years.

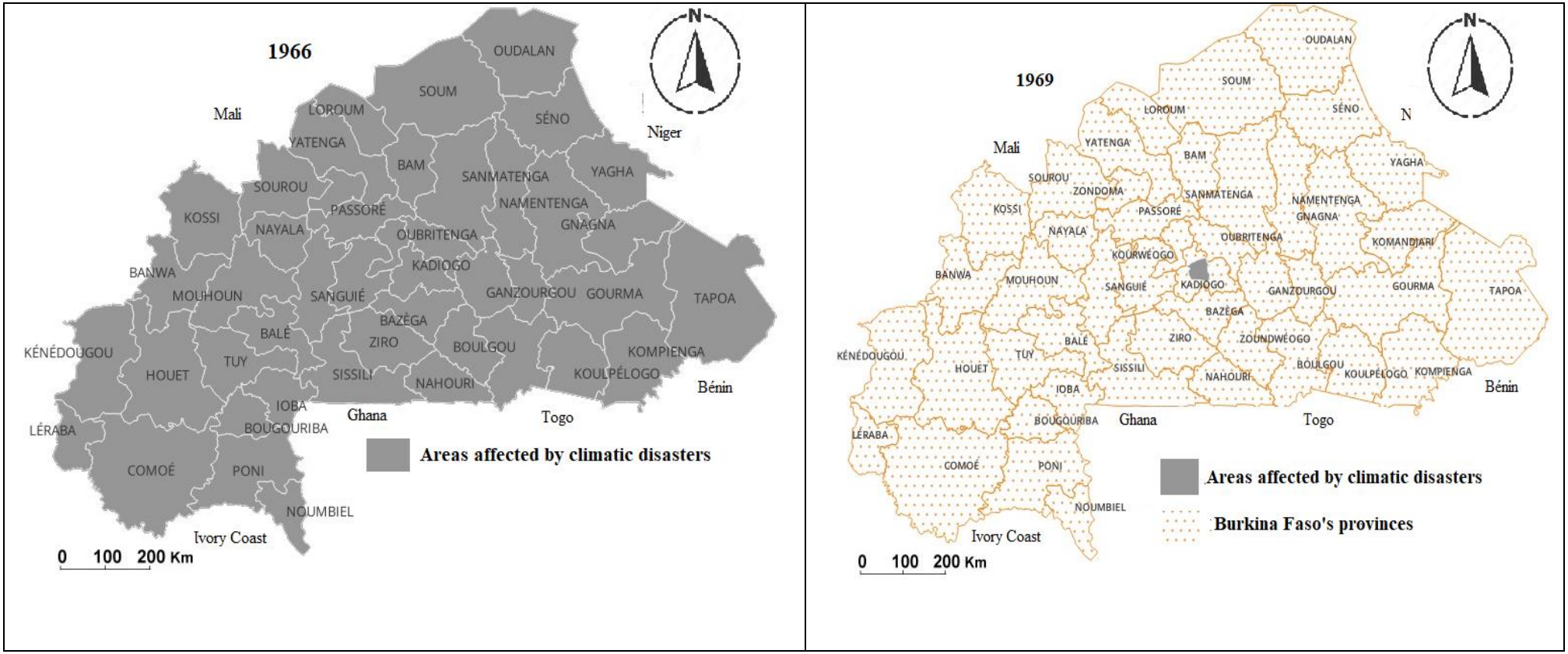

Fig. 2 : Spatial dynamics of areas affected by climatic disasters between 1966 and 1969

Source: ED-MAT, Burkina Faso, 1966-1969

This figure shows that all regions of Burkina Faso were affected by climatic disasters in 1966. In 1969, however, only the Kadiogo region was affected. The climatic disasters were droughts.

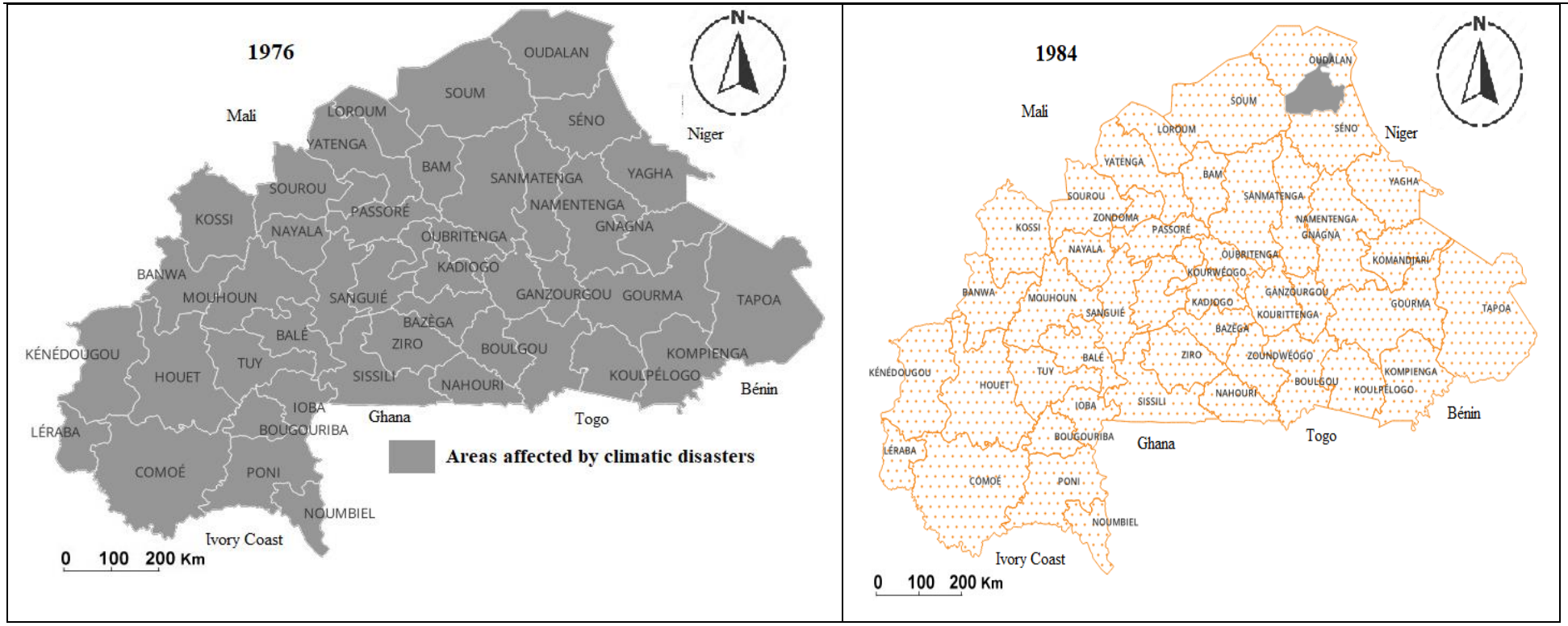

Fig. 3: Spatial dynamics of areas affected by climatic disasters between 1976 and 1984

Source : ED-MAT, Burkina Faso, 1976-1984

The figure shows that all regions of the country were affected by drought in 1976, and only Gorom-Gorom in 1984.

