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Living with Floods in West African Cities: Precarity of Housing and Forms of Resilience in the City of Bobo-Dioulasso in Burkina Faso

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Abstract

This article addresses the issue of precarious housing and resilience strategies in the face of recurrent flooding, which is one of the most frequent and damaging natural disasters in West African cities. They are a source of deterioration in the living environment and damage to people's health. The main objective of the study is to analyse the strategies developed to deal with flooding in the city. The methodological approach used combines quantitative and qualitative approaches through documentary review for the collection and analysis of secondary data, and direct observation and field surveys for primary data. The results show that flooding in the city of Bobo-Dioulasso is intrinsic to hydro-geomorphological conditions, climatic hazards, anarchic land use, precarious housing and the blocking of rainwater drains by the population itself. The combination of natural and man-made hazards has made it possible to determine the level of exposure and resilience of the population. The rainy season increases stress for residents of precarious neighbourhoods and has a negative impact on their health. These include the fear of seeing their houses collapse (100% of those surveyed), of seeing their possessions washed away by the rain, of contracting diseases due to the stagnation of rainwater (malaria, typhoid fever, diarrhoea, dysentery, bronchitis) and psychological problems (stress, trouble sleeping, anxiety, etc.) observed before, during and after a flood. Whatever the causes of the flooding, the state and local authorities have a duty to react.

Keywords

West African Cities, Bobo-Dioulasso, Flooding, Precarious Housing, Risks, Resident Populations

1. Introduction

In recent years, the scientific reports on the effects of climate change and global

warming have consistently reported that developing countries are likely to suffer more due to rise in frequency of climate extremes and climate variability (Bhattacharjee & Behera, 2018). Since the early 2000s, the international community has become aware of the impact of housing conditions on the well-being of people living in urban areas. In 2003, UN-Habitat (the United Nations Human Settlements Agency) spoke of the need to improve the living conditions of people living in precarious neighbourhoods (UN-Habitat, 2014). Several studies on precarious housing around the world have shed light on the specific characteristics of these sites in cities. These stem from the forms of precariousness in the neighbourhoods, namely the accumulation of the following three characteristics: "the precariousness of the construction; the total lack of comfort; a high concentration of households, generally on very low incomes and mostly poor". Precarious housing is defined as "neighbourhoods of precarious dwellings, generally built by their inhabitants on small plots of land". These neighbourhoods, also known as "spontaneous" or "informal" housing, also form a mixture of urban features developed by the local population. At first glance, the inhabitants of these precarious neighbourhoods are considered to be the poorest in the city (Baron, Bonnassieux, & Bontianti, 2016).

Pre-existing socio-economic crises are generally exacerbated by a socio-natural disaster and disrupt the life plans of those affected, leading to the deployment of strategic or tactical actions to deal with them. However, when societies have populations living in conditions of social vulnerability prior to disasters, these actions are more complex and difficult to manage. Also, for Odoyo et al. (2024), communities living along the River are affected by the floods when they occur. In their analysis, Mabrouk et al. (2024) conclude that exacerbating flood hazards, exposure, and vulnerability (including built-up modes, hydrological and environmental processes, intensive anthropogenic activities, and socioeconomic development) are the leading causes of increasing flooding. They hypothesize the urban patterns and spatial distribution of built-up patches are associated with increasing or decreasing flood risk. Their research aimed to reveal the spatial congruency or mismatch between the spatiotemporal dynamics of built-up patterns and flood risk and identify the BE associated with increased flood risk. And for Takin et al. (2023), enhancing flood resilience requires coordinated efforts, effective communication, and collaborative governance among stakeholders.

According to the UN-Habitat report (2014), many cities in West African countries have experienced strong growth in recent years, leading to significant social and spatial change. Spontaneous or irregular neighbourhoods account for a significant proportion of African cities, with around 70% of city dwellers in various countries living in them. Peripheral sprawl is the norm, with horizontal expansion without servicing. As a result, cities consume a lot of space, which has an impact on their ability to provide sanitation and rainwater management infrastructure. Urban issues are therefore most often approached through the problem of exclusionary spaces such as flood zones, by considering "the city faced with its

margins", as shown by the research work analysing segregated urban spaces (whether precarious neighbourhoods or, on the contrary, "gated communities"). In West Africa, extreme weather events, often associated with heavy rainfall and flooding, are becoming increasingly frequent against a backdrop of climate change. Flooding has become an imminent and disruptive threat in many cities. In developing/emerging economies, cities are often more vulnerable to the impacts of flooding (Ahadzie et al., 2016). As soon as a disaster strikes, the inhabitants of precarious neighbourhoods are the main victims because they live in high-risk areas, which are often characterised by hydromorphic soils, slopes exposed to rising water levels, a lack of water drainage channels and rainwater collectors, etc.

