


## Rainfall as a risk factor for flooding in the Hulene B neighbourhood in Maputo City

 <https://doi.org/10.56238/sevened2024.010-009>

Oswaldo Francisco Zandamel<sup>1</sup> and Freitas Fenias Cossa

---

### ABSTRACT

This article aims to analyze the risk of flooding resulting from rainfall in the neighborhood of Hulene "B" in Maputo City. The analytical perspective focuses on the social scope of the risk, taking into account its impact on the population residing in that area.

The study will privilege the mixed method with a focus on bibliographic research based on literary works that address the same theme. During the study, it was found that the forecast for the occurrence of precipitation advanced by INAM for the period from October 2022 to March 2023 is for the occurrence of rainfall with a trend from normal to above normal. Thus putting a good part of the "Hulene B" neighborhood at risk of flooding.

**Keywords:** Precipitation, Risk, Flooding.

---

<sup>1</sup> Bachelor's and Bachelor's Degree in Geography Teaching, Post-Graduate in Engineering and Master's Degree in Environmental Risk Management. Pedagogical University Maputo – Mozambique  
E-mail: osvaldozandamela@gmail.com



## INTRODUCTION

Currently the themes related to climate change have been gaining space in several debates, one of the most addressed topics has to do with tropical cyclones and floods whose effects are felt in the population in all cyclonic seasons. Economic development affected.

There is considerable focus on the impact of climate change and especially on the increase in sea surface temperature, causing the frequency of tropical cyclones to be felt over coastal regions (Goldenberg et al, 2001; Mann and Emanuel, 2006).

The city of Maputo is located in the south of Mozambique, west of Maputo Bay, where the Tembe, Umbeluze, Matola and Infulene rivers flow, in a region vulnerable to extreme inventions resulting from climate change that manifests itself through urban flooding.

The intense and prolonged rains during the months of the rainy season in Mozambique can lead to negative consequences for some cities when added to the lack of infrastructure and the absence of urban planning, since these areas become vulnerable, increasing the risks of damage and losses to the population because when there is a rise in the level of the rivers, In general, there are floods. (Marcelino et al. 2004).

The present work aims to evaluate rainfall as a risk factor for flooding in the city of Maputo, specifically in the Hulene "B" neighborhood, located in the KaMavota Municipal District, with rural characteristics.

## OBJECTIVES

### GENERAL

- To evaluate Rainfall as a Risk Factor for Flooding in Maputo City.

### SPECIFIC

- Define the concepts of Precipitation, Risk and Floods;
- Discuss the factors leading to flooding in the Hulene "B" neighborhood;
- Describe the socio-environmental implications of flooding in the Hulene "B" neighborhood.

## METHODOLOGY

In order to succeed in the elaboration of this scientific article, on precipitation as a risk factor for the occurrence of floods, the following methods were privileged: Qualitative and bibliographic consultation of works that address the theme under analysis.



Scientific research is a fundamental tool for solving collective problems. (Marconi; Lakatos 2002). Selltiz et al. 1965 argued that it was the definition and respect for the application of the methods that could really bring results that were not always satisfactory, but certainly reliable.

- Qualitative Method - Qualitative research is one that works predominantly with qualitative data, that is, the information collected by the researcher is not expressed in numbers, or else the numbers and the conclusions based on them play a minor role in the analysis. (RICHARDSON, 1989).
- As these are phenomena that involve human beings, where it is believed that the best understanding is through people's perspectives, qualitative research, combined with data collection techniques to ensure greater reliability of the results as stated by Bogdan & Blikien (1994), stating that the fundamental issue is the process, as well as the product and the final result, Data should be analysed inductively, delving into the details and specific aspects of the data to uncover important categories, dimensions and interrelationships.