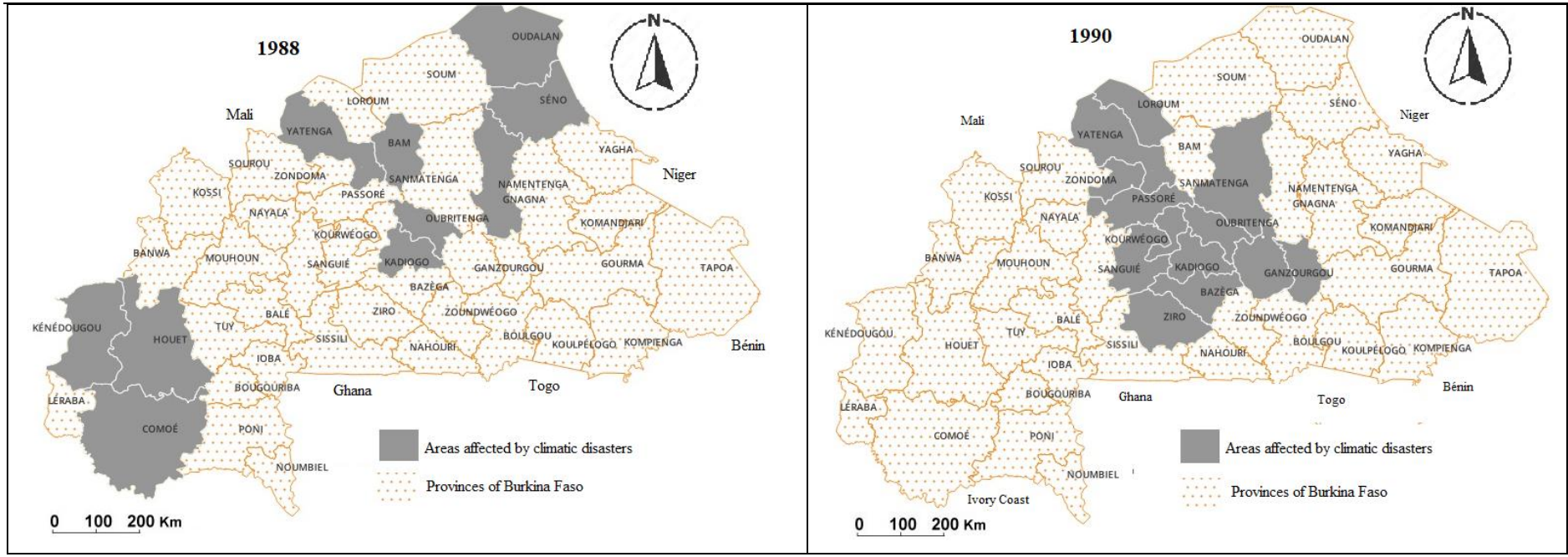

Fig. 4 : Spatial dynamics of areas affected by climatic disasters between 1988 and 1990

Source: ED-MAT, Burkina Faso, 1988-1990

In 1988, it was the provinces of the Sahel, the North, and the Cascades were affected by climatic disasters such as drought. In 1990, droughts affected parts of the northern and central regions.

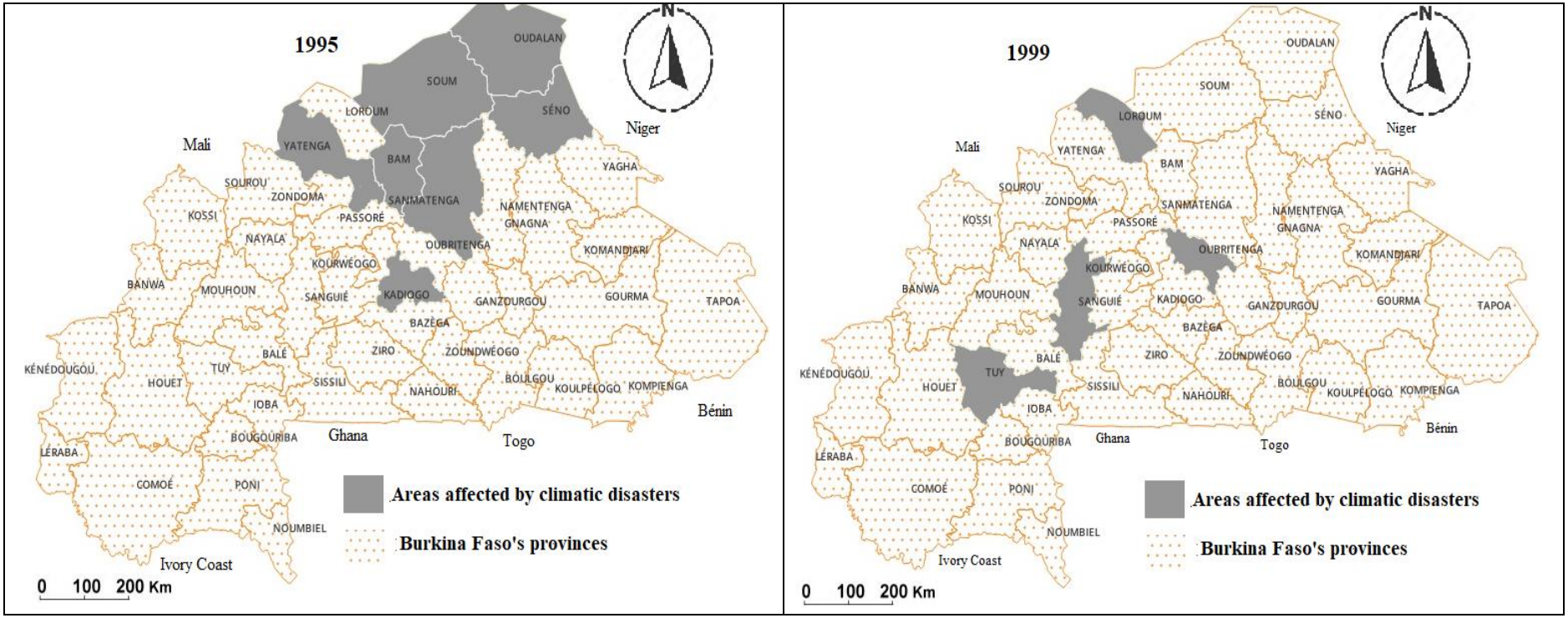

Fig. 5: Spatial dynamics of areas affected by climatic disasters between 1995 and 1999

Source: ED-MAT, Burkina Faso, 1995-1999

The figure shows that floods occurred in the Sahel, the North, and the Centre, while for the period 1999, the spatial distribution varied between several regions (Centre-West, Cascades, North).

