The vulnerability to flash floods from the perception of the people in the Safende district

Research on the vulnerability of the district Safende during the rainy season and the measures that can be implemented to reduce the vulnerability of the community in Safende to flash floods.

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Preface

In recent years, I have focused on applying water management knowledge on home ground in the Netherlands. When I was offered a graduate internship in Cape Verde, I decided to take on the challenge of applying my knowledge in a society and culture different from that of the Netherlands. My insecurities were soon overcome by the beloved people I found myself surrounded by, and during my time in Cape Verde I grew in both my knowledge of the Water Management profession and my personal qualities. The Cape Verdean hospitality 'morabeze' encouraged me to improve my empathy towards my work and personal environment.

During the two months that I've lived in the Capital, Praia, to conduct my study, my main focus was on the flash floods of 12 September in 2020. These flash floods caused a lot of damage to the spatial environment, as well as to people's homes in informal settlements. In the studies I found across on this topic, I saw that little research had been done on the actual experiences of residents during the flash floods in 2020. This led me to focus this research on the experiences of flash floods in the Safende district and the resident's awareness of flash floods.

Through this, I learnt that residents could play an important role in reducing their vulnerability to flash floods. Their experiences, actions taken and knowledge about their habitat, provides an expertise that residents in particular hold. Furthermore, I better understand the potential of collaborations between citizens, government organizations with local parties and that together this can improve safety against flash floods.

The research was commissioned by the Universidade Cabo Verde from the Department of Geography and Geology. The research is of value for the ambition to better understand the personal experiences of residents in times of flash floods and what contribution they can offer in reducing their vulnerability to flash floods.

I would like to thank my supervisors Silvia Monteiro and Rick Heijkoop for their guidance and support during the graduation process. Furthermore, I would also like to thank all lectures at Universidade Cabo Verde who offered help during this research. Lastly, I also thank the student of the Universidade de Cabo Verde and the residents of the Safende district that helped me as a guide and translator in Safende.

I wish you much reading pleasure.

Anoushik Sayyad-Hartounian,
Spijkenisse, 15 June 2023

Summary

This study addresses the challenges facing the City of Praia, the capital of Cape Verde, in adapting to climate changes and reducing the effects of flash floods. Praia is highly vulnerable to these extreme weather events, due to its volcanic scenery, uncontrolled urbanization, and insufficient infrastructure, together with the vulnerability of informal settlements. Although the government has stated their ambitions to improve the city's difficulties, the lack of efficient governmental actions and financial support hinders the realization of the flood-risk measures. In addition, the flood-risks are not mapped per district in the City of Praia. The above difficulties have resulted in inadequate use of international funding to provide for these measures. During the flash floods on 12 September 2020, one of the highly impacted informal settlements was the Safende district. Even though, the district was funded by the African Development Bank Group to implement drainage channels for the protection against flash floods. The drainage channels are disproportionate in size comparing to the natural stream of the Safende river and have been let unfinished during the construction. The aftermath of the flash floods in 2020 show the insufficiency of the drainage channels and leaving residents feeling highly vulnerable to flash floods.

These difficulties have led to answering the main question in this study: *What are the key factors that influence the vulnerability to flash floods of the community in the Safende district?*

The methods used to address the City of Praia's vulnerability and to answer the research questions are related to the exposure to flash floods in the Safende district, to the experience and to the reduction of the resident's vulnerability to flash floods in the Safende district.

To determine the exposure of the residents to flash floods qualitative research is approached, including conducting literature review, making observations, and conducting a review of a hydraulic study of the flood-risks in the Safende district. Exploring the experience of the residents during the floods of 2020 is conducted by a survey. This survey concludes questions related to resident's characteristics, experiences, measures taken, perceptions, alerts, and the needs of the residents of Safende. This data and the data of the method exposure form the base in the motivation to determine that reducing vulnerability of the residents could be executed by non-structural measures. This includes creating awareness among the residents exposed to flash floods in Safende. Suitable stakeholders are chosen to accommodate the main difficulties of the residents and proposed requirements. Literature is reviewed to gain insights into international approaches for integrating awareness strategies and reducing vulnerability to flash floods.

The fourth chapter of this study discusses the results obtained from the method exposure. Evaluating the statistics of the review study, information about the future flood-risks of Safende was obtained with data of the water height in 50 and 100-year return periods. Furthermore, the current state of the Safende river and from both drainage channels were observed, with the description of a critical junction point where the river and both drainages collide in the Safende district.
The fifth chapter of this study analyzed the results from the survey questioned to 22 residents of Safende. The results showed that over a third of the respondents is situated in households vulnerable to flash floods and that almost 70% of the respondents have been personally affected by flash floods but have not succeeded in adjusting the effective measures to reduce their vulnerability. The 30% of residents that have not been personally affected by flash floods have taken measures to reduce their vulnerability or live higher in the valley. Overall, a majority of the respondents agree that they live in a flood-risk

area. Furthermore, the results showed that residents are interested in different ways they can reduce their vulnerability to flash floods and show the importance of being warned before the flash floods occur. Which can be concluded as wanting to enhance their flood-awareness.

Chapter 6 discusses the need to reduce the vulnerability of flash floods of the residents in the Safende district. It emphasizes on the importance of increasing the flood-awareness of the residents in Safende district with the potential collaboration of the Civil Protection Praia and the NGO Safende Tudora. Both parties have societal interests in reducing the vulnerability to flash floods. Furthermore, a strategical planned for this collaboration is elaborated, with the advice to both stakeholders to participate in exchanging their knowledge and give trainings on flood-awareness with each other to organize training sessions about the risks of flash floods with the residents of Safende. The results also showed the importance of regular evaluation of both stakeholder's actions in the approach to spread flood-awareness in the Safende district.

In conclusion, the objective of this study, which aimed to understand the factors affecting the vulnerability to flash floods in the Safende district. The studies key findings included the prediction of future flood-risks, the personal implications experienced by the residents and the dissatisfaction with current governmental measures in the Safende district. Where the potential collaboration of the Civil Protection and the NGO Safende Tudora is highlighted as a solution to fill in the knowledge gaps and increase flood-awareness of the residents. Through preparation between both parties and educating the residents on this topic.

Hereby this study provides several recommendations to the Civil Protection Praia and the NGO Safende Tudora:
Conducting a future study with a larger and more diverse group of individuals to obtain more conclusive information about the vulnerability to flash floods in the Safende district and other informal settlements from similar size.
Second, to provide a follow-up study with an instruction guide on what specific aspects should be observed on in the neighborhood. Additionally, identify residents or other researchers who can help observe a larger area with the help of these instructions. The last recommendation is mainly advised to the Civil Protection of Praia. It is to invite independent experts who have researched vulnerabilities and solutions to flash floods for a brainstorming session. Particularly the professors of the Universidade de Cabo Verde who have done much research about the City of Praia. This session can uncover unpublished research and compare it with existing structural plans to identify the most promising measures to reduce vulnerability to flash floods in the City of Praia.

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Glossary and definitions

Glossary	**Definitions**
Archipelago	A group of islands and the sea surrounding them (Oxford University, 2023).
Landslide	A mass of earth, rock, etc. that falls down the slope of a mountain or a cliff (Oxford University, 2023).
Flash flood	A sudden flood of water caused by heavy rain (Oxford University, 2023).
River basin	An area of land around a large river with streams running down into it (Oxfort University, 2023).
Flood risk	A combination of the probability and the potential consequences of flooding. Areas at risk of flooding are those at risk of flooding from any source, now or in the future (Department for Levelling Up, Housing and Communities, 2022).
PEDS	Strategic Plan for Sustainable Development – Cabo Verde (Government of Cabo Verde, 2017).
Paris Climate Agreement	A legally binding international treaty on climate change (United Nations, 2023).
Perception	An idea, a belief or an image you have as a result of how you see or understand something (Oxfort University, 2023).
Resilience	The ability of people or things to recover quickly after something, such as shock, injury, critical event etc. (Oxfort University, 2023).

1. Introduction

The introduction outlines the framework within which study falls. It also indicates the objective of the research and the problem statement containing the problem in professional practice on governance, spatial and technical level.

1.1. Cause

It's a worldwide fact that climate change impacts our precious world. While climate change is global, the poor are disproportionately vulnerable to its effects. Due to the prevailing low levels of socioeconomic growth in Africa, its economical unavailability makes it harder for its countries to buffer themselves and recover from the worst of the changing climate effects. This doesn't mean there shouldn't be made efforts to adapt to climate change. It is a global problem where some countries need the global support by investing in resources to afford goods and services for Africa's developing countries (UN Environmental Program, 2023).

Cape Verde, a small archipelago, and island, about 500 km from the West-African coast is also suffering from the negative effects of climate change. Cape Verde's extreme and irregular weathers of long periods of drought and a short and intensive rainfall season have caused extensive damage to people's livelihood in urban and rural areas (Mendoza-Grimon & Fernandez-Vera, 2021).

The largest island in Cape Verde is the island of Santiago, where the country's capital, Praia, is located. As the island is designated from volcanic scenery the area can be divined as a set of plateaus surrounded by valleys with big height differences (Cabo Verde). It is encompassed by small-scale catchments containing rivers that flow towards the Atlantic Ocean. Due to the limited size of these catchments, the low-lying neighbourhoods of Praia in particularly are highly vulnerable to flash floods. These rapid and sudden flooding occurrences are brought on during Cape Verde's rain season from August to October (Global Facility for Disaster Reduction and Recovery, 2019).

Praia is strongly experiencing the stresses of urbanization. Since the year 2000 the annual growth of population increases with 2.89% (Devermont, 2021) (World Population Review, 2023). From approximately 160.000 citizens in 2017 to 189.000 citizens in 2023 and is making Praia the biggest urban centre of Cape Verde (World Population Review, 2023). The rush of newcomers has overwhelmed Praia's low-density urban environment which has resulted in a lack of affordable housing and illegal urban planning with nearly one-quarter of Praia's population living in informal settlements. Due to its lack of economic density, it is difficult to provide safe infrastructure to reduce the vulnerability to flash floods (UN Habitat, 2023).