## THEORETICAL FRAMEWORK

**Precipitation** is any particle of water, solid or liquid, that falls from the atmosphere and reaches the ground, coming from clouds, and occurs when cloud droplets grow until they reach sufficient dimensions to fall by the effect of gravity. Precipitation is a fundamental vector of the hydrological cycle, uniting the atmosphere with the other subsystems of the climate system. AYOADE, (1986)

Precipitation is a fundamental vector of the hydrological cycle, uniting the atmosphere with the other subsystems of the climate system. It has a wide variety of forms (drizzle, rain, snow, wet snow, hail, hail, showers, icy snow) and its classification generally depends on the mechanism involved in the cooling that led to cloud formation (convective, orographic, convergence, frontal). Rainfall is expressed as rainfall height, duration, frequency and intensity of rainfall. The amount of precipitation in a given time interval (rainfall height) is the

Quantity  $R = v/s$  where  $v$  is the volume of water collected from a hydrometer, in a container with a horizontal mouth and area  $s$  (hydrometer or rain gauge). It is expressed in millimetres (= litres per square metre).

The duration of precipitation is the period of time counted between the beginning and the end of the rainfall (measured in hours, minutes or days). Frequency is the number of occurrences per year for a given downpour or, the number of years required for a given downpour to occur. The intensity of precipitation  $R$  is relatively  $\Delta$  measured by the variation in the amount of precipitation ( $t$ ) in which it fell.  $\Delta$  to the time interval (Precipitation is a central climatic (or meteorological) element in the



variation of the weather and in the characterization of the climate of a given place. It occurs as a consequence of the evolution of synoptic systems and, together with temperature, is a central element of empirical climate classifications. (Andrade and Bash, 2000).

Is rain the water in the atmosphere? Is water vapor also rain? What is the difference between rain and cloud? Rain is part of one of the most important cycles for life on the planet: the water cycle. According to Silveira (2004), the energy that produces the water cycle comes from the Sun, which begins by causing the evaporation of lakes, seas, and rivers.

The evaporated water (water vapor) accumulates in the air, which expands as it rises due to the decrease in atmospheric pressure. The expansion causes the cooling of the air that loses its ability to contain moisture (water vapour), initiating the process of returning to a liquid state (condensation) in the form of small water droplets. This process results in clouds, when it occurs at altitude, and fog (sawmill), when close to the ground.

For the formation of a single raindrop, it is necessary, on average, approximately one million water droplets formed by condensation (slow process) or capture (fast process). (VIANELLO and ALVES, 2000). With the formation of raindrops, precipitation occurs, which can occur in a liquid (rain) or solid (hail or snow) state. Taking into account the mutliplicity of the rainfall formation process, there are several types, namely:

### TYPES OF RAINFALL AND THEIR FORMATIONS

According to the way the air rises, rain can be classified into three main types (AYOADE, 1998):

- **Convective rain:** it is related to convective instability, that is, the vertical movement of air results from the process of heating of the Earth's surface by the Sun, causing ascending columns of air (air that rises to the upper troposphere). This process results in the formation of **cumulunimbus** clouds, which have a high vertical development and a typical mushroom shape. Generally, these rains are intense and short-lived, occurring more frequently in the summer, in the afternoon.
- **Orographic rainfall:** occurs when the elevation of humid air is caused entirely or mainly by high ground, initiating a process of forced convention (orographic effect). The air is forced to rise, expanding, forming clouds and then orographic rain. This precipitation occurs practically to the windward of the slope, while to the leeward it usually receives no rain.

It is from this process that the high incidence of cloudiness and rain near the high slopes of the mountains arises.



- **Frontal rain:** these are precipitations from the circulation associated with frontal systems. Cold fronts can cause heavy rainfall, which may be accompanied by thunderstorms, hail, gales and tornadoes. Warm fronts cause continuous rain of lesser intensity.

**Floods** are an extreme and temporary natural phenomenon caused by moderate rainfall for long periods or by short but high intensity rainfall. (INGC, 2016).

Floods are treated as a risk from the fact that they cause losses i.e. damage to the exposed elements of the Hulene "B" neighborhood, such as residential infrastructure and businesses. During the rainy season, this neighborhood suffers drastically from the effects of rainwater. It should be noted that floods are part of the risks from the moment they affect the population causing a high degree of loss.

