

# Assessment of Flood Impacts on Agricultural Production and Ecological Vulnerability in the Municipality of Bonou, Benin

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## Abstract

Recurrent flooding is a major constraint on agricultural sustainability and productivity in the municipality of Bonou. This study examines the impacts of flooding on agricultural production and ecological vulnerability within the municipality of Bonou. The methodological approach combines literature review, socio-economic surveys, data processing, and analysis of the results. Data processing involves the use of SPSS 17.0 and ArcGIS 10.8 software. The findings reveal that rainfall rates range from  $-1.90$  to  $2.69$  over the time period (1961-2024). In addition, the years are classified as ‘dry’ in 57 per cent of cases and ‘wet’ in 43 per cent. The rainfall decline began in the 1970s. Drainage density varies from 4.2 to 50.98. Indeed, the districts have a high drainage density of 25%; 17% have medium drainage, and 57% have low drainage density. In the municipality of Bonou, the intensity index of rainfall causing flooding ranges from 1419.68 to 12,027.08. The average monthly river discharge recorded throughout the study period is  $172.24 \text{ m}^3/\text{s}$ . Floods last from 2 days (4 per cent of respondents) to more than a month (61 per cent of respondents). The prolonged submersion of Bonou’s fertile floodplains suffocates the roots of staple crops such as maize and cassava, rotting them completely even before harvest. Flooding also causes the sudden submersion of traditional granaries and storage areas, destroying reserves of maize, cassava, and rice and depriving households of their immediate food security. The sudden rise in waters surprises livestock farmers, causing most small livestock and poultry to drown instantly. Flooding causes widespread leaching of surrounding agricultural lands, releasing substantial quantities of sediments, pesticides, and organic waste into the river system.

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## Keywords

Vulnerability, Floods, Agricultural Production, Municipality of Bonou

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## 1. Introduction

Globally, floods are the most frequent and devastating natural hazards. They account for 43% of disasters recorded between 1994 and 2013, affecting nearly 2.5 billion people and causing economic losses exceeding US\$40 billion during major flood events in 1998 and 2010. Combined with the effects of climate change, population growth, and rapid urbanization, the impact of coastal, river, and rain-induced flooding is expected to intensify dramatically over the coming decades [1]. Floods have always been the most significant and devastating natural disasters. States' ability to respond to this type of disaster is also extremely limited, given the low average annual income of their populations [2]. Floods stand out as the most devastating natural hazard, not only because of their human toll but mainly because of the catastrophic losses to agricultural production systems [3].

Recurrent flooding in Africa is one of the most devastating climate-related shocks for the agricultural sector, whose livelihoods support the majority of the population. The suddenly submerged plains and fertile valleys lead to the immediate and total loss of entire growing cycles of major food crops such as rice, maize, and market vegetables. These disasters not only destroy standing crops but also seed stocks and farming equipment, paralyzing farmers' ability to recover once the waters recede [4]. High-intensity water erosion caused by the force of the floodwaters strips away the topsoil, leading to massive leaching of essential soil nutrients. This decline reduces soil fertility, which permanently impoverishes the soil and jeopardizes yields in future growing seasons long after waters have receded [5].

The violent nature of these floods accelerates the erosion of riverbanks and irreversibly alters the morphology of African waterways. The high turbidity of the water, saturated with sediment and debris, seriously disrupts aquatic ecosystems and suffocates local fish populations. Floods foster the introduction and rapid proliferation of invasive plant species, such as water hyacinth, which choke freshwater bodies [6]. The destruction of riparian forest ecosystems and mangroves deprives many animal species of their natural habitats and breeding grounds. This widespread pollution causes long-term contamination of groundwater and surface water sources that are essential for maintaining biodiversity [7]. Prolonged soil drowning due to stagnant water destroys underground microorganisms, disrupting natural biogeochemical cycles [8]. With their land lost, rural communities often migrate to forested areas or protected parks, exacerbating deforestation and human pressure on these areas. Thus, by simultaneously undermining biodiversity and livelihoods, floods trap African communities in a chronic cycle of food