Conversely, over the period 2001-2020, climatic disasters affected the Boucle du Mouhoun, Cascades and Hauts-Bassins regions, and to a lesser extent the north, centre, centre-west and east regions (Fig.6, fig.7, fig.8, fig.9, fig.10, fig.11, fig.12). However, between 2008 and 2015, the spatial extent of the areas affected increased, as shown by the years 2008, 2009, 2011 and 2012, when a large part, if not all, of the country was affected by climatic disasters.

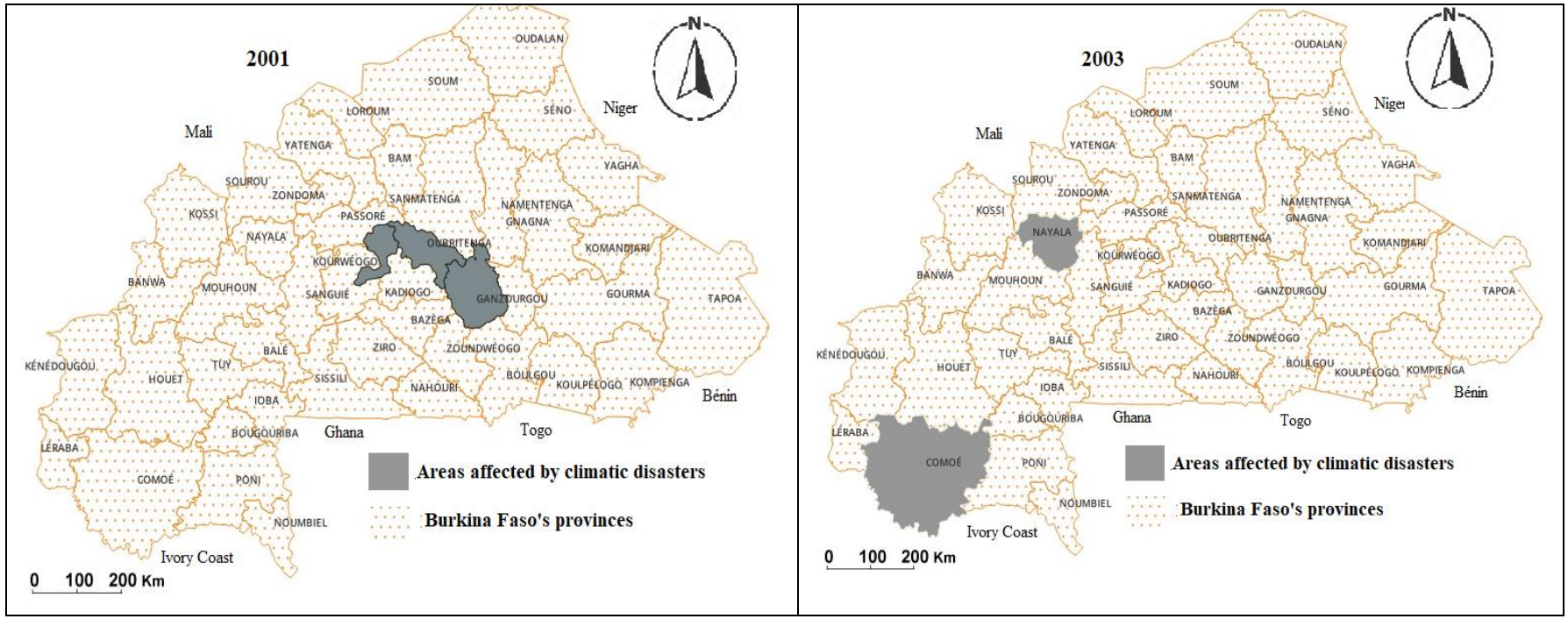

Fig. 6: Spatial dynamics of areas affected by climatic disasters between 2001 and 2003

Source: ED-MAT, Burkina Faso, 2001-2003

In this figure, the Central Plateau, a part of the Cascades region and the Boucle du Mouhoun were affected by floods between 2001 and 2003.