Floods consist of the process of occupation of the plains by water, that is, it is when water overflows from the river channel (KOBİYAMA et al., 2006). Thus, in order to originate an episode of flooding, it is necessary to manifest a pluvial event that, in turn, linked to urban hydrological processes, promotes the overflow of the river that has spatial repercussions on societies. The impacts resulting from floods are complex and, in some situations, destabilize systems, with relevant social, economic and environmental losses (SILVEIRA, et al., 2009).

Floods occur mainly by the natural process in which rivers, streams and urban canals overflow into their larger bed, due to the sudden or gradual increase in the flow of water in the lower bed. This type of event is due to natural processes of the hydrological cycle, being observed in both urban and rural spaces. (TUCCI, 2012).

The frequency of flooding changes due to changes in the watershed. Plate (2002) stated that the pressure exerted by population growth results in the exclusion of the poorest part of the population, who start to live in the floodplain. This type of problem is commonly witnessed in urban areas. Thus, new concepts and practices must be introduced for a better coexistence with this phenomenon.

Flooding, popularly referred to as flooding, is the increase in the level of rivers beyond their normal flow, with the overflow of their waters over the areas near them. These flat areas near rivers over which water overflows are called floodplains. When there is no overflow, although the river is practically full, there is a flood and not a flood. For this reason, in the scientific world, the terms "flood" and "flood" must be used interchangeably.

According to Castro (2003), gradual floods occur when the water rises slowly and predictably, remains in a flood situation for some time, and then gradually drains. Citing the Amazon, Nile, and Mississippi rivers as examples, the same author mentioned that this type of flooding has a seasonality (periodicity). Apparently, this flood is not that violent, but its impact area is extensive.



On the other hand, popularly known as flooding, flash flooding occurs due to intense and concentrated rainfall, especially in regions of rugged relief. The rise in flows is sudden and their flow is violent. It occurs at a time close to the rain event that causes it. The rising waters occur suddenly, causing more deaths, although the impact area is much smaller than gradual flooding. (CASTRO, 2003). This is in the case of the Hulene "B" neighborhood.

However, flooding occurs when a large amount of water is not sufficiently absorbed by the soil because of waterproofing or occupation of areas that formed river floodplains, invading marginal avenues, and streets, residences and buildings (InfoBibos, 2010).

Floods are historical phenomena on our planet with occurrences older than the existence of man himself. However, the frequency and magnitude of their occurrences have become increasingly greater throughout the world, resulting in massive economic losses and loss of human lives. (Genovez. 2009). It is precisely because of this postulate that floods are considered a risk that the conceptual approach to it is made below.

### CONCEPTUAL APPROACH TO RISK RISK

The approach to risk is new, although it is now known that man has always lived and will live with uncertainty (risk)

**Risk** is a situation or a condition. At first sight, the concepts of threat and vulnerability may present some similarity with the concepts of probability and consequence (components of the expression  $R = P \times C$ ), but they end up translating risk situations more faithfully, especially due to the way they are treated, maintaining deep dependence on each other and thus presenting a fear and reductionism. (Marandola Jr. and Hogan. 2004).

The expression  $R = P \times C$  can cause an error of interpretation, offering a distorted view that probability and consequence can be multiplied simply by mathematical logic. In fact, the relationships between the components of the risk situation are much more complex than an arithmetic operation. (Campos.1999).

According to Bley (2007), risk perception is the individual's ability to identify hazards and recognize risks, attributing meaning to it at work, in traffic and in the air. Risk perception is influenced by health status, attention and emotional status.

Risk, a social object, is defined as the perception of danger, of possible catastrophe, and therefore it exists only in relation to an individual, a social group, a society that apprehends it and coexists with it through specific practices. Thus, according to the author, there is no risk without a population or individual who perceives it and who could suffer its effects.