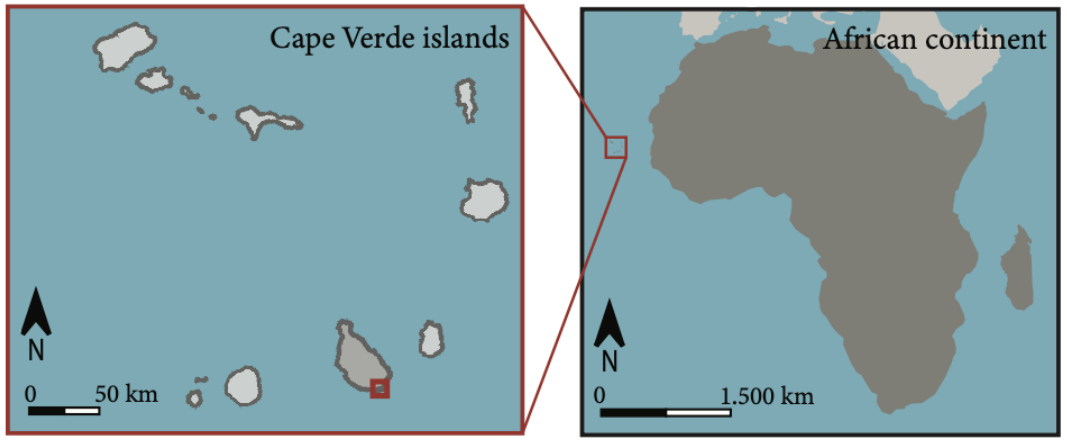


Figure 1 Cape Verde Islands and African continent. (Source: A. Sayyad-Hartounian)

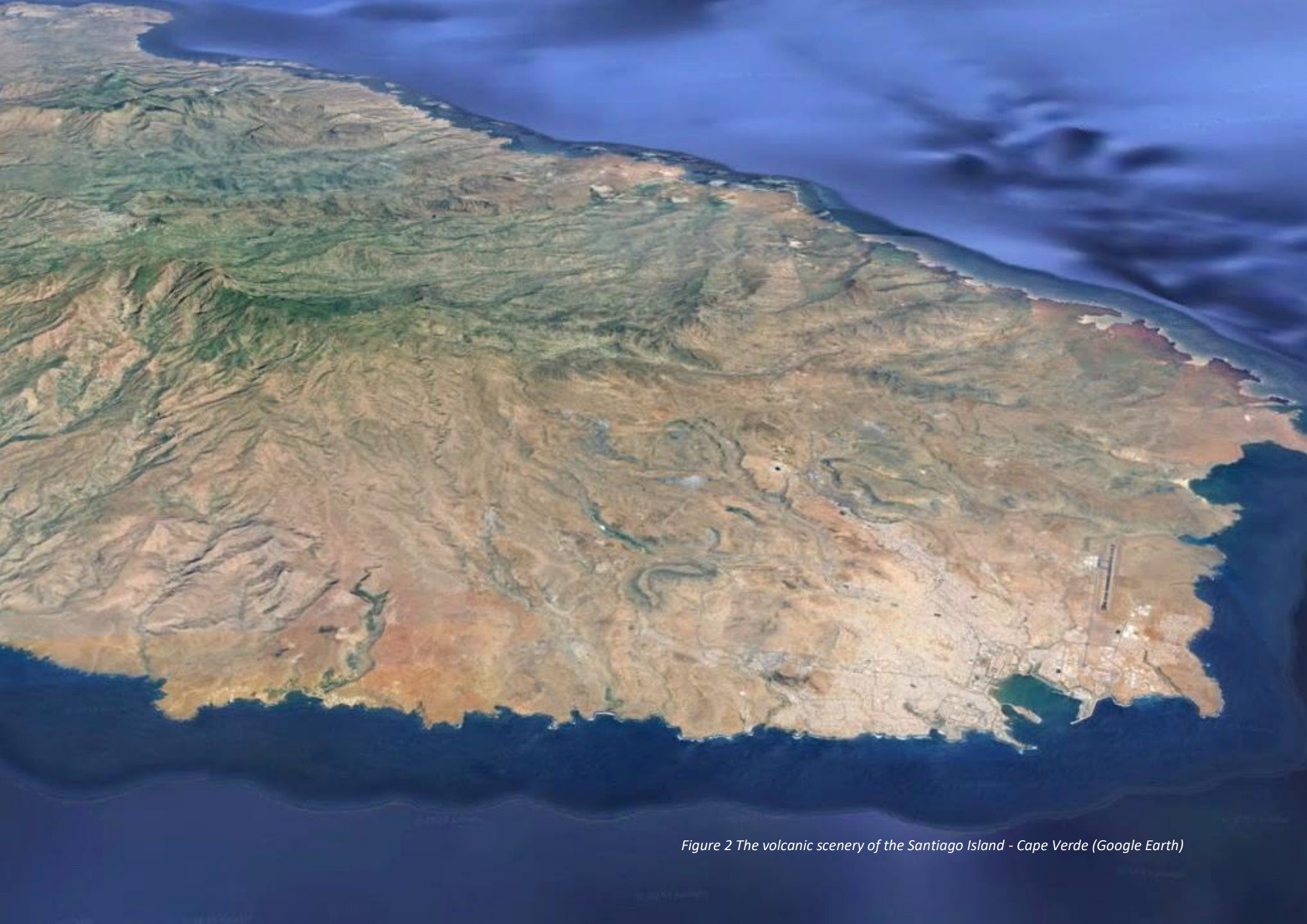


Figure 2 The volcanic scenery of the Santiago Island - Cape Verde (Google Earth)

1.2. Challenges urban city

In this chapter the current state of technical, spatial and governance aspects, situated in Praia have a great influence on how to adapt to these climate changes.

1.2.1. Geographical location and infrastructure

As said earlier, the capital of Praia has been a victim of its geographical position. It is a subject to a wide range of natural hazards resulting in severe climatic conditions with extreme aridity and high irregularity. The extreme weather conditions like, heavy precipitation, uphold the risks of landslides on slopes, and flash floods (Monteiro, Cunha, & Satander Freire, 2016).

The capital of Praia is connected to different basins in particularly the Trindade basin, seen as the wettest area of the municipality, where a great variety of low laying districts (valleys) of Praia are located and affected during heavy rainfall, see figure 3 (Borges, 2013). Figure 3 shows the Trindade basin with its several streams including the Trindade and Safende river. Figure 4 shows the informal settlements that are vulnerable to flash floods caused by the high-risk river streams.
These extreme events have made a huge impact on people's livelihood particularly in informal settlements, located in these valleys. These informal settlements are vulnerable because of the lack of urban facilities, with precarious residences, dominated by unfinished construction of cement blocks, occupation of unstable slopes and riverbanks.

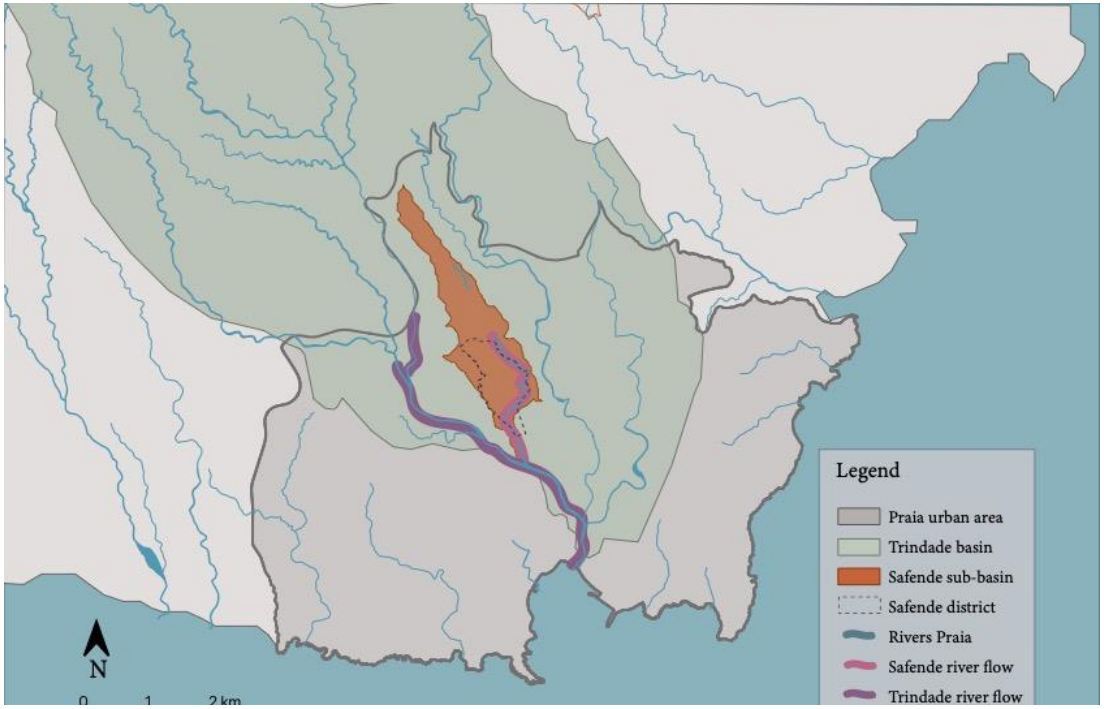


Figure 3 The Trindade river positioned in the Trindade Basin. (Source: (Municipality Praia, 2021) edited by A. Sayyad-Hartounian)

The inner city of Praia provided better infrastructure than in surrounding valleys. In informal settlements the government has almost no territorial advantage which has resulted its current spatial situation in a chaotic use of landscape and is hard to intervene by the Municipality of Praia, which increases the informal settlements vulnerability to flash floods. (Fuller, 2019) (UN Office for Disaster Risk Reduction, 2023).