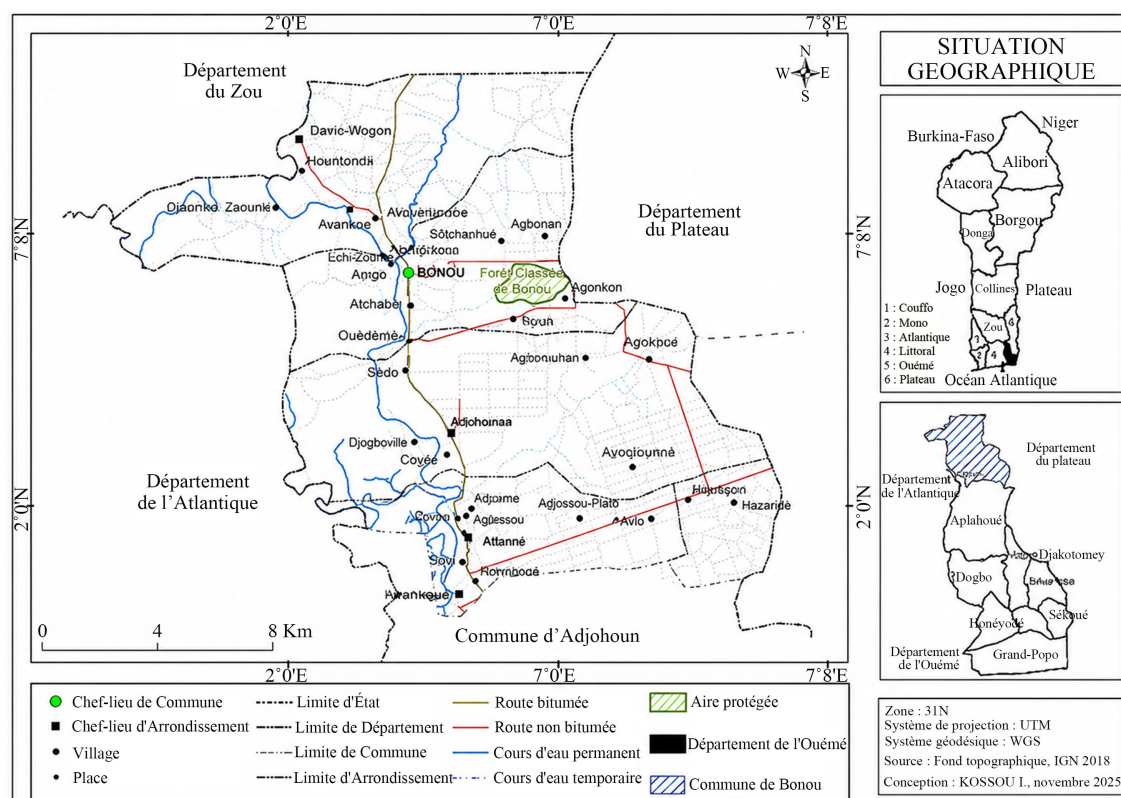
insecurity and environmental vulnerability [9].

In Benin, vulnerability is linked to heavy rainfall, flooding, droughts, coastal erosion, and epidemics. This vulnerability is exacerbated by socio-economic and environmental factors, notably the country's heavy reliance on agriculture and rainfall. Human settlement in flood-prone areas or along riverbeds and lakeshores highlights the issue of spatial planning and land use [10]. Benin has experienced flooding in the past and, especially between 1999 and 2010, five major flood events, the most significant of which occurred in 1999, 2009, and 2010. These are generally caused not only by flooding and the overflowing of the Ouémé, Mono, and Couffo rivers and Lakes Nokoué and Ahémé, but also by rainwater drainage system failures [11].

Periodic flooding in the lower Ouémé valley is a key vulnerability factor, disrupting social, health, and economic stability through the widespread destruction of agricultural production [12]. The municipality of Bonou is also affected. Residents of this municipality are impacted by this phenomenon every year, which affects both the environment and people's health. More deaths are often recorded during floods due to diseases caused by water contamination [13]. People in the municipality of Bonou are exposed to frequent flooding risks. Floodwaters cause submersion and the sudden loss of standing crops, whilst destroying seed stocks and agricultural equipment essential for future harvests. Severe erosion and nutrient leaching cause long-term depletion of soil fertility, which compromises crop yields long after the waters have receded. This agricultural production collapse leads to a drastic fall in farmers' incomes, plunging rural communities into food insecurity and chronic debt. The aim is to analyze the impacts of flooding on agricultural production and ecological vulnerability in the municipality of Bonou.

## 2. Study Area

The municipality of Bonou is located in the department of Ouémé, between 6° 72' and 7° 35' north latitude and between 2° 15' and 2° 40' east longitude. It is bordered to the north by the municipality of Ouinhi, to the south by the municipality of Adjohoun, to the east by the municipalities of Sakété and Adja-Ouèrè, and to the west by the municipalities of Zê and Zogbodomè (Figure 1). The municipality of Bonou covers an area of 250 km<sup>2</sup> and comprises five districts subdivided into 34 villages. Bonou became a municipality in 2003 following the introduction of decentralisation. According to Law N° 97-029 of January 15, 1999, on the organization of municipalities in the Republic of Benin, a municipality is a local authority endowed with legal personality and financial autonomy. Bonou is currently subdivided into five districts covering a total of 34 villages. The municipality remains predominantly rural, with settlements often situated in flood-prone areas, which increases people's vulnerability and makes it difficult to implement effective prevention policies.



**Figure 1.** Geographical and administrative location of the municipality of Bonou.

### 3. Materials and Methods

This research adopts a methodological approach based on hydro-climatic, demographic, agricultural, and socio-anthropological data. The demographic data enabled us not only to determine the sample size but also to gain an understanding of this population's perceptions regarding flood disasters and their effects on agricultural production. Also, rainfall and hydrological data from 1961 to 2024 are collected from Meteo-Benin and used to evaluate flood disaster indicators. The collected data are processed, categorized, grouped, and presented in the form of tables and figures. The sample is composed of farming households from all strata. Respondents have been selected based on the following criteria: being aged 30 or over. These individuals are better placed to provide insights into their understanding of flood disasters and having lived in one of the municipalities for the past 10 years. Consequently, the sample size has been determined using the formula proposed by D. Schwartz (1995, p. 12). A sample of 383 households has been selected. This has been calculated to ensure optimal statistical reliability with a 95 per cent confidence level and a margin of error of  $\pm 5$  per cent of the value under study. Data collection is carried out through random sampling, so that all households within the municipality have an equal probability of being selected for the sample and included in the study. This ensures representativeness at the municipal level and the statistical validity of results from the analysis. The questionnaires are administered through individual interviews using Kobocollect, along with guides