In Burkina Faso, flooding is one of the most frequent and damaging natural disasters in urban areas. They are a source of deterioration in the living environment and damage to public health. The urban fringes of towns, which are vast areas of habitat described as illegal, spontaneous, informal or, more commonly, "non-housed", are the most exposed to flooding (Soma & Rouamba, 2022). At once considered part of the city but with a habitat close to rural habitat, these fringes, still called "non-housed", seem to be spaces of the in-between, at the interface between the urban and the rural (Robineau, 2014). This is the case in Bobo-Dioulasso, the country's economic capital. Bobo-Dioulasso's geographical location, which benefits from the influence of the southern Sudanese climate with annual rainfall of between 1000 and 1300 mm, means that rainfall is subject to spatial and temporal variability, which influences the water system and the living environment of city dwellers.

Flooding and the stagnation of rainwater also present a major health risk for the population. This generally involves exposing people to infectious diseases such as respiratory infections, diarrhoeal diseases, intestinal parasites and even physical disability. However, urban space is shaped by a "cross-fertilisation" between "archaic" housing estates and spontaneous housing, without any real policy of sustainable construction and neighbourhood servicing. The lack of servicing (construction of drainage channels, demarcation and protection of at-risk areas, etc.) undoubtedly generates risks of all kinds that can turn into disasters (Soma, 2015). Against a backdrop of soaring demographic growth in the city, whose population rose from 554,042 in 2006 to 984,603 in 2019, an increase of 78% (according to data from the 2006 and 2019 General Population and Housing Census (RGPH)), the problems of illegal occupation of land and rainwater drainage are becoming acute.

The city of Bobo-Dioulasso is located in the catchment area of the Houet marsh, and therefore on very fragile bedrock. As a result, flooding and the stagnation of rainwater are factors in the deterioration and even destruction of urban land, housing and public facilities (drinking water, sanitation, energy, roads, etc.). Living with the risk of flooding is, objectively speaking, a complex issue for the various actors in this town, despite the existence of regulations on the management of flood-prone areas.

The main question of this study is as follows: How do the people of Bobo-Dioulasso cope with flooding every year? The main aim of this research is therefore to analyse the strategies developed to cope with flooding in the city. Specifically, the study aims to understand the precariousness of housing, which is the cause of flooding; to analyse the repercussions of the stagnation of rainwater on people's living environment; and to identify the consequences or damage to people's health in the city's precarious neighbourhoods. The analysis is structured around the following points: (i) analysis method and materials, (ii) presentation of the study site, (iii) results of the study, (iv) discussion.

2. Study Methodology

Most urban vulnerabilities and resilience assessment research are focused on communities' well-being and use statistical frameworks to evaluate cities' functions. Also, researchers commonly use spatial analysis to study cities' responses to disasters using land use factors. In addition to relying on this approach, the present study is based on a classic quantitative and qualitative methodology. Two types of sources were used: administrative and scientific documents (administrative reports, dissertations, theses, articles, etc.) and primary data collection through a survey based on a questionnaire and qualitative semi-directive interviews, as well as field observations and photographs. The collection of secondary and primary data lasted 4 months, from June to September 2024, which corresponds to the rainy season in Burkina Faso. The data collected using the KoboCollect application was processed in MS Excel for statistical and graphical illustration purposes. ArcGIS software was used to produce cartographic illustrations and for spatial analysis.

According to the results of the General Census of Population and Housing conducted by the National Institute of Statistics and Demography (INSD), the city of Bobo-Dioulasso had a population of 984,603 in 2019. In 2024, the population is estimated at 1,200,000. For this study, the demographic sample consisted of 150 people chosen randomly, but on a reasoned basis (**Table 1**). Three categories of stakeholders concerned with urban issues in general were targeted. These were, on the one hand, regional managers from the Ministry responsible for town planning (05 people), the environment and living conditions (03 people), health (02), managers from the technical services of the Bobo-Dioulasso municipality (10 people) and, on the other hand, people living in precarious neighbourhoods (130 people).