During the flash floods of 12 September 2020, one of the highly affected areas, was the Safende district seen in figure 4. The district is in the Safende basin and directly built in the river Safende and its branches. Figure 2 gives a visualisation of the elevation in Safende, with particularly its lower area, 'Safende-low', mostly located in a flood-risk area.
Safende has been part of international governmental projects reducing its vulnerability to flash floods by building drainage channels to reduce its vulnerability to flash floods (Lopes Monteiro, 2022). Unfortunately, with high-intensity rainfall occurring from 30 mm to 130 mm rain in one day or a few hours, these measures have not effectively protected Safende's citizens and its infrastructure during the flash floods in 2020 in figure 5.

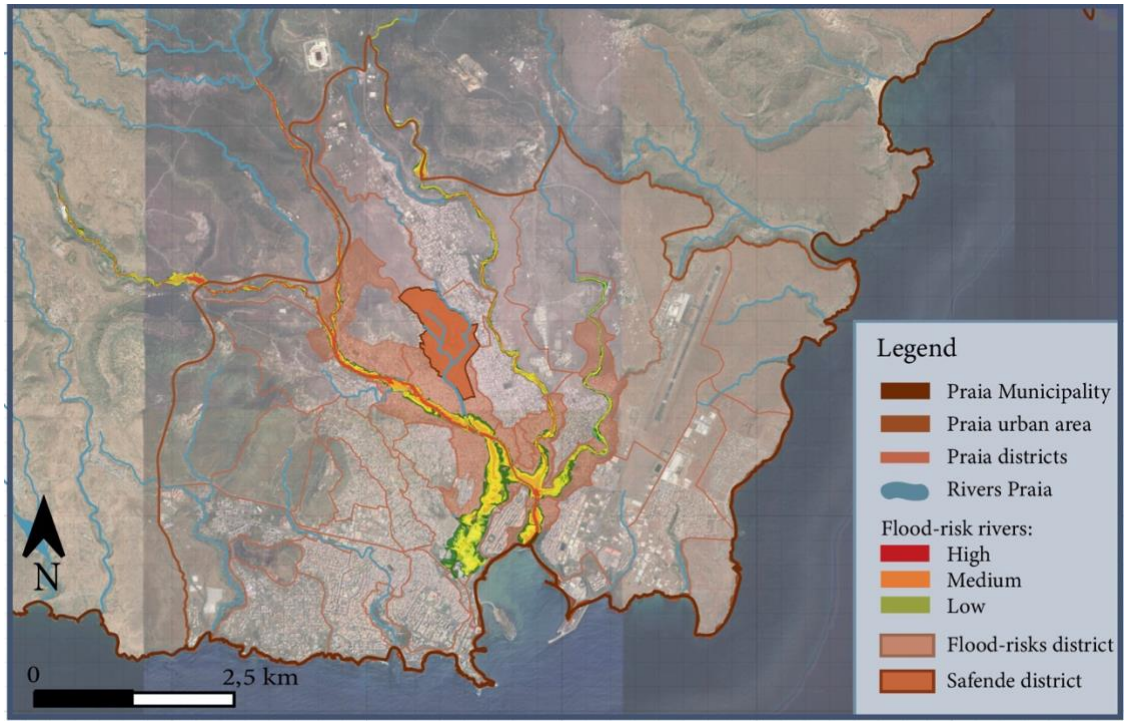


Figure 4 The flood-risk rivers and the connecting districts in Praia

With most of the residents of Safende living on Cape Verde's average minimum wage of approximately 140 euros per month, Safende is seen as one of Praia's deprived areas. It is assumed that most residents have an economic disadvantage and most 40+ year old residents are illiterate and only speak Cape Verde's old language 'Creole'. Therefore, Safende's residents are depending on efficient flood-risk interventions to educate themselves about their vulnerability to flash floods, to reduce water damage to their homes and to reduce the vulnerability of infrastructure so the residents could continue to go to work (Pina, 2023).
For example, only 40% of Praia's population is legally connected to the sewage system. These areas are mostly uphill in the valleys, while lower areas usually illegally connect their house to the sewage system with its current sewage system not capable of collecting high intensity rain. Furthermore, during flash floods, it is complex to identify exactly how much precipitation has reached the surface because of a little amount of rain stations not specifically identifying the amount of rain per district. Also, in informal settlements the economic damage is difficult to calculate due to the unregistered buildings. Data from the rain stations are not easily accessible and not open to public which makes it complex to have access to rain data in short term (Pina, 2023).

1.2.2. Governance

From the PEDS, the Cape Verde governments ambition is to increase its commitment to modern and safe infrastructure. Such as investing in modern meteorological and climatic information to systematically measure, store and publicise it. Furthermore, a national research programme has been established that contributes to studies on sustainable development through scientific research in the economic, social, and environmental fields (Government Cabo Verde, 2017).

Unfortunately, the socioeconomic disadvantage and the lack of concrete plans and enforcement of these plans make for inefficient preparation and implementation of climate adaptation measures in Praia City (Barros Correia, 2022).
It is estimated that the floods that occurred in the city of Praia in September 2020 caused estimated losses of agricultural income at US$2 million. With 150.000 people, houses, land, and crops affected by the September 2020 flash floods in Praia, Cape Verde has ranked 130th out of the 180 countries on the 2021 Global Conflict Risk Index GCRI. The country's heavy debt and dependence on foreign financing and investment exacerbate financial exposure and vulnerability to climate change (Ministry of Agriculture and Environment, 2021). Although financing climate action in Cape Verde is estimated at 2 billion euros, the country is on track to meet SDG 13 on climate action. It has also been ranked 11th out of 180 countries in the World Risk Report in 2019. Failure to meet the Paris Climate Agreement could result in a GDP loss of 0.1-0.27% by 2030 and 2050 (African Development Bank Group, 2022).
From conversations with Civil Engineer experts at ANAS, the international funds that Praia receives are largely used to pay for preparation which leads to minimal financial support to execute decent infrastructure to protect informal settlements from floods (Lopes, 2023).

As shown in figure 4, the rivers seen as potential high risk for floods is the Trindade river. Talking with flood-risk experts and confirming the current public flood-hazard mapping by the Municipality is incomplete, by not referring to other rivers in Praia creating flash floods in informal settlements (Silva P. , 2023). For example, the Safende river, shown in figure 5 also caused flash floods in 2020 in the Safende district.
This is partly due to the lack of legislation by the Municipality of Praia to create and publicise accurate flood-hazard mapping of Praia on districts level. This problem originates from the rapid grow of informal settlements (Barros Correia, 2022).

Figure 5 The flash floods on 12 September 2020 in the Safende district

Figure 6 The Safende district – Municipality of Praia. (Google Earth)

2. Theoretical Framework

This chapter describes the current knowledge related to the research topic and describes developments and solutions paths that could be implemented in the Safende district, regarding the city of Praia. Furthermore, the knowledge gap and scope from the preliminary research are stated to give more structure to the elaboration of this study. As last the conceptual model of this study is presented.

2.1. Literature review

The literature review describes the current knowledge about flash floods from different researchers internationally and nationally in Cape Verde. It describes various sub-topics related to the research topic and serves as preliminary research of this study. Furthermore, developments and solution paths for the aim to reduce the vulnerability to flash floods have been elaborated from the preliminary research. Which could be related to the Safende district.

2.1.1. Current situation and knowledge

The current situation in Praia, regarding Safende from the preliminary research are stated in the following sub-topics.

Natural hazards as a phenomenon

Agrawal defines natural hazards as a natural phenomenon that cause damage to infrastructure, possessions, and ecosystems, as well as harm individuals 'mental health'. These damages are the aftermath of natural hazards and are defined as disasters. Natural hazards can be classified by origin, nature and speed, or size and scale. In addition, this study explains that one of the most common large-scale hazards as physical hazards are floods (Agrawal, 2018). Navarro, et al. states that a flash flood is a type of phenomenon characterized by the rapid flow of a chaotic mixture of solid materials and water that can move at high speeds and typically occurs in mountain basins (Navarro, et al., 2020).

Vulnerability to flash floods

Furthermore, Rougier et al. defines that both our vulnerability to natural hazards and the uncertainty about future natural hazards frequency increases by climate change (Rougier, Sparks, & Hill, 2013). With Monteiro et al. adding that the concentration of increasing populations, critical infrastructure in urban areas with low economic power and the development of exposed flood plains are factors that contribute in this in the city of Praia (Monteiro, Cunha, & Satander Freire, 2016).

Social vulnerability to flash floods

However, during the floods of September 2020 a great disruption of infrastructure and social vulnerability namely in the neighbourhood of Safende was experienced, in figure 5. To elaborate on social vulnerabilities, Martins et al. researched the flood-risk perception by the population of the island Sao Vicente in Cape Verde. He states that citizens agreed that flash floods are a high personal hazard, provoke fear, are not predictable and will tend to increase in the

future. He elaborates on the findings that risk perception is intrinsically subjective and that flash floods risk perception is a complex process wherein local conditions have a major effect on people's knowledge and behaviour (Martins, Nunes, Lourenco, & Velez-Castro, 2019).

Community vulnerability
Zhong, et al. describes that mitigating with hazard risk management, a community is the smallest scale in this concept. Which makes it more vulnerable to flash floods (Zhong, Xiao, Zhang, & Jiang, 2021).

Informal settlements
Discontinuous territories are linked to the definition of informal settlements that are expanding in many parts in Africa. Consequently, most of these settlements are prone to flooding after prolonged precipitation. These settlements are often characterized by high population growth and poor infrastructure (Musungu, Motala, & Smit, 2014).
According to Monteiro (p.195) the increase of unplanned areas at the bottom of the valleys in municipal of Praia, constitutes an aggravating factor of the risk of flooding during the heavy rain season (Monteiro S. M., 2016).