and data collection forms. Following collection, the data are exported to an Excel spreadsheet before being subjected to statistical analysis. The data collected via the questionnaires are coded and cleaned. SPSS 17.0 and STATA 16.0 software are used to calculate measures of central tendency and dispersion (standard deviation, arithmetic mean) and display different figures. The response rate for each question type is expressed using the statistical formula:  $P1 = n/N \times 100$ , with  $n$  representing the number of households that provide favorable responses and  $N$  representing the sample size at the municipal level. Thus, the data collected from institutions and households are processed using Excel 2010 for tables and figures, and ArcGIS 10.8 for creating maps.

### 3.1. Standardized Precipitation Index

The Standardized Precipitation Index used in this study involves changing the precipitation time series into a standardized normal distribution with a mean of zero and a standard deviation of one, also known as a z-distribution, normal distribution, or Gaussian distribution. Standardized precipitation indices are calculated using the formula:  $IAS = \frac{X_i - \bar{X}}{\sigma(X)}$ , where  $X_i$  represents the average annual cumulative rainfall for year  $i$ ,  $\bar{X}$  and  $\sigma(X)$ , are respectively the mean and standard deviation of that series. Drought classification is performed based on the index values (**Table 1**).

**Table 1.** Determining index values.

| Index Values       | Drought severity  |
|--------------------|-------------------|
| −0.99 à 0.99       | Near normal       |
| −1.00 à −1.49      | Moderately dry    |
| −1.50 à −1.99      | Severely dry      |
| −2.00 et moins     | Extremely dry     |
| $2 < IAS$          | Extreme dampness  |
| $1.5 < IAS < 1.99$ | Severe dampness   |
| $1 < IAS < 1.49$   | Moderate dampness |

Source: [14].

The analysis of general rainfall and hydrological trends involves the use of moving averages and regression analysis. It is based primarily on the calculation of five-year moving averages, which provide smoothed hydrometric and rainfall time series for the various stations in the catchment at monthly or annual frequency. The statistical significance of the trend is tested using Student's t-test.

### 3.2. Rainfall Aggressiveness Index

The simplified method described in [15] is used to calculate the rainfall intensity index; this method takes into account only the average annual rainfall ( $P$ ). The

simplified formula, with  $P > 850$  mm in Bonou, is expressed as:

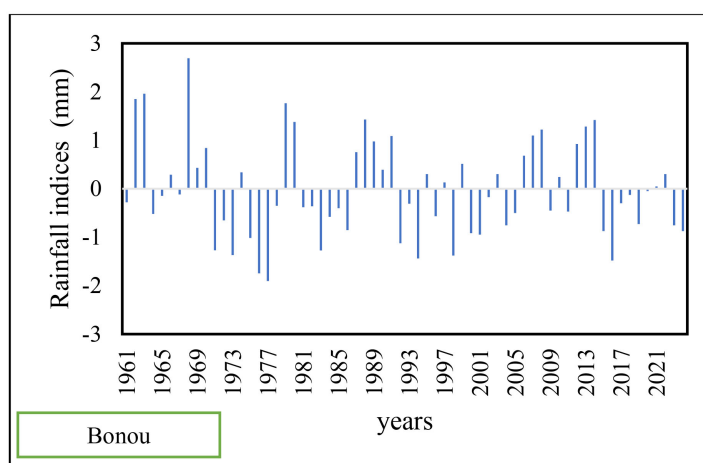
$$R = 587.8 - 1.219 P + 0.004105 P^2$$

R: rainfall intensity index; P: annual rainfall (mm). The classification established by [15] has been used to analyze the results obtained following the assessment of the R index. When the R index is high, the resulting runoff is more powerful and highly concentrated.

## 4. Results

### 4.1. Characterization of Extreme Events in Bonou

Rainfall indices calculated from 1961 to 2024 made it possible to identify years of extreme rainfall in the municipality of Cotonou (**Figure 2**).



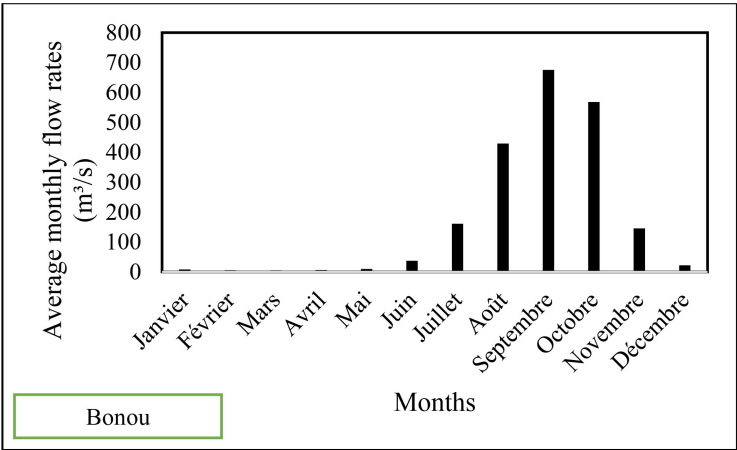
Source: Meteo-Benin, July 2025.