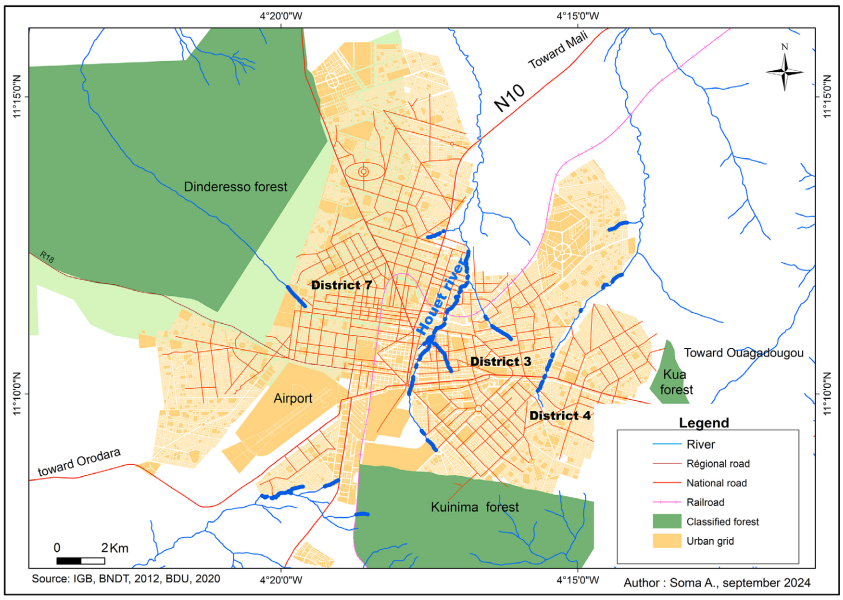
Interviews were conducted with stakeholders in the first two categories. Surveys were conducted among the local population. The spatial sample (see **Figure 1**) covered 03 of the 07 districts, namely district 3 (Bindougousso district), district 4 (Yegueresso district) and district 7 (Belle Ville district). These three districts were chosen because the Houet marsh runs through them. The demographic sample was made up of people chosen randomly but rationally. Three categories of stakeholders concerned with urban issues in general were targeted. These were

executives from the Ministry in charge of urban planning, executives from the technical services of the Bobo-Dioulasso municipality and people living in the Houet marsh catchment area chosen randomly but rationally. Interviews were conducted with stakeholders in the first two categories. Surveys were conducted among the target populations.

Table 1. Breakdown by locality of stakeholders surveyed.

Localities	Headcount	Pourcentage (%)
District 3 (Bindougousso)	40	26.68
District 4 (Yegueresso)	55	36.66
District 7 (Belle-Ville)	55	36.66
Total	**150**	**100**

Source: A. Soma, August 2024.



Source: Geographical Institute of Burkina (IGB), 2012; Author, 2024.

Figure 1. Location of the city of Bobo-Dioulasso.

The data collected was processed using MS Excel software to produce statistics and graphical illustrations. As for the spatialisation of the study sites, the carto-graphic representation has been carried out using ArcGIS 10.4 software and the national topographic database provided by the Geographical Institute of Burkina Faso. The results of this approach call for discussion and suggestions.

3. Geographical Context of the Study

The study focuses on the city of Bobo-Dioulasso in south-west Burkina Faso. It is the country's second-largest city, its economic and cultural capital, and the capital of the Urban Commune. The municipality is subdivided into 07 districts, 33

sectors and 36 attached villages (Municipality of Bobo-Dioulasso, 2009) covering an area of 1595.7 kilometers square (**Figure 1**).

The city has a southern Sudan climate, with annual rainfall of between 1000 and 1300 mm, spread over four to six months of the year, and average temperatures ranging from 20 to 34˚C.

4. Results of the Study

The results obtained are structured around the issue of flood risk management in the city of Bobo-Dioulasso with regard to the precariousness of housing and the means of resilience mobilised by the population to cope.

4.1. Substratum and the Hydrographic Network: Determining Factors in the Precariousness of Housing in the City

The town of Bobo-Dioulasso is located in a groundwater catchment area that covers the entire Hauts-Bassins region and the Boucle du Mouhoun region (covering 45,000 kilometers square) in south-west Burkina Faso. The town has been developed over the years in one of the aquifers of the Taoudéni sedimentary basin. Its geographical limits are marked by a sandstone slope that is the eastern and northern extension of the Banfora cliff in its southern part. The average altitude of the bedrock is 400 meters.