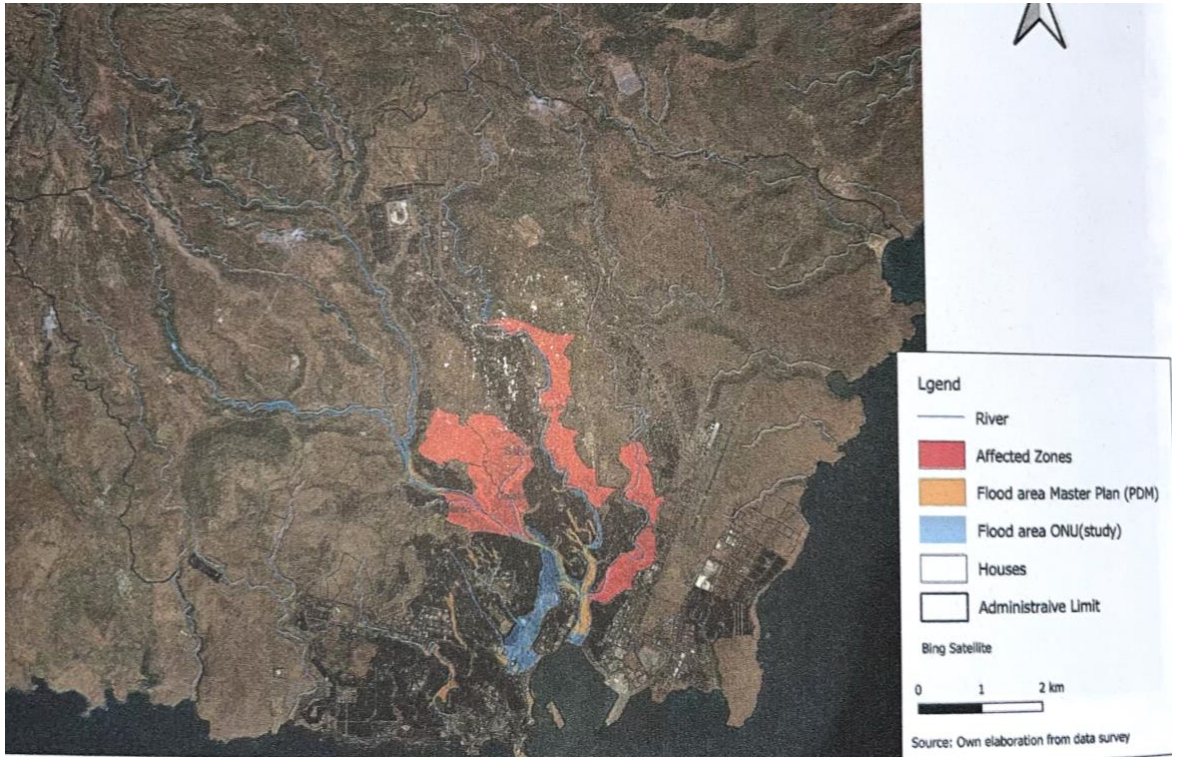


Figure 7 Areas most affected by floods of 12 September 2020, Praia Municipality, Cape Verde Source: (Carlos, 2022)

Carlos (2022) also highlights the susceptibility of Praia's urban area to natural hazards, particularly floods and inundations, are due to a lack of awareness in informal settlements, from the book in appendix 1.1. The 2020 tropical storm affected many neighbourhoods like Fazenda; Safende; Agua Funda; Paiol; Sao Paulo and Sao Pedro, see figure 7 and appendix 1.1. (Carlos, 2022). Silva (p.782) stated that in these settlements there is a scarcity of infrastructure, in the area to delineate the rivers, in high-density locations especially in the Safende district (Silva & Negreiros, 2017).

2.1.2. Developments and solution paths
The developments and solution paths in the preliminary research are stated in the following sub-topics.

Risk management and mitigation

Ferreira Semedo describes essential tools in risk assessment that should be the basis for decision-making in the Safende district. When prioritizing intervention in risk mitigation, contingency and response planning, assessment of vulnerability to prevention or reconstruction actions that improve risks, it is necessary to use essential tools in risk assessment that should be the basis for decision-making in different areas (Ferreira Semedo, 2021). These tools stand out as:

- The focus on civil protection and hazard maps, with the emphasis on preparing for the response, emergency, hazard identification and assessment and exhibition.
- Spatial planning and sustainable urban management combined with understanding flood-risks at different levels.

Ferreira Semedo's hydraulic modelling modifies considerably the flow as well as the impacts of the floods. Therefore, its modelling is solely based on digital terrain models and require a terrain validation. He elaborates on the fact that informing population groups, sectors, and different users to give information about prediction of extreme events not in scientific terms, but to communicate in a way to of the potential flood impacts (Ferreira Semedo, 2021).

Monteiro indicates that risk management aims to mitigate risks by reducing vulnerability or susceptibility/hazardousness. It involves the identification of risk and its acceptability (by technicians and politicians), as well as its prevention, preparation to respond to crisis situations and the respective recovery, to reduce its destructive effects (Lopes Monteiro, 2022). Carlos elaborates that flood-risk can be mitigated by reducing vulnerability through structural and non-structural measures, such as river bank, dam, diversion channel and so on and the non-structural measures, such as human activities and awareness, development of disaster information at the time of emergency and so on (Yachiyo Engineering CO., LTD., 2016) (Carlos, 2022).
Monteiro (p.287) elaborates this by identifying solution approaches, in structural and non-structural measures, that can help mitigate climate risks in the Municipality in Praia, which broadly amounts to the following:

Flood-risk structural measures:

- Integrated management of water resources in the hydrographic basins located upstream of the urban area, namely the Trindade and Palmarejo Grande, is necessary. This management will involve the implementation of structural measures such as heavy correction works (small or large size, of water barriers) and flow basins and rainwater retention, as well as the maintenance of existing infrastructure in these basins.
- Moreover, better planning and arrangement of urban land, restriction of occupation and use of land according to their vocation, is essential. To achieve this goal, it is necessary to approve the municipal Master Plan of the Praia municipality.
- Participatory planning is also recommended. Additionally, hazard/sensitivity maps should be used and updated to support public policies of mitigation and risk reduction.

(Lopes Monteiro, 2022).
S. Monteiro (2022) further addresses an example of structured measures, developed by the NGO Africa 70, in neighbourhoods of informal settlements in Safende district in 2019 (Lopes Monteiro, 2022).

Flood-risk non-structural measures:
To increase awareness, Monteiro advises that information and training campaigns should be conducted in areas considered high-risk to flash floods. To this end, informative lectures, and direct contacts should be established (Monteiro S. M., 2016).

Martins, et al. elaborates on the importance of studies including people's social and cultural interpretation of flood risk instead of being limited only to statistical data (Martins, Nunes, Lourenco, & Velez-Castro, 2019).
Okoth Okaka and Odhiambo elaborate the mitigation of risk by reducing vulnerability through non-structural measures. The study showed that non-structural measures provide evidence about how residents of flood-prone informal settlements perceive flood risk and how the exposure to flooding impact their health. Okoth Okaka and Odhiambo elaborate that a households decision affects the vulnerability to a disaster risk and choice of action. The study indicated that flooding had a negative physical and mental health impact on members of households. Although adaptive measures were taken by most households, a majority of these were short-term, mainly due to financial constraints, lack of knowledge and government support. In this case perception of flood risk and gender were found to have a strong influence on taking long-term adaption measures at the household level (Okoth Okaka & Odhiambo, 2019).

Martins defines that by creating educational programs on flash flood risks, through training sessions, informational flyers, and other sources of communication. The focus must be on understanding the causes and possible consequences of floods to public (Martins, Nunes, Lourenco, & Velez-Castro, 2019).

Flood-risk perception
As last, Zhong, et al. the findings in Zhong's study suggests that the communication inside communities can influence the actions taken to reduce their vulnerability to flash floods. This creates a perception on flash floods and helps people to decide how to contribute to enhancing the community's resilience, based on the appropriate actions taken that contribute to the mitigation of future flash floods (Zhong, Xiao, Zhang, & Jiang, 2021).

2.2. Knowledge gap

The research appointed in the problem statement indicates that the database of the Municipality of Praia shows very little or no information and mapping about flood-risks, on a district-level. It is assumed that there is also very little, or no information known about the vulnerability of the people and people's perception to flash floods for Safende.
In this study there was no concrete information found about the experiences of the residents in the aftermath of the flash floods in 2020 in the district of Safende. This study did not conduct any other study, apart from Silvia's research in 2016, that have examined the residents' perceptions to flash floods in times of heavy rainfall in the City of Praia.

Ferreira Semedo's study is particularly focused on the technical components of investigating flood hazard mapping of the Safende district. The study concludes that a terrain validation in Safende is needed to compare its flood-risk assessment with the reality. Furthermore, the study advises that it is of great importance to look at the impact on the community in Safende after the flash floods of 2020.
Understanding these factors may be significant for government agencies that are the enforceable body of the implementation of flash flood protection and awareness measures. This study may also be of interest to local organisations that are a reliable source for most communities.

This study fills these gaps and provides new insights into the factors that contribute to the community's vulnerability to flash floods in Safende district.

2.3. Scope

This study focuses on the Safende district, one of the highly impacted neighbourhoods by flash floods in Praia, particularly deeper in the valley, called Safende 'entrada', see figure 8.

This study focusses mainly on the aftermath of the tropical storm in 2020 during the rainy season from August to October which had affected the low part of the Safende district. This study focusses on the vulnerability of the community in the Safende-low area, seen in figure 8. From the resident's perspective information about their experiences, perception, needs etc are conducted. Followed by an observation of the areas where residents of Safende are questioned.