**Figure 2.** Rainfall indices between 1961 and 2024 in the study area.

**Figure 2** shows that the indices range from  $-1.90$  to  $2.69$  over the study period (1961-2024). Further, 57 percent of the years are dry and 43 percent are wet. Water deficit began in the 1970s. The alternation between years of below-average and above-average rainfall creates a risk of flooding and affects people's activities in the municipality of Bonou. **Figure 3** shows the hydrological regime in the municipality of Bonou between 1961 and 2024.

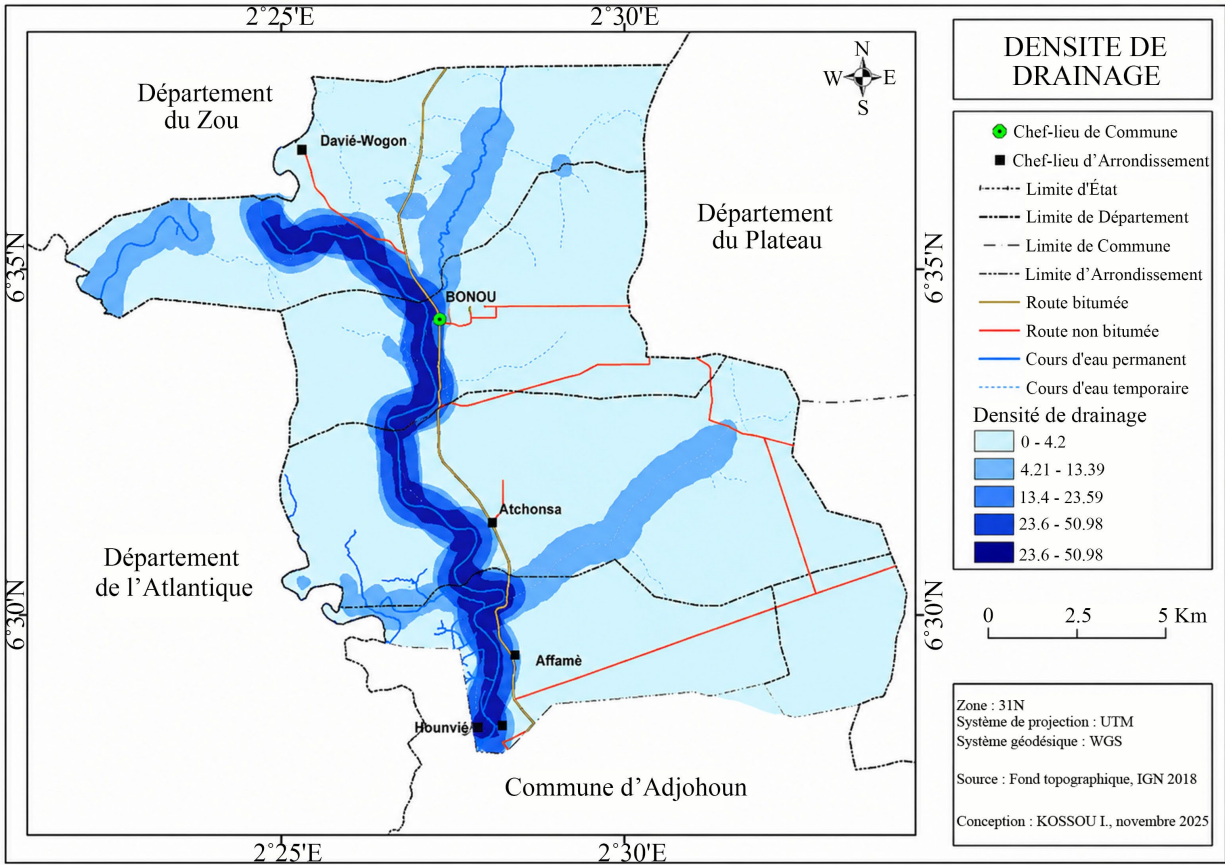
The results from **Figure 3** show that the hydrological regime is unimodal. The flood season occurs only once a year and starts in August. A long dry season, from December to May, is characterized by a sharp drop in river flow. The average monthly flow rate observed over the entire data series is  $172.24 \text{ m}^3/\text{s}$  in the municipality of Bonou. Therefore, September and October are often favorable periods for flooding. From December to May, the river is at low water, which may lead to ecological risks. Most of the floods occurring at the municipal level are caused by rising water levels in the River Oueme as it flows through the municipality of Bonou. According to respondents, these are times when they face damaging socio-economic, environmental, and health consequences, including prop-

erty damage, the destruction of crops, and loss of life. **Figure 4** shows the drainage density in the municipality of Bonou.



Source: Meteo-Benin, August 2025.