According to the town's master plan for development and urban planning, the geological substratum is essentially made up of the following units: staggered sandstone plateaus dissected by valleys and culminating in hillocks and hills, occupying 33.38% of the municipal area at altitudes ranging from 320 to 500 m; a glacis with an average altitude of 320 m, which covers 30.19% of the municipality and is made up of alluvial plains and rocky, armoured hills resting on crystalline and schistose formations of the Precambrian basement, covering 5.84%; a cliff with a difference in height of 80 to 100 m, running north-east to south-west, which separates the layered sandstone plateaus from the basement zone. Bobo-Dioulasso's soils are shallow and poor in nutrients. And according to the soil map drawn up by the National Soil Office, the municipality of Bobo-Dioulasso comprises the following soil units: indurated leached ferruginous soils (68.38%); slightly desaturated ferralitic soils; low-humidity hydromorphic soils with pseudo-gley (5.6%); lithosols on armourstone and sandstone (7.54%). This geological formation not only prevents rainwater infiltration but also encourages groundwater to rise. It is intersected in places by low-lying areas at an average altitude of 200 meters.

As for the hydrographical network, Bobo-Dioulasso is drained by four marshes: the Kou with its tributaries the Bingbélé, the Houet and the Niamé. Most of the city is located in the Houet sub-basin, which covers an area of 4717 hectares. The other sub-basins cover 366 hectares of the Kou, 497 hectares of the Bingbélé and 420 hectares of the Niamé respectively. The Houet marsh crosses the town from south to north for about 8 kilometres. In addition to the Houet marigot, the town is drained by other small watercourses such as the Sya and Sagnon

marigots, which are home to catfish considered to be the protectors of the Bobo Mandarè, the majority ethnic group in the urban district of Bobo-Dioulasso (Soma, 2015).

In view of the nature of the bedrock, the suitability of the soil for agricultural activities, particularly market gardening and rice growing, and the town's abundant water system, these natural elements are already determining factors in the precariousness of housing, especially during the rainy season. Indeed, field observations and spatial analysis indicate that many dwellings are built on hydromorphic soils with no real foundations to support the houses. As a result of the stagnation of rainwater, the walls of the buildings have deteriorated over the years, making them fragile and vulnerable in the event of heavy rain or flooding. People have to live with these hazards because "you can't move the city, you have to adapt to it".

4.2. An Urban Dynamic in the Houet Basin, a Factor in Housing Precarity

The urban agglomeration of Bobo-Dioulasso has grown and reached the natural spatial constraints that framed its development, in particular the cliffs in the south-east, the head of the Kou basin and the Kuinima classified forest in the south and west, the market gardening and orchard areas in the north and south, the Kua classified forest in the east and the Dindéresso classified forest in the west.

4.2.1. High Residential Pressure on Land and Fragile Buildings

In the 1980s, the total developed area of Bobo-Dioulasso was 4650 hectares, of which only 21.2% had been parcelled out and 78.4% occupied by informal settlements. Between 2009 and 2011, development operations known as "commando subdivisions" were undertaken by the authorities to restructure communal areas. These operations resulted in the creation of more than 11,746 plots for residential use, with an average size of 300 m^2. By 2012, the total number of residential plots had already reached 92,623. By 2023, it is estimated that there will be more than 120,000 plots in the conurbation. The period 1987-2010 produced more plots in the space of 10 years than in 80 years (1906-1986). This high level of plot production is justified by the pressing need expressed by the population to have access to plots of land and to build their own homes. However, the quality of the buildings has not kept pace with the production of plots. The following pictures illustrate the situation (**Figure 2**).

The areas that have been developed have not benefited sufficiently from drainage and rainwater evacuation systems. Similarly, the housing built by households remains fragile, given the precarious nature of the building materials used. In precarious neighbourhoods, the majority of buildings are made of cement-improved banco without foundations adapted to the subsoil of the basin on which the town is built. The high pressure on land and the fragility of the buildings expose people to risks that can turn into disasters when flooding occurs.

Source: Soma, site visit, August-September 2024.

Figure 2. Quality of buildings in two precarious neighbourhoods after flooding.