Technical calculations and the elaboration of hydraulic modelling are beyond the scope of this study. On this aspect, this study provides a review on the hydraulic modelling of the Safende sub-basin that has already been executed in 2021. Furthermore, repeated interviews with governmental agencies are also beyond the scope of this study and will retrieve general information from the involved parties

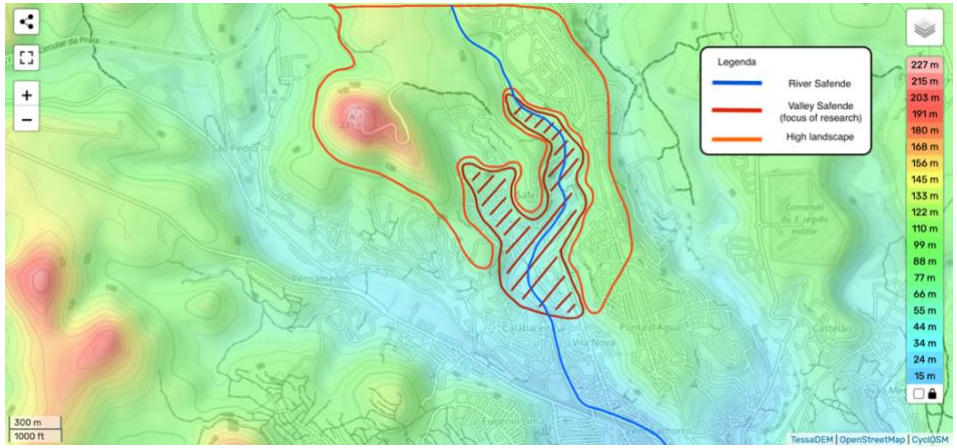


Figure 8 The scope of research

2.4. Objective

The objective of this study is to understand the factors influencing the Safende communities' vulnerability to flash floods. By understanding the circumstances, they are exposed to, during the flash floods in September 2020 and by verifying resident's experiences and taken actions during the flash floods. Also, by verifying their perception to flash floods to give new insights and a better understanding of the factors that influence the resident's vulnerabilities to flash floods. Then, to use these findings to identify an appropriate solution to reduce the vulnerability to flash floods, considering the economic feasibility of the residents and the lack of resources of involved governmental authorities to implement flood-risk measures.

2.5. Conceptual model

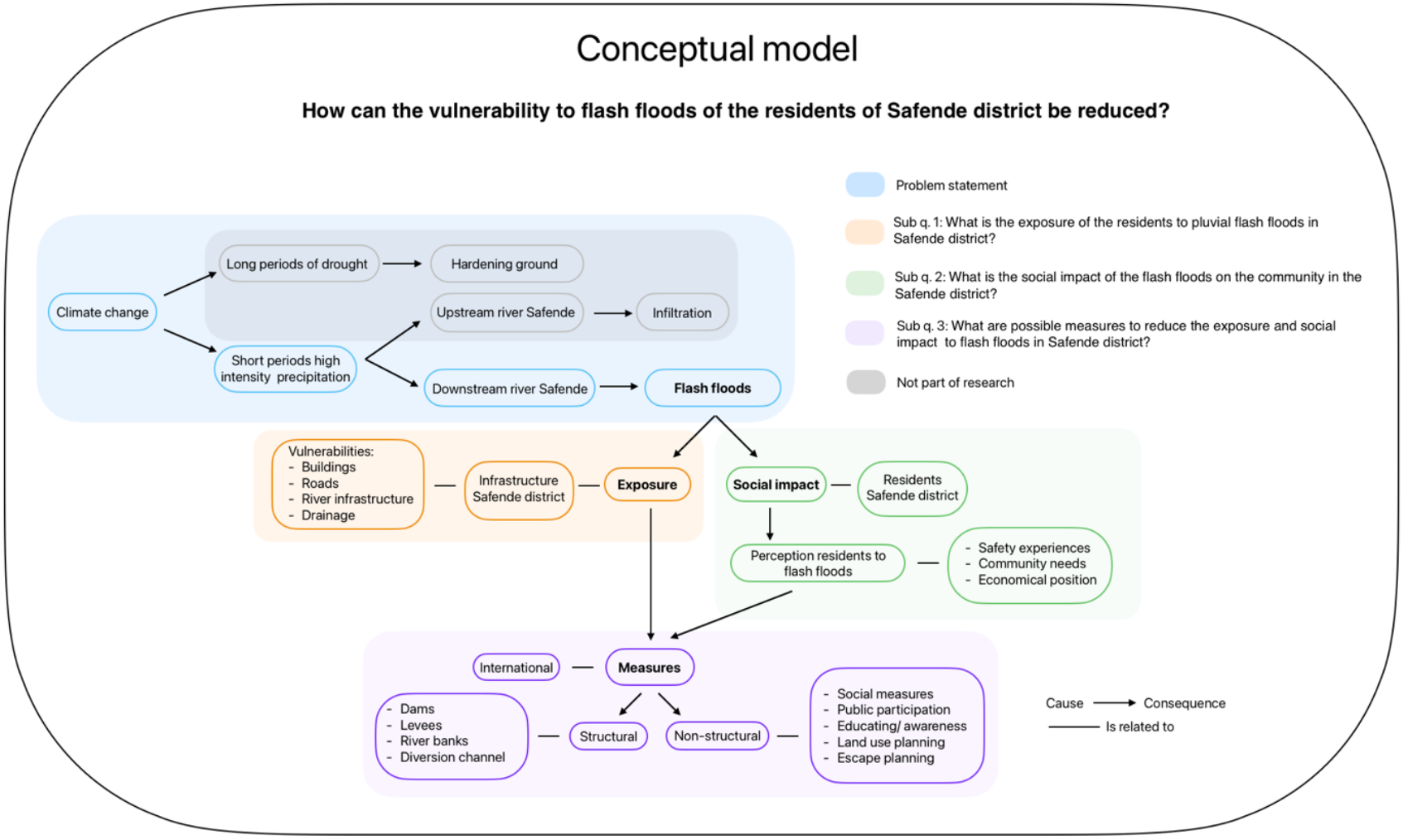


Figure 9 Conceptual mode. Last updated April 202.3 (Source: A.Sayyad-Hartounian)

3. Research plan

To answer the main question, several research methods have been established and are used during the study. First, the main question and sub-questions are stated. Then, for each sub-question, the research method and its reliability and validity are specified from which the professional product is formed. In this study the following main question and sub-question are answered:

What are the key factors that influence the vulnerability to flash floods of the community in Safende?

Sub-questions and the appropriate methods:

Table 1 Summary research plan

Summary research plan	
Sub questions	Research method
1. What is the exposure of the residents to flash floods in Safende district?	• Literature research • Data- analyses and QGIS mapping • Observation (fieldwork)
2. What is the social vulnerability of the community in Safende to flash floods?	• Surveys (SPSS) • Observation (fieldwork)
3. What are the possible measures to reduce the vulnerability of the community's exposure to flash floods in Safende?	• Literature research • Design-oriented research

Sub-question 3 is consecutive to sub-questions one and two, as the information from the first and second sub-questions is the determining factor to explore which measures are promising to apply in Safende. On the following pages, the methods for each sub-question are elaborated more concretely.

3.1. Method exposure

The following sub-question is addressed:

"What is the exposure of the residents to flash floods in Safende district?"

To answer this research question, qualitative research is conducted. Literature review, observations and QGIS mapping are used to understand what and where the current spatial vulnerabilities are in the Safende district.

Literature research

This method is used to understand the current state of floods risks in Safende and the volume of rainwater that intrudes Safende. Specific literature is collected through Google Scholar and books collected from the Universidade Cabo Verde. Also, the approach to the sources found online is as follows:

- Academic sources are used only those published from 2013 and after.
- Journals and newspapers articles that are not scientifically/governmental characterised are not used.
- The use of pictures documented in times of flash floods in 2020 are checked for relevance by fact-checking its date and location.
- The relevance of a source is determined by reading the abstract and conclusion of source.

The following terms are searched in Google Scholar:

Table 2 Search terms method exposure

Primary search terms	Relevant Second research term
Flash floods	Floods
Rain season	Precipitation
Flood risk-mapping	Flood risk
Trindade basin	Safende river
Unplanned areas	Informal settlements
Safende	Praia
Natural hazards	Natural disaster
Risk map	Vulnerability map

3.1.1. Review study hydrological Safende sub-basin

The study of S.J. Ferreira Semedo is evaluated to understand the hydrological modelling and hydraulics behind areas that are assumed to be vulnerable to flash floods in the sub-basin of Safende. The following steps are taken to understand and evaluate the hydrological assessment by S.J. Ferreira Semedo of the Safende sub-basin:

- Methods used in the study.
- Understanding the relation with HEC-HMS and HEC-RAS with the SCS.

- An evaluation of the used rain data.

3.1.2. Observations

Observations are done to support the literature about flood-risk statistics in Safende. This approach is based on geomorphological active areas within the Safende river streams and the drainage channels.
During the observations the following topics are accessed:

- Current state of Safende river and branches
- Current state of drainage canals
- Water damages

As last, the programme of SW Maps is used to digitalise the observations done in this study. SW Maps is a free QGIS and mobile mapping app for collecting, presenting, and sharing geographic information. It allows to save pictures and notes on coordination and transferring the data to QGIS.

3.2. Method experience

The following sub-question is addressed:

"What is the social impact of the flash floods on the community in the Safende district?"

3.2.1. Survey

To answer this sub-question, a survey will be used to understand the factors that play a role in residents' vulnerability to flash floods, and what their perspective is to flash floods.

Target group

The residents of the Safende-low district who have experienced, particularly, the flash floods in 2020 and have or have not been personally affected by the flash floods. The residents will be selected randomly but are required to have a minimum age of 18 years.

Preparation

Many residents in Safende do not speak, read, and write the Portuguese language. Most residents speak Creole and do not read or write. For this, the survey will be translated to Portuguese and at least two translators will be available during the fieldwork. Open questions will be written down in Portuguese and translated after the excursion.