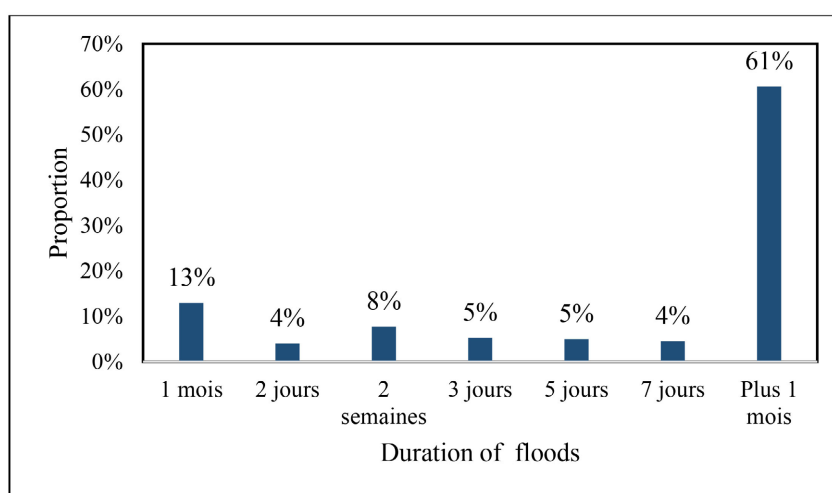
**Figure 3.** Hydrological regime of the study area (1961-2024).



**Figure 4.** Drainage density in the municipality of Bonou.

**Figure 4** shows that drainage density varies from 0 to 50.98. Indeed, 25% of the district area has a high drainage density, 18% a medium density, and 57% a low

density. The commune of Bonou has an extremely low drainage density because it is almost entirely devoid of any artificial network, such as culverts or concrete gutters. Water management in this rural landscape relies exclusively on the natural topography. However, this dependence is detrimental to local communities during floods, as the river reverses its course and floods the land by backflow instead of draining it. This lack of technical infrastructure exacerbates local degradation and transforms every downpour into a real scourge for the region. In the absence of canals to channel the water, uncontrolled runoff erodes the soil, carves deep gullies in the roads, and isolates villages from any access routes. At the same time, deforestation of the riverbanks destroys the natural “absorption ditch” that once acted as a sponge, while the silting up of the outlets slows the drainage of stagnant water. The municipality has no control over this natural resource and is at its mercy, which destroys crops and weakens the foundations of traditional houses. **Figure 5** shows flood duration in the study area.



**Source:** field survey, August 2025.

**Figure 5.** Flood duration in the study area.

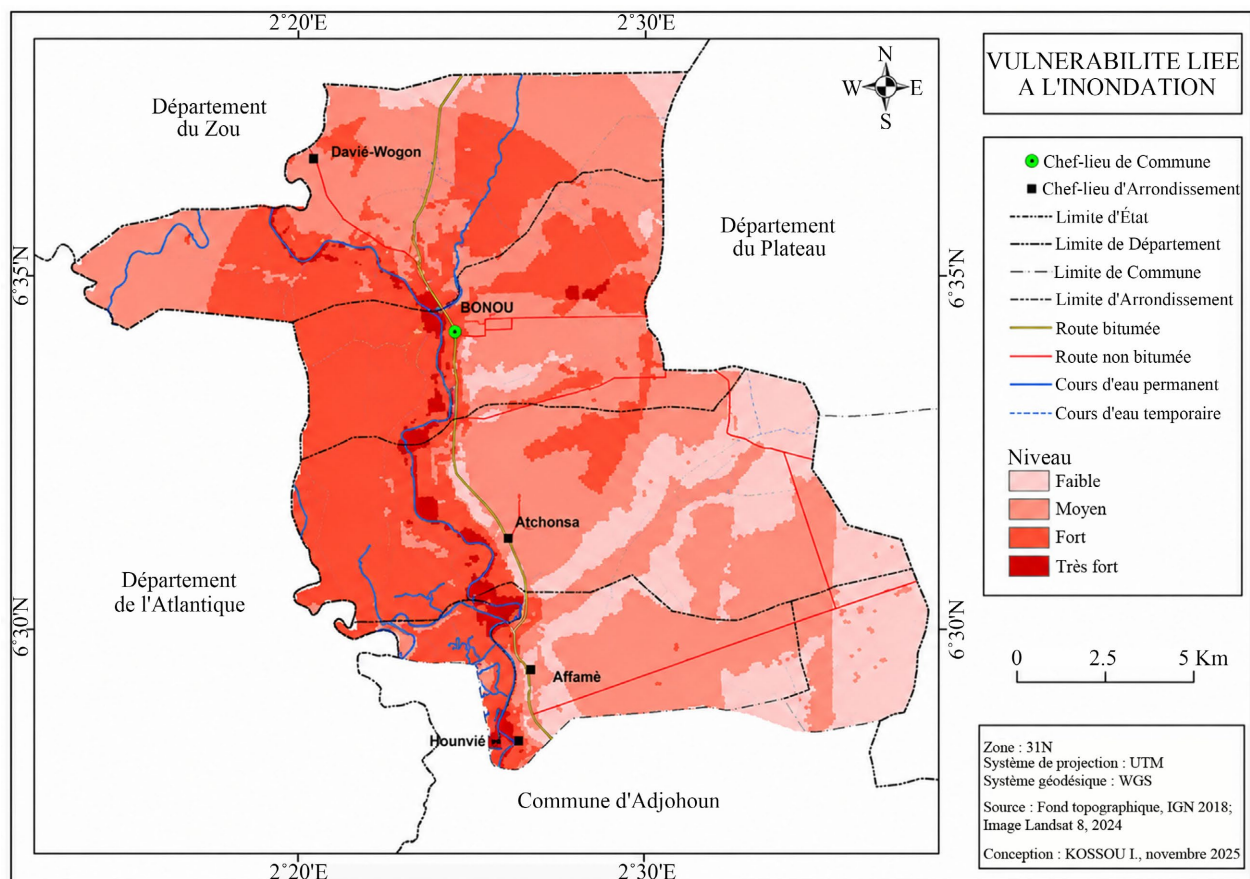
**Figure 5** shows that flooding lasts from 2 days (4 per cent of respondents) to more than a month (61 per cent of respondents). The municipality of Bonou is located in the lower Ouémé valley. After heavy rainfall upstream in the catchment (including in central Benin), it takes several days until the water recedes. The river then rises gradually, with the flood peak occurring well after the peak of local rainfall. Flooding can be prolonged, with water remaining in the floodplain for several weeks or even months (September to December).