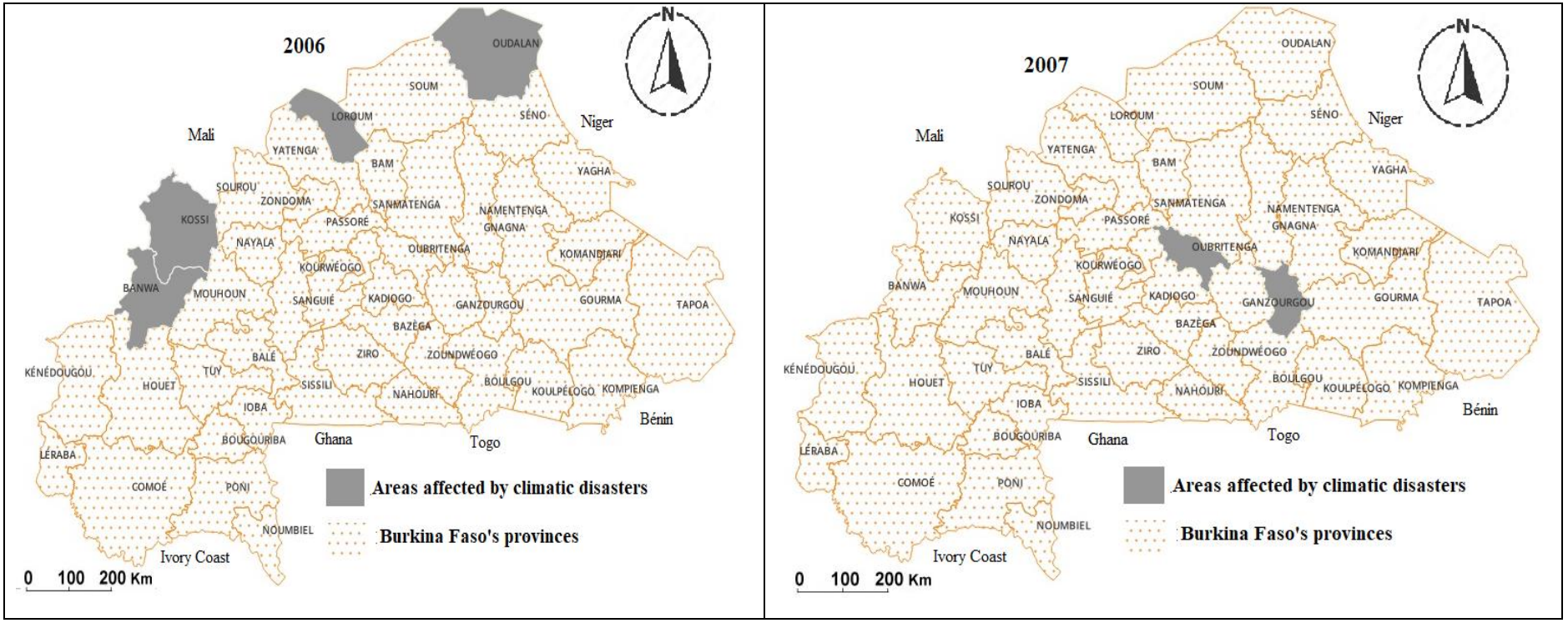

Fig. 7: Spatial dynamics of areas affected by climatic disasters between 2006 and 2007

Source: ED-MAT, Burkina Faso, 2006-2007

In 2006-2007, floods affected parts of the Sahel, North, Boucle du Mouhoun and Center-East.

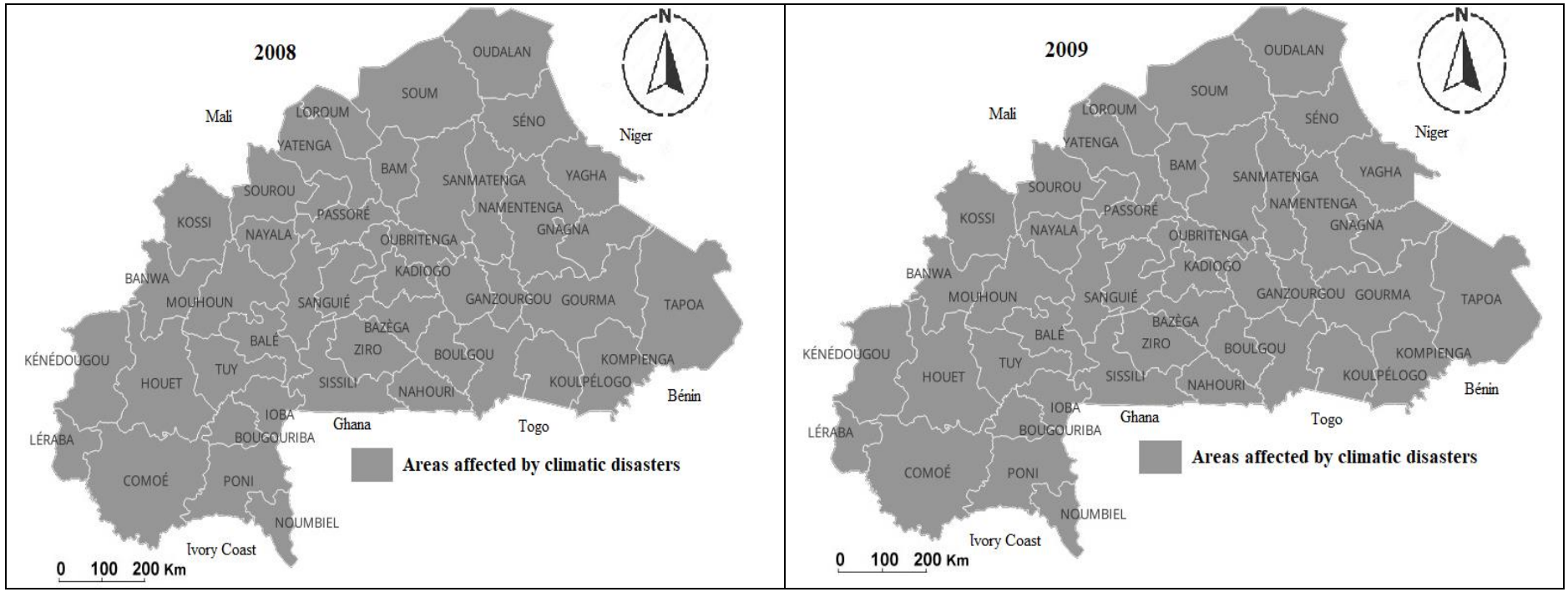

Fig. 8: Spatial dynamics of areas affected by climatic disasters between 2008 and 2009

Source: ED-MAT, Burkina Faso, 2008-2009

In the period 2008-2009, the spatial distribution of the floods was harmonious all over the country.