Implementation

- Methods and questions from other studies done in Safende have been inspired in the making of the questionnaire (Okoth Okaka & Odhiambo, 2019).
- Translators of Creole to Portuguese and from Portuguese to English are requested to aid during the interviews.
- The surveys will be completed face to face and filled in during the first interaction with the residents.
- Participants must give their consent verbally before the interview.
- Two test surveys will be applied with two residents and evaluated before other residents participate in the survey.
- Construct validity is measured by using scales in the questionnaire in which a score is given as an answer.
- The survey is mostly based on multiple choice questions to validate answers. The minority of open questions will also be included in SPSS.
- Each interview is done with the same questionnaire and method of the above, see appendix 3.1.

This survey is mainly focused on the flash floods that have occurred in 2020 in Praia. The survey will be focused on different themes to understand the factors that can have influence on their perspective on flash floods. The survey is based on the following themes:

- Characteristics
- Experiences flash floods 2020
- Function measures
- Perception flash floods

- Taken actions
- Alerts and needs

When completing the surveys, the total results will be evaluated in the Statistical Package for the Social Sciences (IBM SPSS) and compared to verify the reliability of the answers. SPSS it is possible to easily analyse large amount of quantitative data (IBM SPSS, 2023). After the evaluation, the results will be compared with the observations from the first sub-question to understand the factors that influence the vulnerabilities to flash floods of the residents in Safende.

3.3. Method reducing vulnerability

The following sub-question is addressed:

"What are possible measures to reduce the exposure and impact on the Safende district?"

3.3.1. Evaluate previous results

To answer this sub-question, it is important to understand the different type of measures that can influence factors that increase the vulnerability to flash floods of the residents in Safende.

As said previous in this study, the advised structural measures to control the flash floods in Safende include an integrated management of water resources in the hydrographic basins, including the Safende sub-basin. For an effective implementation of these measures an active role from within the Municipality of Praia is preferred to execute these structural measures.
In this study, the focus has been particularly on the perspective from residents and so emphasizes to non-structural measures, as the following:

Creating awareness among the residents exposed to flash floods in Safende.
Attempting to decrease the vulnerability to flash floods by increasing flood preparedness.
This method is elaborated in table 3.

Table 3 Strategy flood-risk awareness plan Safende district

Strategy for flood-risk awareness plan Safende			
1. Results and conclusions first and second sub-questions		2. Not - structured interviews	3. Own interpretations from results step one and two
Main difficulties	Requirements	Suitable stakeholders	Appropriate plan in preparation for implementation
…	…	…	…
…	…		
…	…	…	

1. The results from the first and second sub-questions view the most common factors that increase vulnerability to flash floods. From these outcomes, the necessities that can reduce vulnerability to flash floods are selected.
2. Secondly, suitable stakeholders are selected, that are willing to recognise the difficulties and requirements, from the resident's point of view, to undergo future cooperation. The stakeholders will be approached by a semi-structured interview to understand their possible role in a future cooperation.

3. Lastly, the previous results from steps one and two are combined to form an appropriate plan that the stakeholders identified can use to prepare for possible cooperation.

3.3.2. Literature

For this method, specific literature is collected through Google Scholar, seen in table 4. The objective of this method is based on understanding international ways of integrating awareness strategies attempting to reduce the vulnerability to flash floods to the people of Safende. The approach to the sources found is as follows:

- Academic sources are used only those published from 2013 and after.
- Academic sources are used in semi volcanic and/or dry landscape and climate as Cape Verde.
- Academic sources have implemented the strategy to provide personal data about needs of residents.
- Journals and newspaper articles that are not scientifically characterised are not used for this study.

The following terms are searched on Google Scholar:

Table 4 Search terms method

Primary keyword/ search terms	**Relevant / similar terms Second research term**
Awareness	Training
Flood preparation	Flood-proofing
Non-structural measures	Measures
Flash floods	
Informal settlements	Unplanned areas
Involvement NGOs	Involvement government agencies

3.4. Professional product requirements

The professional product concerns a brochure that provides recommendations on non-structural measures to the residents in Safende and is based on the following results of this study. The recommendations are simple and supported with images to be understandable for illiterate residents in Safende. The brochure is directly aimed to local organisations, with social objectives in Safende, that are willing to engage and spread flood-risk awareness with the use of the brochure.

As a result, the brochure is not only a method to raise awareness in Safende but can also be used in other informal settlements of need to be more aware of flash floods. Furthermore, the brochure is written in English and Portuguese and is also based on international flood-risk measures.

The measures from the brochure are categorised as the following:

1. Instruction of the brochure for engaging parties

2. Advise to current residents
    - preparation for flash floods in neighbourhood
    - preparations for flash floods in home and in households
    - actions during flash floods

4. Results exposure

This chapter covers the current state of the Safende river and describes the vulnerabilities to flash floods seen during the observation in within the Safende's-low district boundary.

4.1. Evaluating statistics

Semedo developed and tested a detailed hydraulic model using the following methods:

1. HEC-HMS: precipitation in mm/h is transformed into flow of m3/s supported by methods of Soil Conservation Service – Curve Number (SCS-CN). The chosen duration of the flash flood is 4 hours.
2. HEC-RAS: is used for hydraulic modelling with editing geometric elements. Referring to the recent drainage works in 2019 such as ditches, passages, protection walls for dwellings close to streams. The results of the modelling are exported in ArcMap10.8 and reclassified the raster's depth and speed of the floods. The reclassification is shown in four main classes (Low, Moderate, High, and Very High).
3. GIS and ArcGis10.8 ©(ESRI) and its extensions: to calculate some morphometric parameters of the sub-basin.

The simulation from Semedo's study shows the expecting and extreme flood events. Calculating with a T50 and a T100 return period the results show that during the T50 the water height could reach 2.4 meters high in the Safende district and during the T100 this value increases to 3.7 meters. These high numbers coincide with areas where the valleys are naturally narrower in the Safende district. Concluding that an estimated of almost 5% of the Safende subbasin presents a hazard class from 'high' to 'very high'. This low percentage still reveals worrying from the point of view of risks of flooding, because more than 98% of the riverbed area in Safende are marked by urban occupation, see appendix 2.1. hydraulic modelling with the hydraulic modelling maps from the study of Semedo.

4.1.1. Evaluation rain data

A period of 27 years (1976 – 2002) is in Semedo's study used as one of the base data to support the hydrological modelling, shown in figure 10. In this study the rain data from the Civil Protection Praia has been conducted and added to the maximum daily rainfall (in mm/day). Figure 10 shows the added rain data from 2003 - 2021 implemented in the figure used in Semedo's study. The figure shows an irregularity in the maximum daily rainfall in mm recorded at the Praia Airport rain station. Although, table 5 does shows an increase in maximum daily rainfall in mm.

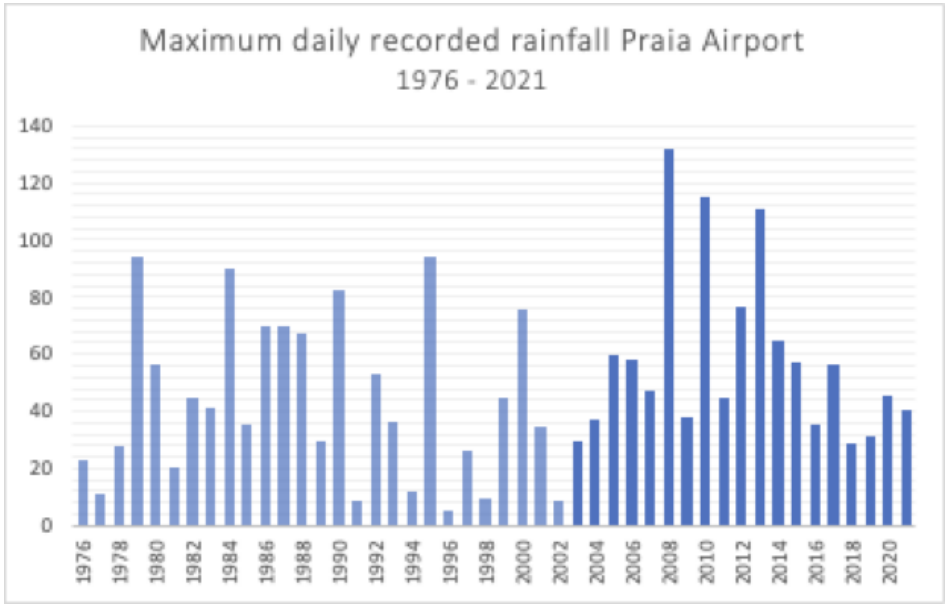


Figure 10 Maximum daily recorded rainfall Praia Airport 1976 – 2021 (Source: (Ferreira Semedo, 2021) edited by A. Sayyad-Hartounian.

Table 5 Comparing maximum and minimum rainfall Semedo's study and current study.

Semedo's study		
Year		mm
1995	Maximum daily rainfall	94,40
1996	Lowest recorded rainfall	5,60
Current study		
Year		
2008	Maximum daily rainfall	132,0
2018	Lowest recorded rainfall	28,90

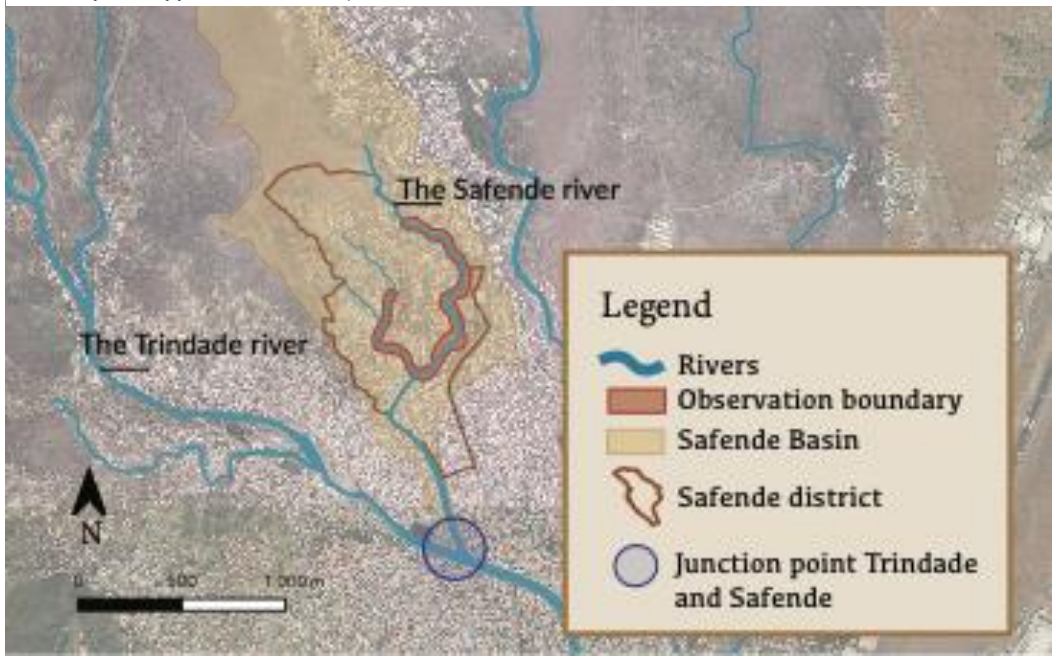
4.2. Current geographical difficulties

This chapter also covers the current state of the Safende river and its branches, the drainage channels in Safende and current water damages allegedly made during the floods of 2020 which are all observed during the fieldwork.