#### 4.2. Mapping of High-Risk Areas and the Most Vulnerable Boroughs

**Figure 6** shows the distribution of the research sector’s vulnerability to flood risk.

**Figure 6** shows that the high-risk zone encompasses the district of Bonou, as well as significant portions of the Damè-Wogon district to the north and the

Hounviguè district to the south. The medium-risk zones extend on either side of the high-risk zones, covering a significant part of the territory, including the district of Atchonsa and part of Affamé. Vulnerability is lower at the eastern edge of the municipality, near the border with the Plateau Department, where the altitude is likely higher relative to the river system. The district of Bonou is located in an area of high to very high vulnerability. The area of high vulnerability often matches the fertile alluvial plains. Although these lands are suitable for flood-recession crops, they are at risk of total crop loss for rain-fed crops in the event of early or exceptional flooding. The municipality of Bonou is vulnerable to structural flooding due to its river geography.

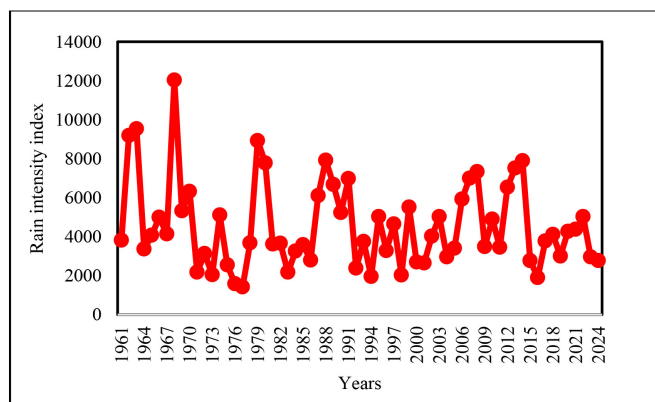


**Figure 6.** Level of vulnerability to flooding in the municipality of Bonou.

### 4.3. Rainfall Intensity Signs in the Municipality of Bonou

**Figure 7** shows indices of rainfall intensity in the municipality of Bonou.

**Figure 7** shows that the rainfall intensity index ranges from 1419.68 to 12,027.08 in the municipality of Bonou. The year 2010 experiences higher rainfall intensity. The index value is very low in 1977 and 1988 and very high in 1968, 2010, and 2012. A high rainfall erosivity index shows that rainfall has high impact energy. Rainfall erosivity is influenced by climatic factors, mainly by increased frequency and intensity of extreme rainfall events.



Source: Meteo-Benin, July 2025.

**Figure 7.** Trends in the rainfall intensity index between 1961 and 2024 in the study area.

#### 4.4. Vulnerability and Losses in Crop Production

##### 4.4.1. Destruction of Staple Food Crops (Corn, Rice, Cassava) and Vegetable Crops

Prolonged flooding of the fertile floodplains of Bonou suffocates the roots of staple crops such as corn and cassava, rotting them completely even before harvest. Although rice tolerates moisture better, the force of flash floods and excessively high water levels destroy young seedlings by either completely submerging or uprooting them. Vegetable plots, established along the riverbanks to facilitate irrigation, are swept away at the very onset of rising waters, resulting in the total loss of high-value crops such as chili peppers and tomatoes. This widespread destruction of food crops leads to an immediate food shortage in local markets, depriving households of their daily food supply (53% of respondents). Crippled by the loss of their seasonal investments, farmers are left without the resources to replenish their seed stocks and restart production cycles.

##### 4.4.2. Loss of Crop and Seed Stocks, and Damage to Farming Equipment

During floods, the sudden inundation of traditional granaries and storage facilities destroys reserves of corn, cassava, and rice, depriving families of their immediate food security. This loss is compounded by the destruction of carefully selected seed stocks, which eliminates the biological capital needed for subsequent cropping seasons. Exposed to floodwaters and thick mud, essential farming equipment such as hoes, machetes, and small draft tools rust, sink, or are swept away by the current. The inability to safeguard these basic means of production creates an immediate technical breakdown as soon as the waters recede. Deprived of both seeds to plant and tools to work the land, farmers in Bonou find themselves physically unable to resume their activities without external assistance or substantial indebtedness.