4.2.2. Illegal Occupation and Obstruction of Rainwater Drains

The city's first rainwater drainage operations began really in 1990. Today, the sewerage network covers only 40% of the city, and comprises a network of 15 km of masonry drains and 25 km of earth drains, and a secondary network of 210 kilometers of masonry gutters and 270 kilometers of earth gutters (Soma, 2015). The inadequate coverage of the city by the network, the undersizing of the existing network, the production of sub-divided areas without taking account of the drainage problem, and the inadequacy of refuse and waste collection have resulted in recurrent overflowing of the gutters, leading to flooding, the development of regressive erosion phenomena leading to gullies that threaten the environment and property.

As a result of the strong pressure on the peri-urban area, the sites that are considered unbuildable are increasingly subject to anarchic occupation and obstruction of rainwater drains. In fact, these areas are home to a variety of settlements: housing, economic activities, domestic waste, etc.

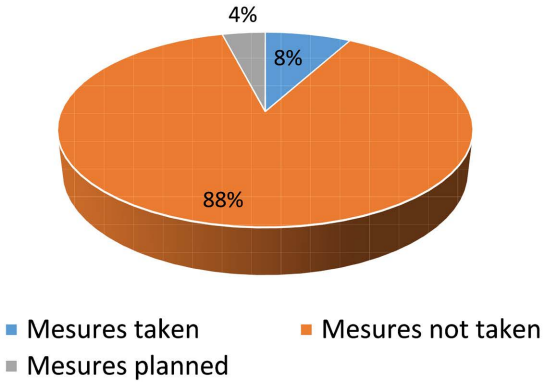
In addition, the major beds of the marshes that run through the town are used extensively for market gardening and rice growing. Unfortunately, market gardeners obstruct the water meanders when ploughing the soil and forming ridges. This obstruction slows down the natural flow of rainwater, facilitating the development of flood waves and the rapid rise in water levels that eventually cause flooding in the riverside neighbourhoods.

The considerable reduction in permeable surfaces due to construction and the clogging up of watercourses, combined with a lack of adequate rainwater drainage systems, all contribute to accentuating the occurrence of flooding following the slightest downpour, thereby increasing the vulnerability of buildings.

4.2.3. Perception and Forms of Resilience of Populations to the Recurrence of Floods

The answers given by the people surveyed (men, women, homeowners, tenants, workers, etc.) reveal a diversity of views regarding the flood risk experienced each rainy season. What emerges is a knowledge of how the flood hazard manifests itself, a more or less mixed awareness of flood risks, a feeling of vulnerability, a subjective acceptability of flood risks, little consideration of flood risks on a daily basis, a well-expressed secular relationship with the home site, divergent support for the authorities' proposals to combat flooding, etc. Overall, in terms of flood

risk prevention measures, three types of response were given by the people surveyed (Figure 3).



Source: A. Soma, site visit, August-September 2024.

Figure 3. Measures taken by city dwellers to protect themselves against risk of flooding.

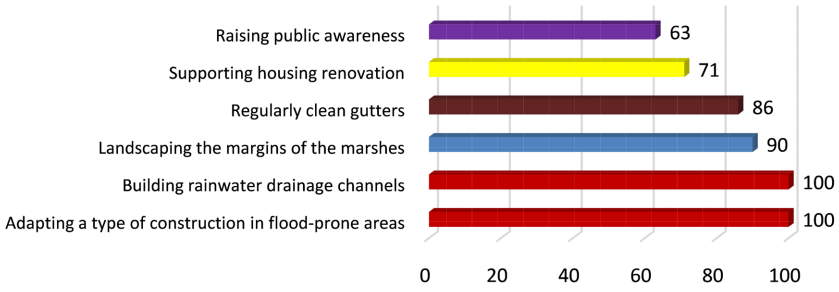
The analysis of the data in the graph reveals that people do not take measures to cope with flooding. They put forward several reasons for this. For 82% of those surveyed, these reasons included not feeling concerned by flood risk prevention measures; for 4% of city dwellers, they thought that the probability of a flood disaster occurring was low; for 6% of those surveyed, they thought that prevention measures were random and pointless; for 3%, they cited a financial constraint; and for 4% of those surveyed, they thought that prevention measures were the responsibility of the local authorities and/or the State.