4.2.1. Current state of Safende river and branches

The Safende River is spread over the Safende district and has branches spreading to the west side. In the northern part of the district, the river flows without physical restrictions through its natural flow towards the junction point with the Trindade river in figure 11. The uncontrolled construction of housing in Safende, during the times of urbanization, has taken the lead in spatial planning of the district. This has resulted in houses located in between the riverbanks of the Safende river and in its natural flow.

Figure 11 Junction point Trindade river and Safende river (Source: (Municipality Praia, 2021) edited by A. Sayyad-Hartounian).



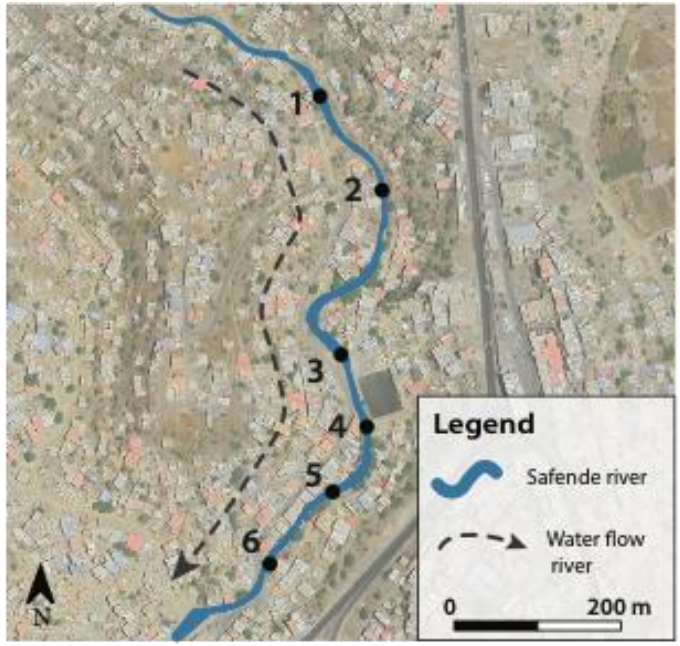


Figure 12 The Safende river and observation marks (Source: A. Sayyad-Hartounian)

Within the boundaries of the observation, the river has almost no construction that can guide the flash floods safely through the neighbourhood. In figure 12 the 'natural' construction of the river Safende is shown, with some construction walls to guide the river. Other structural modifications controlling the river stream during flash floods was not seen in this study's observations and leaves the river in control by the intensity of the flash floods.

Several defects and damages to the Safende river stream are shown in the pictures 1 – 6, where on picture 3 an unpaved road crossing the river is shown. The flash floods reached a height of one meter during the September 2020 floods, which could mean that the road was not accessible during this time.

The Safende river

Figure 13 Pictures from observation marks the Safende river.

4.2.2. Drainage channels

More southern of Safende two drainage channels have been constructed in the Safende River. These channels (A & B) were funded by the African Development Bank Group and implemented by the Municipality of Praia in 2019, see figure 14. These drainage channels serve primarily to guide the river to the main channel of the Safende River where the junction point with the Trindade River is located seen in previous figure 11.
During the observations in this study several defects in the construction of the drainage channels were also encountered. The defects are stated as the following:

Figure 14 Drainage channels built in 2019 (Source: A. Sayyad-Hartounian).

Drainage channel A

Dimensions +/-: Length = 195m/ Width = 1.0 - 1.50 m/ Depth = 0.60 - 1.80 m

Figure 15 shows the drainage channel connected to the Safende's main river branches and located right next to the inhabited houses and is constructed completely open. Beginning and end of drainage channel A are not connected to underground or above ground water works, shown on the pictures in figure 16, where the channel is seen as not finished and demolished. The drainage channel is placed right next to the resident's homes with one commenting that the location of the channel has increased their vulnerability to flash floods. Also, from the resident's experience during the 2020 floods the water height reached far above the channel's depth into the resident's house, stating that the drainage could be too narrow, see pictures from 2020 in see pictures in figures 18.

A comment from a respondent in this study stated the following according to both drainages:

"The government agencies were installing both drainage channels, but the workers did not finish the connection because they saw residents using the unpaved road." Seen in figure 17.

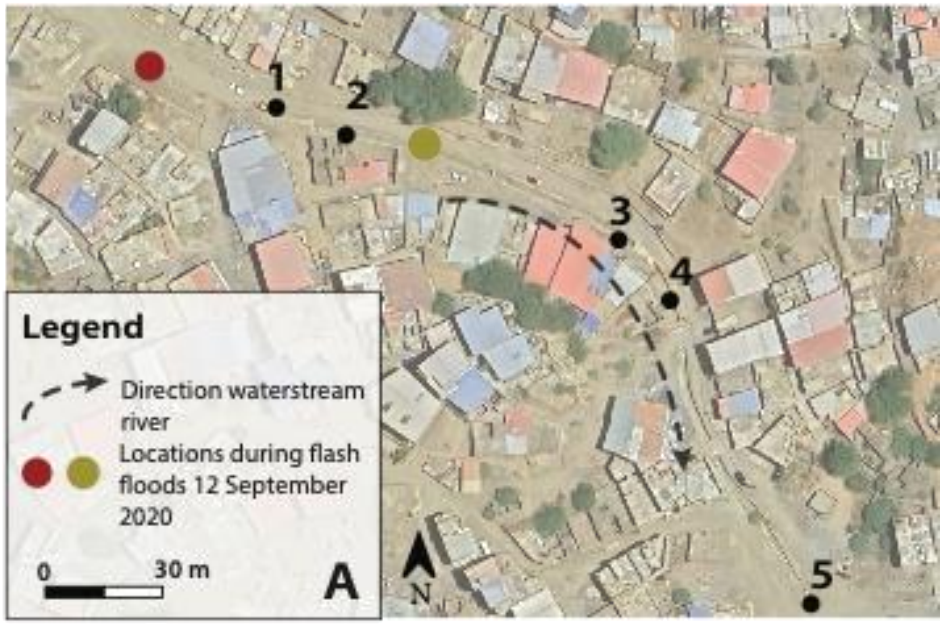


Figure 15 Observation marks drainage channel A. (Source: Google Earth and edited by A. Sayyad-Hartounian

Drainage channel A

Figure 16 Pictures of observation marks drainage channel A. (Source: A. Sayyad-Hartounian).

The pictures below and in appendix 2.2. shows a visualization of the 12th of September flash floods in 2020 in the Safende district. These pictures are taken at the same location as drainage channel A.

Figure 17 Unpaved road blocking drainage channels A & B and the mainstream of the Safende river. (Source: A. Sayyad-Hartounian.)

Figure 18 Flash floods on 12 September 2020 near drainage channel A. Source: (Ferreira Semedo, 2021)

Drainage channel B
Dimensions +/-:
Length = 112 m/ Width = 2.0 - 6.0 m/ Depth = 1.20 - 1.80 m

This drainage channel runs under a bridge connecting the road to the Safende district's entrance and exit points. The drainage channel is connected openly with the mainstream of the Safende river, shown in figure 19. Remarkably, the width and depth of the drainage does not parallel to the natural flow of the Safende river. As shown in pictures 1 – 5 the drainage channel is partly constructed next to the houses of the residents and is by observation very different in size comparing it to the river itself in figure 13 and 20.

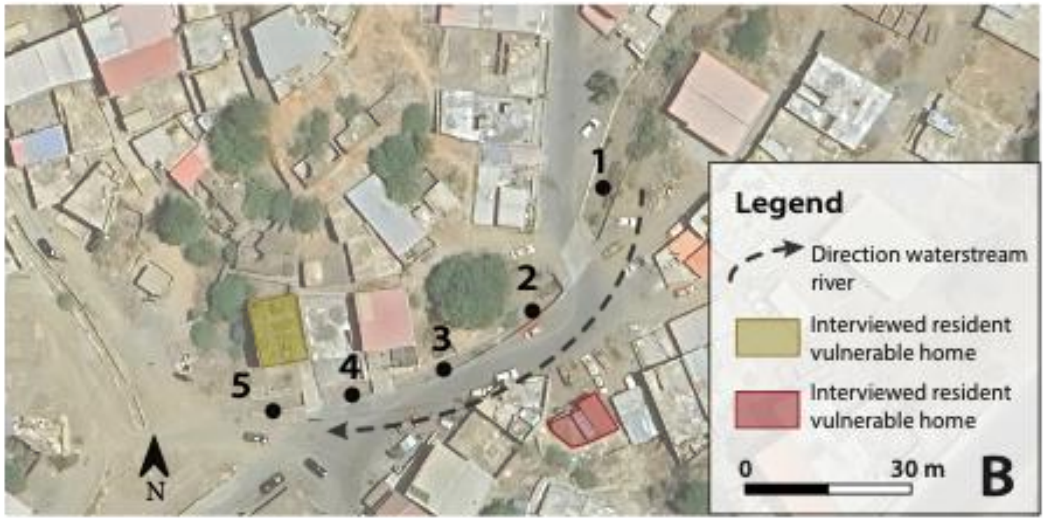


Figure 19 Observation marks drainage channel B. (Source: Google Earth and edited by A. Sayyad-Hartounian)

Drainage channel B

Figure 20 Pictures of observation marks drainage channel B. (Source: A. Sayyad-Hartounian)

During the observations two residents showed the water height on their house during the flash floods in September 2020, see their locations in figure 19 and figures 21 and 22.