##### 4.4.3. Farm Calendar Changes and Disruption to Crop Rotation Cycles

In the municipality of Bonou, the early or delayed onset of floods severely disrupts the traditional agricultural calendar, preventing farmers from planning their sow-

ing activities with confidence. Prolonged flooding of fields compels farmers to delay planting post-flood crops, which dangerously shortens the available production window before the dry season. This disruption shortens or abruptly interrupts the crop cycles of sensitive crops such as corn and chili peppers, resulting in immature or poor-quality harvests. To cope with these constraints, farmers are forced to abandon certain long-cycle local varieties in favor of early-maturing seeds, which are often less productive but more resilient to the unstable water cycle. Ultimately, this systemic disruption reduces the number of possible harvest cycles per year, plunging family farms in the lower valley into chronic food insecurity.

#### **4.5. Impacts on Livestock Farming and Fisheries Dynamics**

##### **4.5.1. Decimation of Livestock (Cattle, Poultry) and Destruction of Grazing Land**

During flood events in the municipality of Bonou, the rapid and unpredictable rise in water levels catches farmers off guard, resulting in the immediate drowning of a significant portion of their small livestock and poultry. The surviving animals become stranded on small, overcrowded patches of land, where these crowded conditions accelerate the spread of deadly epizootic diseases such as small ruminant plague. Prolonged flooding of the plains completely destroys grazing lands, depriving herds of their sole source of food. This acute food shortage forces herders to resort to early, unplanned transhumance, exacerbating the animals' malnutrition and the overall mortality rate (37% of respondents). The combined loss of livestock and grazing resources permanently depletes the capital of herding households, which rely on their livestock as an emergency savings fund.

##### **4.5.2. Disruption of Aquatic Ecosystems and Its Impact on Local Fisheries**

Flooding causes large-scale leaching of surrounding farmland, releasing a huge amount of sediment, pesticides, and organic waste into the water system. This sediment load results in excessive water turbidity, which clogs fish gills, reduces light penetration, and severely disrupts spawning grounds (28% of respondents). In addition, the massive influx of nutrients triggers an uncontrolled proliferation of water hyacinth, an invasive plant that suffocates the ecosystem by depleting available oxygen. Given this ecological degradation, local fishermen experience a drastic decline in catches and frequent destruction of their fishing gear (nets and canoes), which are swept away by the violent current. The resulting depletion of fishery resources deprives the riverside communities of Bonou of an essential source of animal protein and a major pillar of the local economy.

#### **4.6. Socioeconomic Effects on Farming Households**

##### **4.6.1. Declining Farm Income and Chronic Indebtedness of Farmers**

The entire loss of the corn, rice, and vegetable crops instantly cuts off the main source of cash flow for farming households in Bonou. Deprived of these seasonal

earnings, farmers are unable to cover essential family expenses, such as their children's education or health care. Thus, farmers are forced to seek loans from informal lenders at often usurious interest rates to finance the next growing season or ensure their daily survival. As debts mount amid increasingly frequent floods, farmers are trapped in a financial cycle where repaying old loans absorbs future profits before they are even earned. This economic deadlock forces 63% of affected households to sell off their last productive assets, such as small livestock or farming tools, thereby jeopardizing any chance of a sustainable recovery.

#### **4.6.2. Food Insecurity and Poor Nutrition in Times of Crisis**

Flooded granaries and emergency seed stocks destroy household food reserves, disrupting families' self-sufficiency immediately. Combined with the higher costs of river transport, the physical isolation of villages leads to a sharp rise in the prices of the few basic foodstuffs still available in the local markets within the municipality. Given this decline in purchasing power, households drastically reduce the number of daily meals and compromise the quality of their food, causing their dietary diversity score to plummet. Such prolonged deprivation leads to a dramatic rise in cases of acute malnutrition, mainly affecting children under five and pregnant or breastfeeding women. This nutritional insecurity, combined with the forced consumption of surface water contaminated by floodwaters, weakens people's immune systems, paving the way for waves of waterborne and infectious diseases.

### **4.7. Soil and Water Resource Degradation**

#### **4.7.1. Water Erosion, Nutrient Leaching, and a Lasting Downturn in Soil Fertility**

As floodwaters surge across Bonou's farmland, they trigger intense water erosion that strips away the upper soil horizons. This strips away the topsoil rich in organic matter, sweeping away the fine soil particles that give structure to the arable substrate. Meanwhile, infiltration and runoff cause massive vertical and lateral leaching of essential nutrients such as nitrogen, phosphorus, and potassium. Stripped of these fertile elements, the soils of the lower Ouémé Valley undergo severe chemical depletion, which limits the normal resumption of underground biological activity. Once the floodwaters recede, farmers are left with hardened, infertile soil, leading to a drastic and lasting drop in yields over several consecutive growing seasons.