He also adds that the risk and the perception of it cannot be focused on without considering the historical context that produced it and, especially, the relations with the geographical space, the modes of occupation of the territory and the social relations characteristic of the time. (Veyret. 2007).

According to Veyret (2007), the occurrence of the allege (possible event and its probability of realization) can affect more or less strongly the functioning of human societies and that socio-economic factors often increase the vulnerability of threatened populations.

The imprecision of the terminology used in the concept of risk is further fueled by the different translations of the English "*hazard*", quite common in North American literature. For (Marandola Jr. and Hogan. 2003): "The truth is that there is no corresponding word in Portuguese (or in other Latin languages, such as Spanish and French) that expresses the true meaning of this word." In Portuguese, the authors of *Geografi* have interpreted the term *hazard* sometimes as risk, sometimes as accident. (Xavier. 1996) sought to adopt it as a synonym for risk, whereas (Monteiro. 1991) opted for the translation as accident.

Employing other words, (Marandola Jr. and Hogan. 2003) endorse the previous explanation: "what is it to be at risk? It is to be susceptible to the occurrence of a hazard." Therefore, the term hazard can be understood as synonymous threat or danger, while "*risk*" refers to the joint existence of threat (or danger) and vulnerability, approaching the proposal of Campos (1999), Lavell (1999) and Cardona (2001).

Based on this definition and knowing the difference between *hazard* and *risk*, we can infer that the expression environmental risk refers to a situation of environmental threat (physical, technological and even social) acting on a population that is known to be vulnerable.

Therefore, risks must be treated as a result of the intricate relationship between threat and vulnerability, which are deeply dependent on each other. The notion of risk is established on the basis of the conflicting relationship between man and his environment, in a process of mutual influence. Therefore, one must also try to reject the Manichean idea of the existence of an aggressor natural event acting on a society that, in turn, is seen as a victim. (Gilbert. 2002).

The research carried out by the above-mentioned authors leads to a reflection that the perception of risk varies from individual to individual, is influenced by internal and external factors.

In the modern concept of risk, two characterizations are considered: the REALISTIC and CONSTRUCTIVIST models, where in the realistic model, the risk is constructed by the elements that compose it itself, being independent of the observer or whoever is subject to him. Thus, if we assess the risks of a nuclear power plant in a certain region, for example, we would be doing empirical and scientific research. (Aquino et al, 2017).

In the case of Mozambique, cities have played a very strong role in the perception of environmental risk, to the extent that the population ignores or cohabits with the environmental risk.



The low-income population without purchasing capacity or power has in urban centers sectors of basic activities such as: Employment, School, Transport, Markets and others. These factors cause the population to settle in areas vulnerable to flooding.

### **CAUSE OF FLOODING IN MAPUTO**

The rapid growth of the population in the city of Maputo and the search for better living conditions, make the population of the remote areas abandon their places of origin to the outskirts of the city because they are close to the means of survival, settling in areas without observance of the basic principles of territorial planning, sanitation of the environment, lack of resources for the construction of decent housing, thus placing this population in areas at risk of flooding as is the case of the Hulene neighborhood

Floods cause risks as the land is occupied inappropriately and represent a serious problem not only for public authorities, commerce and industries, but mainly for the population living in low-lying areas and risk areas, causing, in most cases, enormous damage, many of them irreparable as loss of human life. objects of personal value and works of historical value. (TUCCI et al 1995).

The disorderly occupation of non-inhabitable areas or areas close to the banks of rivers modifies the process of water infiltration into the soil and promotes the sealing of the watershed. As a result, during the rains, water runoff through the surface increases, raising flows above the capacity of the drainage network, causing flooding in areas occupied by humans. (TUCCI 1995).

The urbanization process is highlighted as a main cause of flooding in developing and underdeveloped countries. It is a set of actions that have worrisome consequences, both social and environmental (OLIVEIRA, 2004).

Urban growth in developing countries has been carried out unsustainably with deterioration of the quality of life and the environment. Urbanization is spontaneous, urban planning is carried out only for the part of the city occupied by the middle and high-income population, while for low-income areas the process takes place irregularly or clandestinely (WORLD BANK, 2007).