At the end of the day, people in certain neighbourhoods are carrying out work of common interest to deal with the run-off and stagnation of rainwater. When faced with the risk of flooding their homes, residents often fill sandbags and place them perpendicular to the direction of rainwater run-off. This helps to reduce the speed of water run-off and, consequently, the degradation of the soil through leaching. The piles of sand also make it possible to plug the holes created by the stagnation of rainwater in order to facilitate circulation and also to prevent these holes from becoming mosquito nests. However, analysis shows that this work of common interest remains precarious, as it is an eternal repetition in every season. These operations often create misunderstandings between neighbouring residents when they are poorly carried out, channelling the water into the houses instead.

More often than not, these people find it hard to think about moving, arguing that they have a long-standing attachment to their place of residence. However, the people surveyed were quicker to express their desire to improve their living environment (Figure 4).

The expectations expressed are more directed towards municipal and government authorities. The responsibility of local authorities for flood protection should be able to influence the adoption of preventive measures for residents living in at-risk areas. 94% of people believe that municipal and government

authorities are primarily responsible for the occurrence of floods or for the implementation of protective measures, provided they are convincing. Aware of the precariousness of their homes and living environment, city dwellers say they are willing to take part in operations or projects aimed at mitigating the risk of flooding (Table 2).



Source: Soma A., field survey, October 2024.

Figure 4. People's expectations facing flood risk.

Table 2. Level of participation expressed by city dwellers in flood-fighting operations.

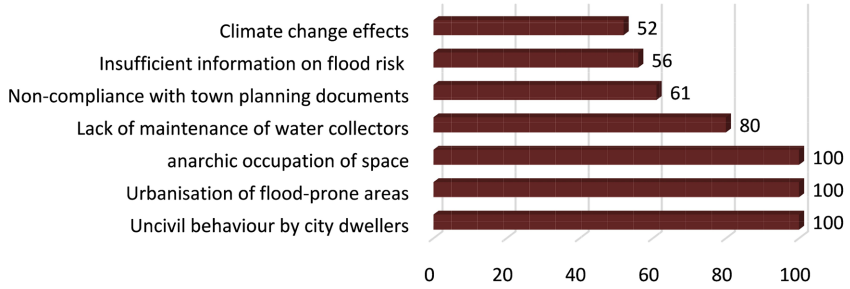
Contribution	Modalities of answers (in %)		
	Yes	No	Do not know
Physically	88	07	05
With Material	48	30	22
Finance	07	91	02

Source: Soma A, Survey results, September 2024.

4.3. A Responsibility Put by Decision-Makers and Managers of Urban Space for Their Actions

For the city's decision-makers and managers, the risks of flooding are increasingly visible and experienced by all the city's stakeholders (government, local authorities, local populations, technical and financial partners) at all times of the year. Flooding is presented as an "almost normal phenomenon, more or less accepted and something we have to live with". This implies that flooding is a natural phenomenon, and that there is little we can do about it other than to avoid exposing ourselves to it. It is therefore a major issue for "areas undergoing major spatial and social restructuring".

Admittedly, the flood hazard is perceived directly by decision-makers and managers as an "imminent" risk and not as a random phenomenon in the city. However, most of the time, they point to the local population as being the cause of flooding, in view of certain actions deemed to be uncivil. From this stems their position on the occupation of areas at risk of flooding by local people (Figure 5).



Source: A. Soma, September 2024.

Figure 5. Reasons given by decision-makers for the increase in flood risk.

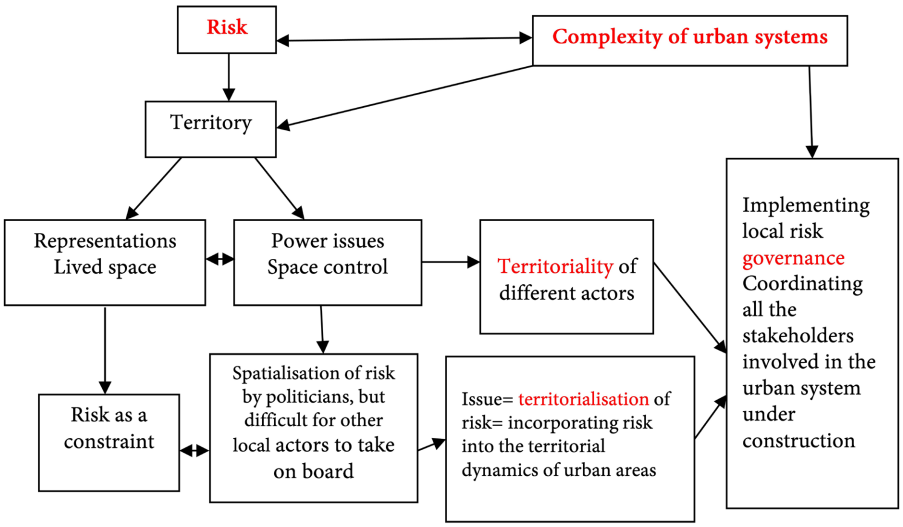
Flood risk prevention is seen as a duty for all the managers and decision-makers surveyed, as evidenced by the drafting of numerous regulatory urban planning documents to reduce the city's vulnerability. However, prevention tools are not sufficiently popularised and operationalised to anticipate flood risks. Indeed, 80% of the decision-makers interviewed confirm the limits of the flood risk prevention resources mobilised by the municipal authorities in the short and long term. In terms of flood forecasting and warning, for example, the National Meteorological Agency's current system is unable to forecast the weather accurately, which makes it difficult to convey reliable preventive and warning information to the public.