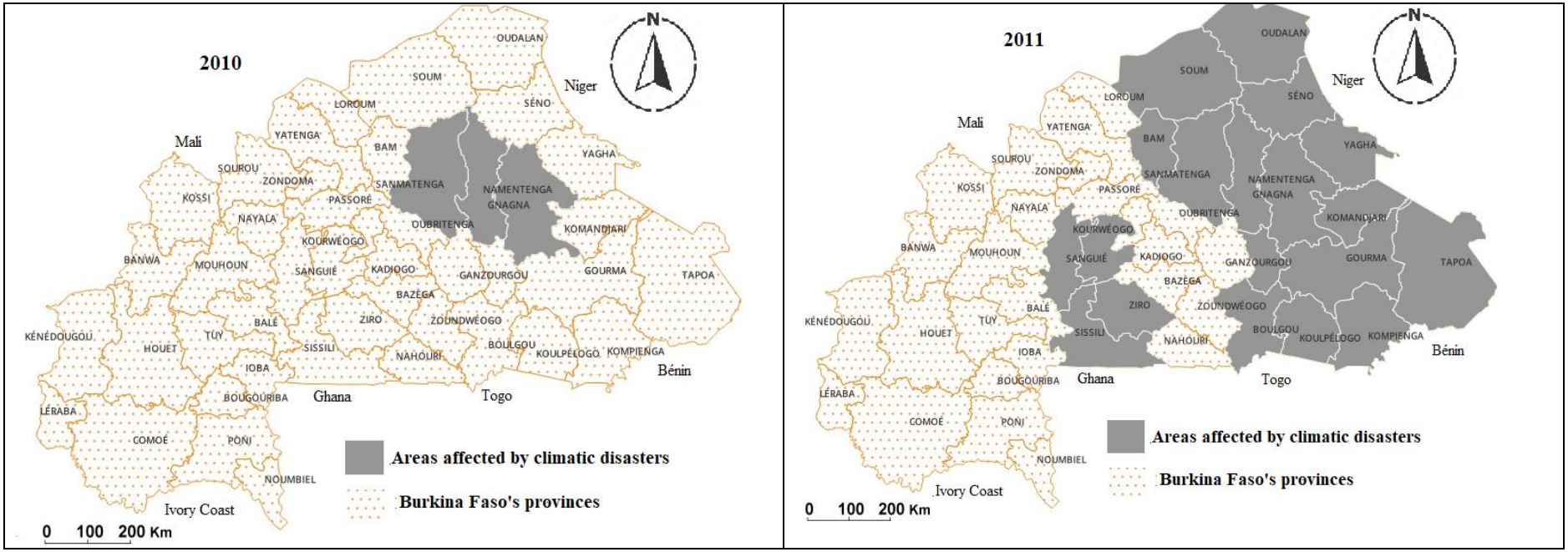

Fig. 9: Spatial dynamics of areas affected by climatic disasters between 2010 and 2011

Source: ED-MAT, Burkina Faso, 2010-2011

However, the 2010-2011 period saw an uneven spatial distribution of flooding across the country. In 2010, some of the northern and eastern regions were affected by flooding. In 2011, on the other hand, flooding tended to affect the Sahel and the northern, eastern and central-western regions of Burkina Faso.

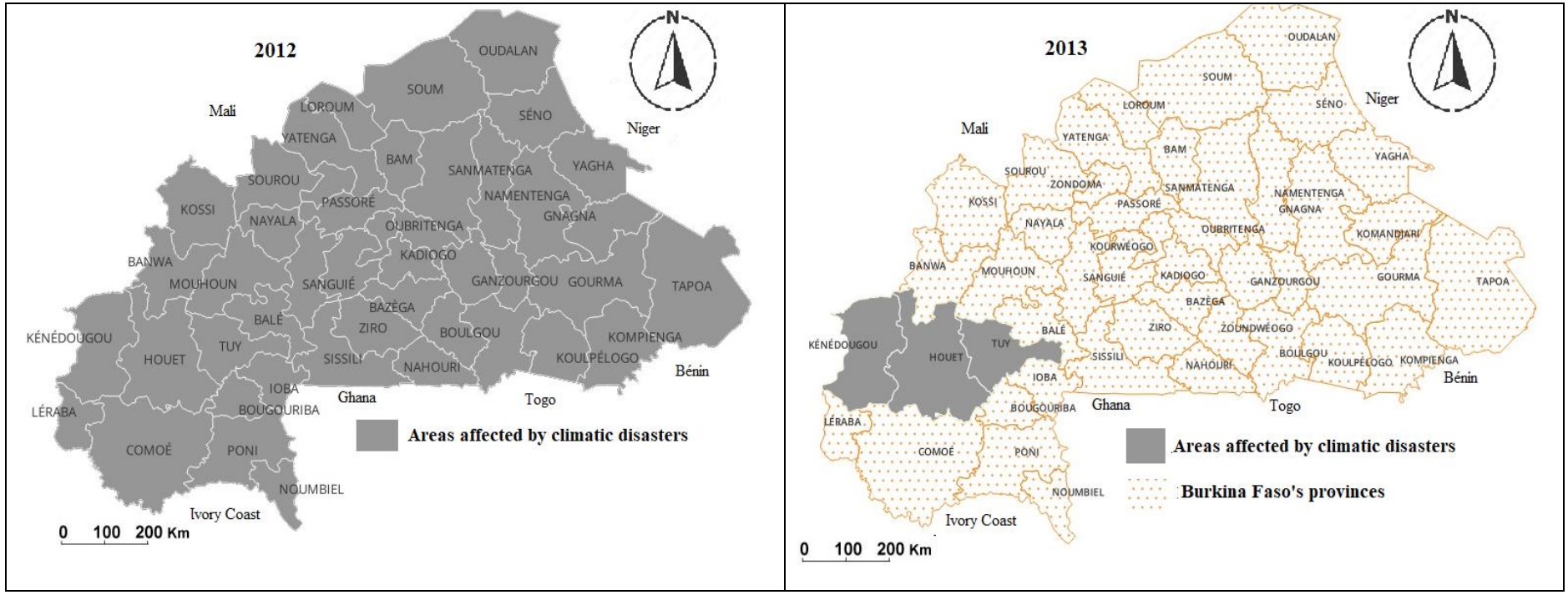

Fig. 10: Spatial dynamics of areas affected by climatic disasters between 2012 and 2013

Source: ED-MAT, Burkina Faso, 2012-2013

The figure shows the floods that affected all regions of the country in 2012. The Scacades region was affected in 2013.