According to the World Bank's Global Fund for Disaster Reduction and Recovery, urban flooding represents a real threat to populations, especially in peripheral areas where there is a lack of sewage collection and treatment, as the population comes into contact with contaminated water, contributing to the spread of diseases such as leptospirosis. (GFDRR. 2014).

It is important to highlight the causes linked to floods that can come from natural phenomena that probably cannot be anticipated, such as the occurrence of tsunamis, soil compaction and sealing, dam rupture associated or not with adverse meteorological phenomena, destruction of vegetation cover, slopes and banks, increasing soil runoff and erosion and increasing environmental pollution that is reflected in the seas and rivers (BANK MUNDIAL, 2007).





In cities, river floods and, consequently, floods are caused by precipitation and surface runoff generated by soil sealing. Urban aquatic waters are fluid through the drainage systems of the water bodies that, even in periods of greater flow, occupy their largest bed or, even, the flood slopes. However, when a population occupies the flood extensions, the problems are frequent and the consequences are disastrous. (TUCCI. 2012).

## **SOCIO-ENVIRONMENTAL IMPACT OF FLOODS**

Hulene B is a peripheral neighborhood of the city of Maputo that is located specifically in the Kamavhota municipal district, this neighborhood suffers from flash floods annually in the rainy season due to rapid population growth, urban expansion, soil degradation, lack of territorial planning, disorderly constructions by residents.

In this city, every rainy season of the year from October to March, residents suffer from flood risks resulting from the rainfall in the reference period. The population leaves their homes for other areas or for the resettlement centres provided by the INGD where they can continue with their day-to-day activities.

During this period, the population faces several risks, from the loss of their property, the loss of human lives and the proliferation of diseases resulting from the precipitation developed by mosquitoes of the anopheles genus that is responsible for the spread of malaria. There is also the development of cholera, a disease caused by various bacteria that thrive in places with serious sanitation problems.

There is occurrence of leptospirosis which is closely related to environmental factors. The most common ways to acquire the disease is in situations of floods and floods, when the urine of rats, present in sewers and manholes, mixes with the runoff and mud of floods. (Genovez. 2009).

In addition to water-borne diseases, the population has suffered theft of their property from their homes because when they leave their homes, they are unable to take all their property with them.

After the rainy season, the population returns to their homes and resumes their normal life, but as the area is characterized by the approach and saturation of the water table, the population lives with the waters in their backyards, adopting adaptation measures for survival, such as the placement of bags containing area at the entrances and stones.

Floods disrupt the lives of the affected populations and cause significant deterioration in the quality of life, as well as material damage, both for civil society and for the public authorities, not to mention the irreparable damage such as loss of human lives and physical buildings of historical value and consequently, of their constant summer rains, these types of phenomena are very impactful, both for the natural and social environment According to TUCCI 1995).



Although there are technological means that can minimize the effects of floods, the consequences of these are still, in some cases, quite harmful to Man and, several times, to Nature (WORLD BANK, 2007).

The urban environment is an open system, where the city is the result of the interrelations between natural and man-made elements. From this perspective, the environment in which the city is inserted is the result of human action on a certain feature of the earth's surface. The urban environment - also understood as an urban ecosystem - is, therefore, a product of human action in interface with a certain natural dynamic or even with the elements of the physical environment, such as, for example, an urban agglomeration that is established along the banks of a main river and between the meanders of its tributaries (BRANDÃO. 2006).

Floods cause immediate and long-term impacts on the health of the affected population, resulting from displacement and degradation of living conditions. health risks from floods can be stratified as a function of time, (Paterson et al. 2018).