4.4. The Necessity of Integrating Flood Risk into Urban Governance

An analysis of the resilience measures taken by the population and the local and state authorities shows that the current method of flood risk management in the city is much more reactive than proactive. The primary driver for action by the state and local authorities is, on analysis, much more based on post-flood disaster management. Faced with the recurrence of floods, one of the major concerns is to think holistically about how we can move from spatialising the risk (which is the first stage in raising awareness and appropriating the risk) to genuinely territorialising it, i.e. integrating it into the city's planning and development policies and into the behaviour of city dwellers.

Whatever the causes of flooding, the State and local authorities have a duty to react. State policy should, first and foremost, aim to control urbanisation in flood-prone areas and support local authorities in incorporating the risks into their town planning documents. Flood risk management is therefore a fundamental issue that needs to be incorporated into the planning and development of urban projects. Flood risks need to be assessed beforehand, so that they can be managed more effectively and people's vulnerability can be reduced at the same time. An appropriate flood risk mapping system based on the articulation of perceptions at all levels remains an essential step. This must link these perceptions with management measures and planning choices for areas affected by flood risk. From a practical point of view, designing a territorialised flood risk management means ultimately attempting to circumscribe the urban space in all its complexity in order

to reintegrate the management of areas at risk into the policies for implementing sustainable urban development. The aim is to design sustainable urban developments that take account not only of the socio-economic and political issues at stake, but also of the reality of the existence of flood risks that could affect city dwellers and their activities. The issues at stake in the territorialisation of flood risk are represented in this respect by the diagram (**Figure 6**), according to the model adapted from Soma (2015).



Source: From Beucher (2010) adapted by Soma (2015).

Figure 6. The challenges of establishing local flood risk governance.

5. Discussion

The physical aspects of the bedrock on which the city of Bobo-Dioulasso is built suggest that this anthropised area is exposed to flooding every year. The study reveals that the city's substratum is characterised by flatness, hydromorphic soils, a scattered hydrographic network and low rainwater retention and infiltration capacity. These characteristics expose the urban area to the risk of flooding. This observation is made by Gueye (2004) and Soma (2015, 2019), who indicate that the hazards associated with topography, soil morphology, slope and rainfall variability are all natural factors that expose the cities of Dakar in Senegal and Ouagadougou in Burkina Faso to flooding. The same observation was made by Nguendo-Yongsi (2021) in the Bobongo district of the city of Douala in Cameroon.

In addition, the study notes that the high pressure on land, the fragility of buildings, the uncontrolled occupation of spaces and the obstruction of rainwater drainage channels are indicators of the vulnerability of populations living in precarious urban neighbourhoods. This finding corroborates that of Le Jallé (2013), who stresses that the spontaneous settlement of new urban dwellers in the cities of developing countries often takes place in high-risk areas (low-lying areas, flood zones, swamps, shores, etc.) where the lack of rainwater management can have serious consequences for health through prolonged contact with contaminated