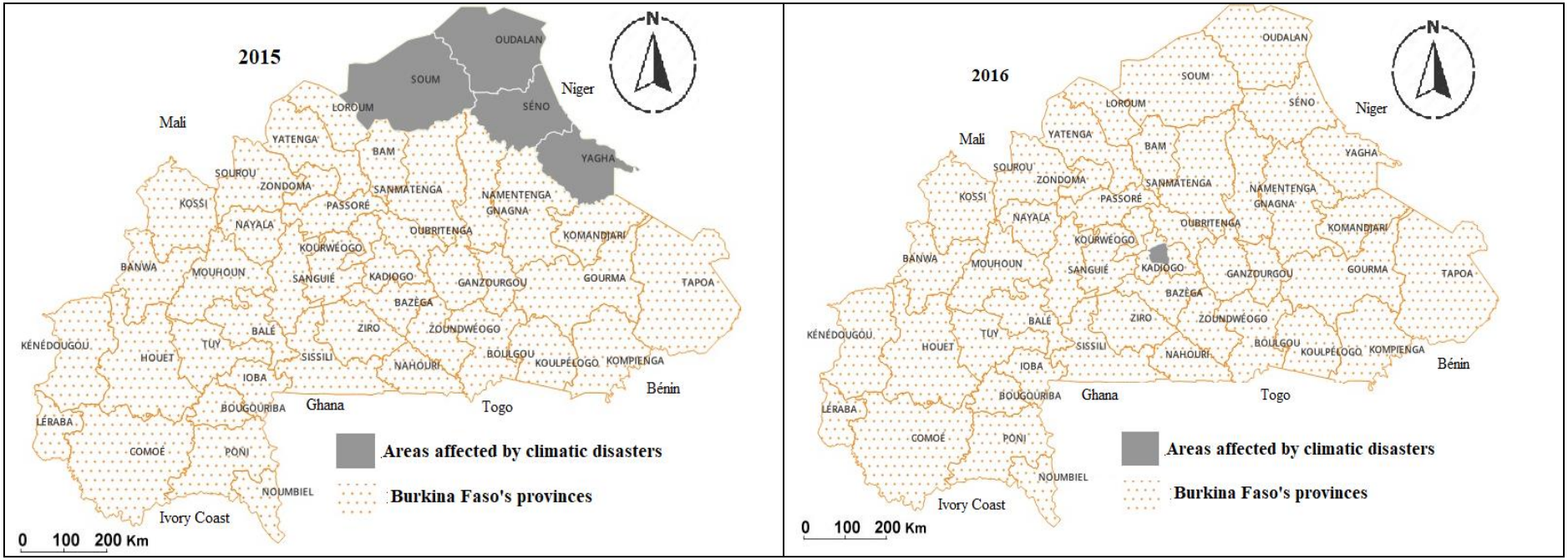

Fig.11: Spatial dynamics of areas affected by climatic disasters between 2015 and 2016

Source: ED-MAT, Burkina Faso, 2015-2016

The figure shows that only two regions, the Sahel and the Central, experienced floods between 2015 and 2016.

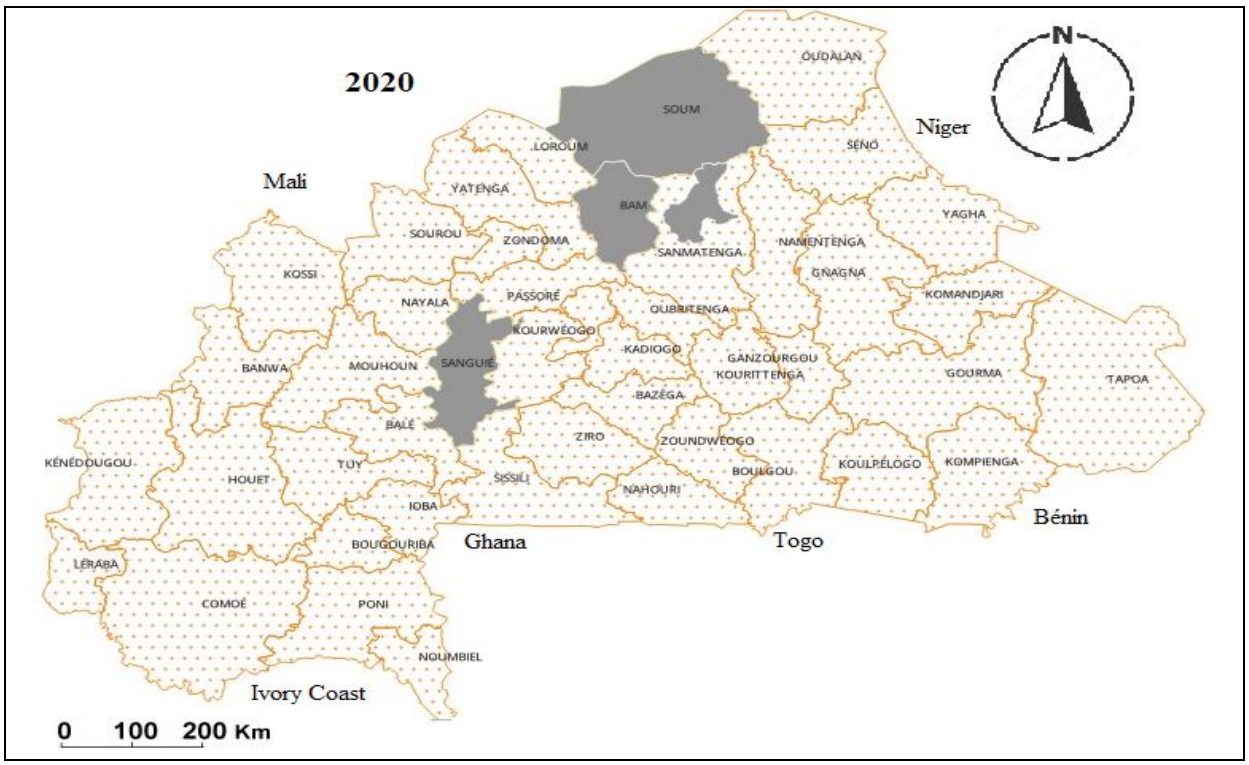

Fig.12: Spatial dynamics of areas affected by climatic disasters between 2020

Source: ED-MAT, Burkina Faso, 2020

3.3. Socio-environmental consequences of climate-related disasters

The consequences can be observed over the periods 1960-1999, and 2001-2020. Over the 1960-2020 period, the occurrence of climatic disasters led to famines in 1969 and crop failures in 1988. Food shortages were recorded in 1995 and 1998. Figure 13 below shows that several thousand populations are affected.