## FLOOD MITIGATION MEASURES

The Hulene B neighbourhood is an area at risk of flash floods resulting from rainfall and the approach of the water table, without the water drainage system, without the urban sanitation system, in order to reduce the impacts of the floods that devastate that population, it is necessary to adopt mitigation measures that refer to an "action to reduce the sources or factors that cause floods". (Bulkeley. 2010). such as, zoning of the flood risk area to assess the real dimension of the problem, environmental education that consists of raising awareness about the responsibility they have over the environment they live in, demonstrating the degree of importance that the community has in cleaning and in the various activities, structural and non-structural measures such as, the installation of a water drainage system, which consists of the construction of open drainages for water drainage. Flood control measures can be classified as structural, when man modifies the risk, and non-structural, when man lives with the risk (REIS BARBOSA, 2006).

In the first case, there are control measures through hydraulic works such as dams, dikes and plumbing, among others. In the second case, there are preventive measures, such as zoning of flood areas, an alert system linked to Civil Defense and insurance.

It cannot be assumed that preventive measures will be able to fully control floods, since preventive measures are always aimed at minimising their consequences. In order to control flooding efficiently, it is necessary to combine structural and non-structural measures, in order to guarantee the population the least possible damage, in addition to enabling a harmonious coexistence with the environment (REIS BARBOSA, 2006).



## CONCLUSION

The factors leading to the risk of flooding in Bairro Hulene "B" are linked to social and environmental vulnerability, combined with the lack of territorial planning, characterized by sporadic occupations, that is, settlements that do not obey any occupation rules.

With each rainy season, vulnerability increases in the Hulene "B" neighborhood, as demographic and infrastructure growth grows and flood risk mitigation measures are far from responding positively to the wishes of the population. The mapping of areas susceptible to flooding would be one of the measures to be implemented to ensure that populations do not settle in risk areas.

Given that rainfall is concentrated at a certain time of year, it would be important for the authorities to establish a flood risk response plan based on rainfall forecasts.

Based on the current state of climate emergency, caused by several factors, the immediate development of viable flood mitigation and adaptation mechanisms is of utmost importance. This article reflects on rainfall as a risk factor for flooding in the Hulene "B" neighborhood, identifying some main strategies to deal with flood risks, such as: zoning of the area under study, construction of drainages, environmental education.

It is important to clarify that there is no definitive solution to address flood risks, all technologies and techniques must be combined and deployed to reduce impacts. Therefore, alternative flood reduction or mitigation measures cannot be ignored as the neighbourhood in question is located in an area at risk of flash flooding.



## REFERENCES

1. FARIAS, Ariadne; MENDOCA, Francisco. Riscos socioambientais de inundação urbana sob a perspectiva do Sistema Ambiental Urbano.
2. MASATO, Kobiyama et al. Prevenção de Desastres Naturais: Conceitos Básicos. Impresso no Brasil, 2006.
3. SAMPAIO, Ricardo; JUNIOR, Salvador. Riscos Ambientais: Conceitos e Aplicação, 2007.
4. SOUSA, Alexandre. Diagnóstico da Percepção do Risco Ambiental. Lavra: UFLA, 2015.
5. CAVALCANTE, Juliana da Silva. Percepção de Riscos Ambientais de População Vulnerável a Inundações e Deslizamento de dunas. Natal-RN, Brasil, 2013.
6. AQUINO, Afonso, et al. Risco Ambiental. BLUCHER Ltda, 2017.
7. BARBOSA, Lucas; ZANELLA, Maria E. Percepção de Risco Ambiental: Teoria e Aplicações. UFC Fortaleza Editora, 2009.
8. RIBEIRO, B. Shakil. Gestão de Inundações: Como Amenizar seus Efeitos em Moçambique. ACARAPE – CE, 2018.
9. XAVIER, A. Ricardo. Riscos de Cheias e Inundações, Estratégias Comunitárias para a Gestão e Redução da Vulnerabilidade em Moçambique. Fevereiro, 2022.
10. ANDRADE, José; BASCH, Gottlieb. Clima e estado do tempo. Fatores e elementos do clima. Classificação do clima. Universidade de Évora.
11. AYOADE, J. Introdução à climatologia para os trópicos. São Paulo: DIFEL, 1986.