water. In the same vein, Bouvier (1989), Livangou and Berton (2018) point out that in sub-Saharan African urban neighbourhoods located in at-risk areas, particularly low-lying areas and marshlands without an adequate rainwater drainage system, the related damage is greater than elsewhere. The same observation is made by Rouamba (2011), who mentions that the particular geographical conditions at the mouth of the Rio Pongo (Boffa prefecture) in the Republic of Guinea-Conakry favour the settlement of humans, who are unfortunately exposed to the bites of tsetse flies (an insect that carries the parasite responsible for sleeping sickness). Beaudoin (2018) notes that the abundance of concrete and paved surfaces in the cities of Ottawa and Gatineau, for example, prevents infiltration into the soil and recharge of aquifers. Chouli (2006) concludes that the stagnation of rainwater in cities prevents the smooth running of urban activities and jeopardises public hygiene. For Le Jallé (2013), access to quality sanitation is a prerequisite for guaranteeing people's dignity and combating poverty in urban areas. One of the hypotheses put forward is that the "precariousness" of housing is, in itself, a determinant of the vulnerability of households in urban areas. Thus, different situations of vulnerability are linked to the built environment, the population and the local materials used.

Taking into account the natural and man-made factors mentioned above, the analysis reveals that flooding in the city of Bobo-Dioulasso is a phenomenon with a multifaceted impact on the living environment and health of residents. Several studies have shown the correlation between poor drainage of rainwater and an increase in water-borne diseases in urban areas. The study distinguishes three categories of health problems linked to the deterioration of the living environment, prevailing soil humidity and the modification of biotypes. These results were obtained by various authors. Le Jallé (2013) mentions that the permanent humidity of the soil and the stagnation of water in African cities encourages the development of vectors carrying diseases such as malaria, dysentery and cholera. Varnai & Moles (2018) and Nguendo-Yongsi (2021) note that the damage caused by flooding to the health of residents in the Bobongo catchment area is multi-varied. These include health problems linked to the awareness and occurrence of floods (stress, anxiety, sleep disorders), health problems linked to the prevailing humidity (acute respiratory infections), health problems linked to the deterioration of the living environment (malaria, ascariasis, cholera, typhoid fever). Bouvier (1989) and Desbordes and Bouvier (1990) distinguish between two levels of pathologies associated with water in urban Africa: vector-borne diseases (malaria, bilharzia, onchocerciasis) and viral diseases (typhoid, cholera, hepatitis). According to Bustinza (2014), floods can cause direct effects (such as injuries and drowning) and indirect effects (such as infectious diseases and poisoning) on human health.

The study reveals that the different perceptions and forms of resilience expressed by the populations surveyed in the face of recurrent flooding make it possible to determine the level of precariousness and exposure of the built

environment to the risks of flooding. The start of each rainy season in Bobo-Dioulasso is synonymous with psychosis and fear among the population.

Ultimately, we agree with Beaufils (2014) and Laganier (2006) that flooding poses a threat to territories, public health and services, and has a multi-faceted impact on people's health. In this respect, Rode (2017) believes that we need to "reclaim watercourses in order to develop the city". However, as Blanchard (2006) points out, "there is no single solution or miracle recipe for curbing the risk of flooding" in urban areas. In short, whatever the causes of flooding, the Government and local authorities have a duty to react. Porosity-based urban configuration and spatial distribution of built-up patches in harmony with nature-based solutions are recommended for shaping flood-resilient and effective urban planning, as said Mabrouk et al. (2024). In another approach, Peiris (2024) proposes the development of a spatial planning framework for assessment of urban resilience to floods, applying a case study using bottom-up spatial interactions among natural, physical, and social systems within Colombo city, the commercial capital of Sri Lanka.

6. Conclusion

This study identified the issues associated with flood risk management in an African city located on a site drained by rivers, where housing is still precarious. It emerged that the bedrock and the hydrographic network are determining factors in the precariousness of housing in the city of Bobo-Dioulasso. Similarly, the urban dynamic in the Houet basin, with its strong residential pressure on land and the fragility of buildings, anarchic occupation and obstruction of rainwater drains, and the modest means of resilience mobilised by city dwellers, is a factor in the precariousness of housing in the face of the floods that occur each year in the city.

Public policy issues concerning the management of precarious neighbourhoods in West African cities thus arise for the present (to improve the living conditions of residents) as well as for the future (to prevent them from becoming established). As housing is one of the essential needs of every human being, precariousness in this area in an urban environment naturally has critical consequences for the other aspects that contribute to improving people's living conditions.

Whatever the causes of flooding, the State and local authorities have a duty to react to alleviate the anxieties of people living with flooding. Of course, government policy should be aimed above all at controlling the urbanisation of flood-prone areas and helping local authorities to incorporate the risks into their town planning documents, but support for city dwellers is also a way of ensuring that their living environment is improved.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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