#### **4.7.2. Chemical and Organic Pollution of Surface and Groundwater**

The overflowing of human-made areas leads to systematic flooding of traditional latrines, causing tons of fecal matter to be discharged directly into surface waters. This significant organic contamination loads the local river system with pathogens and fecal coliforms, turning the river and its tributaries into epicenters of disease. Runoff carries away chemical inputs, including residual synthetic fertilizers and pesticides, applied upstream in cotton- and vegetable-growing areas. These toxic pollutants and nitrates seep through saturated soils and unprotected wells, reach-

ing the shallow aquifers that supply the community. This physicochemical and biological degradation permanently impairs the quality of the aquatic ecosystem and jeopardizes local residents' access to safe drinking water.

## 5. Discussion

Prolonged flooding of lowlands suffocates and rots staple crops such as maize and cassava, whilst violent floods uproot young rice plants. Vegetable plots established along the riverbanks are swept away at the very onset of rising waters, resulting in the total loss of high-value crops such as chili peppers and tomatoes. This widespread destruction deprives farmers of the basic resources needed to replenish their seed stocks and restart production. The sudden overflowing of traditional granaries destroys emergency food reserves, whilst farming equipment rusts, sinks, or is swept away by the current. The unpredictable arrival of floods disrupts the traditional agricultural calendar, reducing the number of possible harvest cycles per year. The rapid onset of flooding surprises livestock farmers, leading to the immediate drowning of a large proportion of small livestock and poultry. The surviving animals are confined to overcrowded islands, where the cramped conditions favour the spread of deadly epizootics such as small ruminant plague. The overall loss of natural forage leads to unplanned, early transhumance, exacerbating malnutrition and mortality rates amongst the remaining herds. Fish stocks are affected as runoff carries sediment, fertilizers, and pesticides into watercourses, disrupting fish reproduction. This influx of nutrients fuels the proliferation of water hyacinth, which chokes the aquatic environment, leading to a drastic decline in catches for local fishermen. The loss of these livelihoods cuts off households' cash flow, forcing farmers to take out loans at usurious rates from informal lenders. Thus, 63% of affected households end up selling off their last productive assets at rock-bottom prices in order to survive and attempt to repay their mounting debts. The isolation of villages and the collapse of purchasing power lead to acute food insecurity, marked by an alarming rise in child malnutrition. Farmland is subject to severe water erosion, which strips away the topsoil and leaches vital nutrients such as nitrogen, phosphorus, and potassium. Flooded latrines discharge faecal matter into the water system, causing long-term contamination of surface and groundwater. These findings back up those of [8] and [14], which pointed out that seasonal floods lead to the prolonged submersion of fertile floodplains, immediately destroying staple food crops such as maize, rice, and cassava. Vegetable gardens, usually set up along riverbanks to facilitate irrigation, are swept away by the very first rising waters, destroying chilli and tomato crops. Not only do the violent floods devastate standing crops, but they also destroy traditional granaries, washing away food stocks and reserves of selected seeds. Severe water erosion strips away the topsoil and leaches out essential nutrients, which permanently depletes soil fertility and causes yields to plummet in future growing seasons. With no income and farming equipment often lost or damaged, nearly 80 percent of farming households are heavily in debt and physically unable to re-

start their activities without external help. According to [16], crowding surviving animals onto overcrowded islands creates close quarters that are conducive to fatal epizootics, such as small ruminant plague. Left without natural forage due to the flooding of the plains, livestock farmers are compelled to undertake early and unpredictable transhumance, which exacerbates malnutrition and mortality amongst the surviving livestock. Meanwhile, surface runoff carries sediment, fertilizers, and pesticides into the river system, significantly altering fish spawning grounds. This excessive influx of nutrients fuels the spread of water hyacinth, which chokes the aquatic environment and causes a drastic drop in catches for local fishermen. This overall collapse in production leaves households without cash, trapping them in a cycle of debt to informal lenders charging usurious interest rates.

## 6. Conclusion

This study highlights that prolonged flooding of the plains suffocates and rots staple crops such as maize and cassava, while fierce flooding uproots young rice plants. Market-garden plots along the riverbanks are swept away by the very first rises in water levels, resulting in the entire loss of chilli and tomato crops. This extensive destruction strips farmers, already ruined, of vital resources needed to replenish their seed stocks and restart production. The abrupt flooding of traditional granaries destroys emergency food reserves, while farming equipment rusts, sinks, or is swept away by the current. The unpredictable onset of floods disrupts the traditional agricultural calendar by limiting annual harvest cycles. The sudden rise in waters surprises livestock farmers, causing most small livestock and poultry to drown instantly. Thus, rescued animals are confined to overcrowded islands, where the cramped conditions favour outbreaks of deadly epizootic diseases such as small ruminant plague.

## Declaration of Generative AI and AI-Assisted Technologies in Manuscript Preparation

During manuscript preparation, the authors used Claude (Anthropics) solely for limited language editing of selected sentences in order to revise in order to improve clarity. No AI tool was used to generate research content, analyze data, interpret results, or prepare references, the ideas, argument, and intellectual contribution of the paper are entirely original. All AI-assisted suggestions were reviewed, revised where necessary, and approved by the authors, who take full responsibility for the final manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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