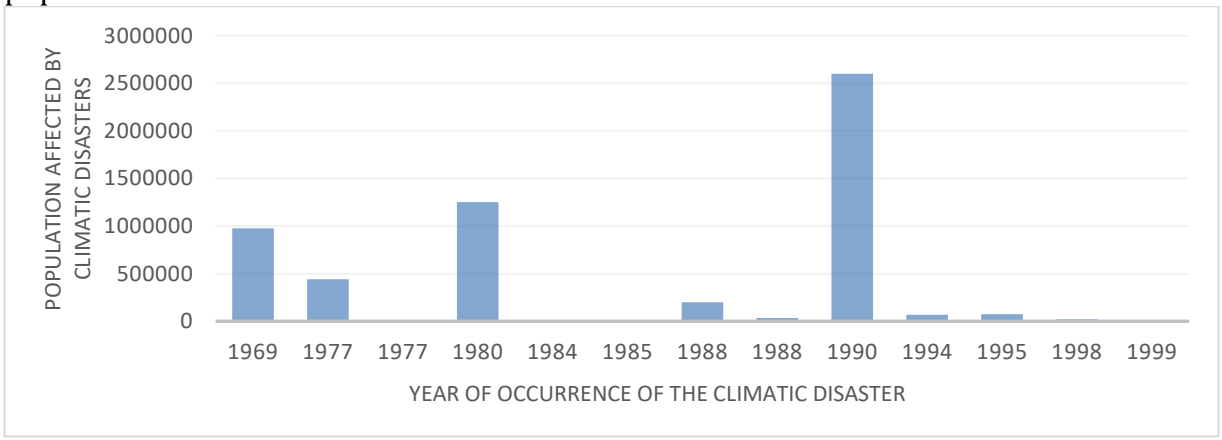

Fig.13: Population affected by climatic disasters between 1960 and 1999

Source: ED-MAT, Burkina Faso, 1966-1999

Over the period 2001-2020, climatic disasters, in this case floods, caused dam failures in 2006 and 2010 in the country. In addition, there were food shortages in 2011, 2014 and 2020. Several million people were affected by flooding over this period (figure 14).

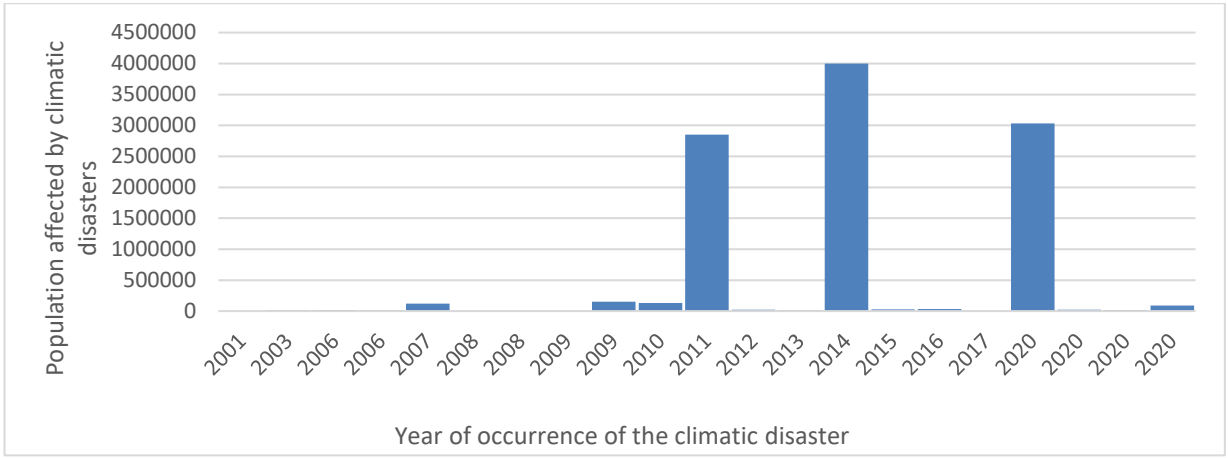

Fig.14: Population affected by climate-related disasters between 2001 and 2020

Source: ED-MAT, Burkina Faso, 2001-2020

Several dams in the country have burst, most notably in 2006 and 2010. Dam failures lead to eutrophication of the water and the cessation of horticultural activities around the dams. The case of the Poni dam, Dassa in the province of Sanguié and Villy-centre in the province of Boukiemdé in the centre-west of Burkina Faso, is instructive. The failure of the dam led to the eutrophication of the reservoir (water lilies on the surface) (photo 1).

Photo 1: The eutrophication of the dam after the breach has occurred
Source: Photo shooting, Joseph Yaméogo, 14/09/2023

The breaching of the dam has led to the abandonment of market garden plots near the dam (photo 2).

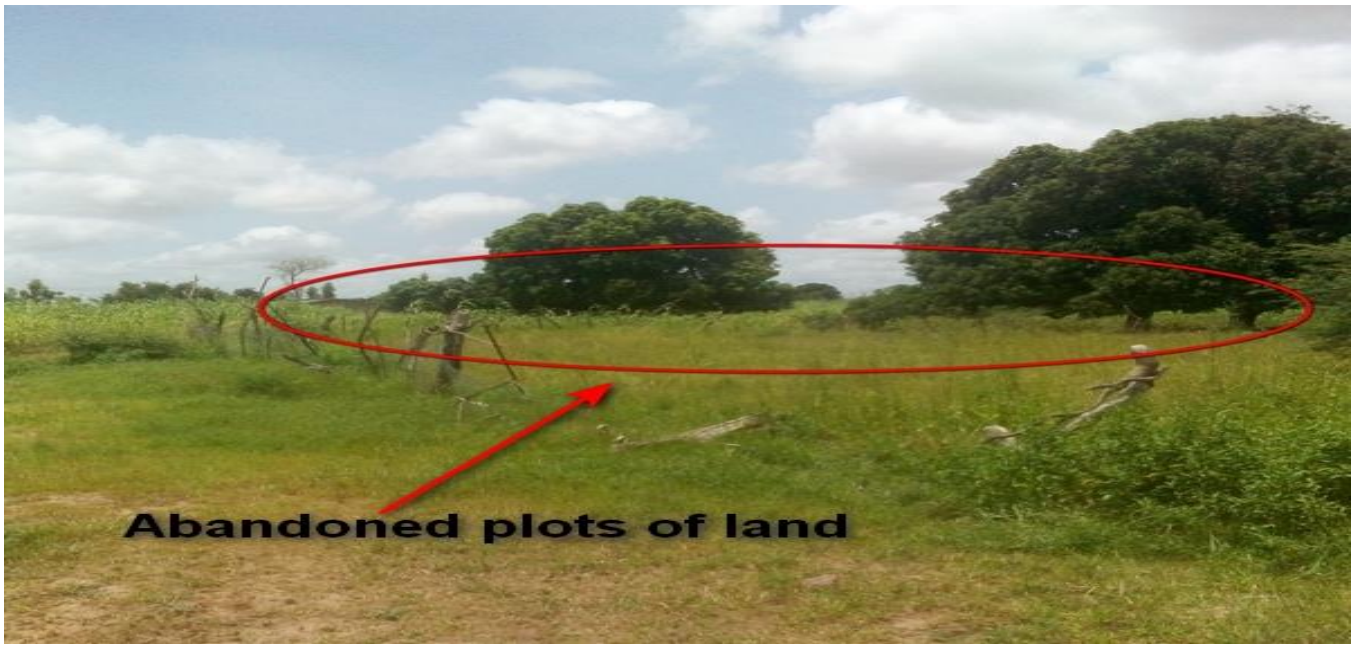

Photo 2: Plots abandoned after dam burst
Source: Photo shooting, Joseph Yaméogo, 14/09/2023

This creates socio-economic problems in the villages, particularly in the localities of Villy-center, Dassa and Poni in the central-western region of the country (table 5).

Table 5: The problems caused by flooding for people living near dams

Dam	Province	Socio-economic problems	Frequency of citations
Villy-Center	Boulkiemdé	Rice production stopped	10%
		Abandoned plots of land	2%
		Vegetable production requires less water	30%
		Lower income	30%
		Food problems during the year	28%
Dassa	Sanguié	Rice production stopped	5%
		Abandoned plots of land	5%
		Vegetable production requires less water	20%
		Lower income	50%
Poni	Sanguié	Food problems during the year	20%
		Rice production stopped	13%
		Abandoned plots of land	20%
		Vegetable production requires less water	12%
		Lower income	50%
		Food problems during the year	5%

Source: Field surveys, 2021-2023

4. Discussions

4.1. Variability of climatic disaster types in Sahelian West Africa

The evolution of climatic disasters varies from period to period. Between 1960 and 1999, droughts and floods occurred throughout Burkina Faso. However, over the period 2001-2020, floods have supplanted droughts and become dominant in the country. This situation could be explained by the changing nature of rainfall in Burkina Faso. In fact, the 1970s and 1980s were periods of climatic deterioration in Sahelian West Africa, and in Burkina Faso (Ouédraogo, 2001), while the period 2000

to 2020 saw an upturn in rainfall in Burkina Faso (Yanogo & Yaméogo, 2023). This situation led to both droughts in the period 1960-1999, and floods in the period 2001-2020. The same trends were noted between 1901 and 2014 in Sahelian West Africa. Indeed, the worst droughts of the twentieth century in the Sahel occurred between 1982 and 1985, while between 2005 and 2015, drought episodes and their intensities decreased to make way for wet periods over the Sahel (Ndehedehe et al., 2020). The recurrence of drought periods between 1960 and 1999 in the study area is also part of an overall movement in the 1960s. Indeed, the change in rainfall in the Sahel took place during the 1960s, culminating in the 1970s and 1980s (Batterbury & Warren, 2001). For Hulme, 2001, the trend towards drought in the region began long before independence. In fact, periods of drought occurred in the 1930s to 1950s and continued in the decades from 1970 to 1990. It's only natural that the period 1960-1990 should see climatic disasters (notably droughts), as the trend in rainfall is downward during this period. The return of moisture to the Sahel that took place almost in the 2000s ushers in a phase of humidity in the region (Odoulami and Akinsanola, 2018; Biasutti, 2019). This period of humidity has also been accompanied by extreme rainfall (Barry et al., 2018), which favors the occurrence of floods in the Sahelian West African region) (Tazen et al., 2018; Fofana et al., 2022). It is therefore clear that Burkina Faso, which lies in this region, is also experiencing a wet phase, with the ensuing extreme rains (Yanogo & Yaméogo, 2023) causing flooding in the country.

4.2. Socio-environmental consequences of Climatic disasters

Climatic disasters (droughts and floods) have resulted in crop failure due to excess water and famine. Dams have also collapsed under the weight of huge quantities of water. All these consequences have affected people and the environment. The work of Yaméogo et al. (2022) in the Sanguié province, in the Nedialpoun lowland, shows that climatic disasters (flooding) lead to soil erosion in the lowland and the loss of market garden production during the rainy season. In the province of Balè, in the Boucle du Mouhoun region, flooding has affected banana growers around the Petit Balè dam, who have seen their incomes fall as a result of the reduction in the area devoted to banana production following incessant flooding during the rainy season (Yaméogo et al., 2023). Müller et al (2023) add that flooding in Burkina Faso has also affected food security. According to 49% of farmers, the floods damaged at least one of their fields. 13.7% had no harvest because of the floods, while 14.8% had lost part of their harvest (Müller et al. (2023). Similar results were noticed by Musah et al., 2013 in Ghana, who noted that floods destroyed the inhabitants' farmland, causing the destruction and total loss of crops. In the locality of Builsa, Ghana. Doris et al. (2018) arrived at the same results as the previous authors. These results are also confirmed by Sighomnou et al., 2013 in Niger with the floods that occurred in 2012.

5. Conclusion

Climatic disasters fluctuate according to Burkina Faso's climatic characteristics. For example, the slowdown in the climate between 1970 and 1999 led to alternating periods of drought and flooding in the country. Conversely, the return of humidity from 2000 to the present day has led to flooding throughout the country. Furthermore, the spatial footprint of areas affected by climatic disasters is a function of Burkina Faso's climatic zones. Droughts are recurrent in the Sahel, North and Centre regions, while floods are observed in the southern zone, such as the Cascades, Hauts-Bassins and Boucle du Mouhoun regions. These various climatic disasters have affected both people and the environment. It would therefore be important to conduct studies on the adaptation strategies of populations affected by climatic disasters to ensure their resilience.

6. AKNOWLEDGEMENT

This work was made possible thanks to the data provided by ED-MAT, the local residents of the Villy Centre, Dassa and Poni dams, and the NGO Action Micro-Barrage, which provided us with a vehicle to visit the breached dams. We would like to thank them for their contribution to this study.

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This study did not receive any funding.

8. AUTHORS' CONTRIBUTIONS

- YAMÉOGO Joseph: Research ideas, Conceptualization, Investigation, Formal analysis, Methodology, Manuscript writing
- ROUAMBA Songanaba: Research ideas, Formal analysis, Methodology, proofreading the manuscript

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10. KEY TERMS AND DEFINITIONS

Climatic disasters: are extreme climatic events that occur in a given area. In Sudano-Sahelian countries such as Burkina Faso, these are mainly droughts and floods.

Socio-environmental: comes from the contraction of two (02) words: social and environmental. Thus, socio-environmental focuses on the social and environmental context in which human activities are embedded. In the context of this study, it refers to the social and environmental consequences of climate-related disaster.