Figure 22 Critical home next to drainage channel A. (Source: A. Sayyad-Hartounian)

Reaching +/- 110 cm water height in home.
Resident stated that during the floods in 2020 the water flowed over the drainage channel and reached their home.

1,10 meter

1,10 meter

1,10 meter

Figure 21 Critical homes next to drainage channel A. (Source: A. Sayyad-Hartounian).

Reaching 110 cm water height in home and on home of neighbour.

Resident stated that during the floods of 2020 the water flowed over the drainage channel due to many trees that blocked the drainage channel.

4.2.3. Critical junction point

Figure 24 below, shows the junction point of the drainage channels. In this junction point, the mainstream of the Safende river as both drainage channels are coming towards this junction point. The figure shows that both drainages are not connected with the Safende's main river stream that would eventually flow towards the junction point with the river Trindade in previous figure 11. It was stated before that the government agencies stopped finishing the connection of the drainages because residents used that area as a cross over leading to the entrance and exit point of the Safende-low area. Figure 5 also shows the vulnerability of the drainage channels not being connected with the main river. During the flash floods of September 2020, the floods blocked a big part of the location where the junction point is located. The area is mainly unpaved and became muddy and not accessible by car and was also dangerous to walk through. The paved area in figure 23 shows that the paved roads were still slippery by flash floods, but not heavily drained by mud. Comparing the pictures, it can be assumed that the unpaved roads take longer to dry up and recover post-flood than that paved roads do. In appendix 2.3 pictures of this junction point and the road that crosses through the junction point are taken during this study.

Figure 23 Flash floods of 12 September in the Safende district.
Source: (Ferreira Semedo, 2021)

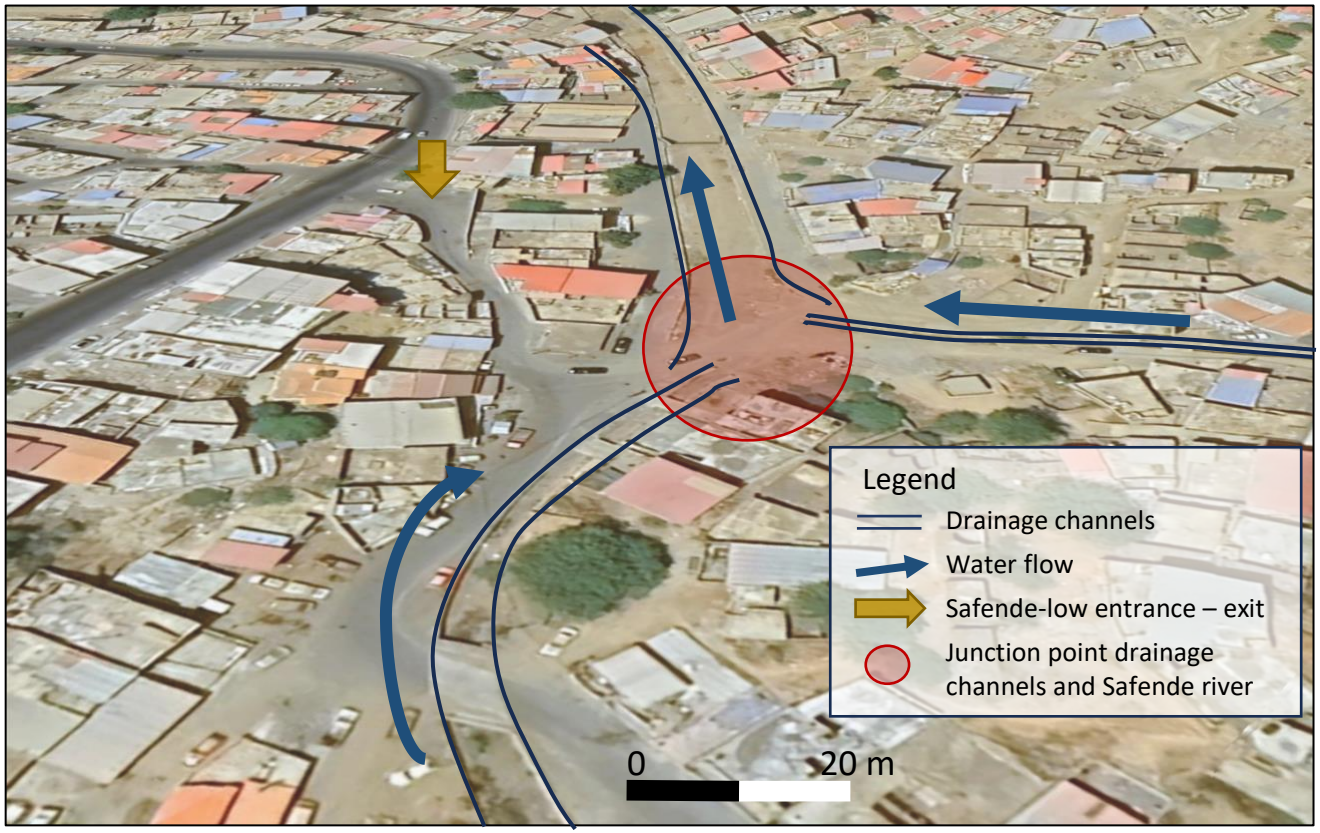


Figure 24 Junction point drainage channel A & B and mainstream Safende river. (Source: Google Earth and edited by A. Sayyad-Hartounian)

4.3. Conclusion

In conclusion, this chapter showed a short overview of the hydraulic modelling of S. Semedo's study in the Safende district. Semedo's study employed several methods and tools to develop a detailed hydraulic model of the future floods in Safende. The study used rain data conducted from the Civil Protection Praia of 1076 – 2002. The study used HEC-HMS to convert precipitation data and simulate a 4-hour flood duration, supported by the Curve Number (SCS-CN) to estimate the water flow. The method HEC-RAS provided the possibility to include the current drainage works, such as ditches and protective walls. These results were then exported to ArcMap 10.8 for further analyses and visualisation. Hereby Semedo's study concluded that future water heights could lead up to 2.4 meters with the 50-year return period and a water height of 3.7 meters with a return period of 100 years. The study finalises with valuing 5% of the Safende sub-basin at a very high risk for flash floods. Considering that more than 98% of the riverbed area of the Safende river is marked by urban occupation.

To understand the statistical data from Semedo's report this study concluded fieldwork by observing the vulnerabilities of the main river Safende including both drainage channels built in 2019. The observation showed several flaws in the main river stream of the Safende river and both drainage channels. Regarding the Safende river, the mainstream lacks proper construction to safely guide the flash floods out of the Safende district. Furthermore, during the observations, many affected houses were situated between the riverbanks and the natural flow of the river. The observation of the current drainage channels and the historical events leads to the conclusion that the drainage channels are too narrow in comparison with the natural mainstream of the river Safende and are unfinished. The events in 2020 show the consequences of the disproportioned drainage channels and the fact that both drainage channels are open which have led the floods to spread across the junction point in figure 24. The current drainage channels have not been restored or finished since the flash floods in 2020 which can support the claim of lack of legislation and enforcement from within the Municipality of Praia to directly take structural measures after the occurrence of floods.

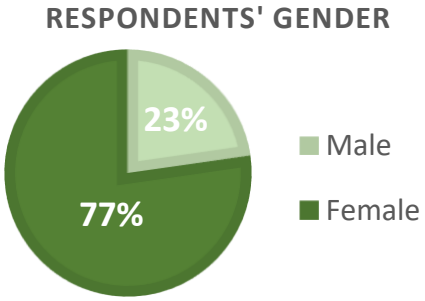
5. Results the experience to flash floods

This chapter covers the results from the interviews done in the Safende district to understand the experiences of the residents during the flash floods of September 2020 and understand their perception to flash floods. Firstly, the interview results from the tested surveys are addressed following the themed results from the final surveys. The interviews were taken over a period of three days. During this period, a total of 22 residents, randomly selected, were included in the same survey and interviewed. All the respondents were during the time of the interview residents of the Safende-low neighbourhood.

5.1. Results survey

During the first two surveys the results were evaluated and changed, see appendix 3.1. The total results from all the questions are elaborated in appendix 3.2. After analysing the results from the first two surveys several alterations were made. Referring to both respondents not feeling comfortable with answering questions related to the personal characteristics. It was decided to keep the questions but to add the options 'rather not say' and 'I don't know' to some questions in the survey.
The most important results from the final survey is the following:

5.1.1. Respondents' characteristics

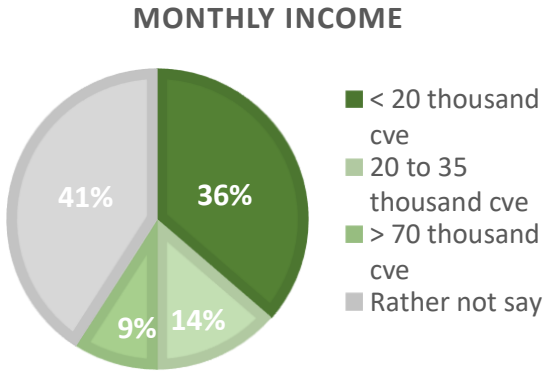


Age total respondents			
18 - 25	25 - 35	35 - 50	50 - 65
23%	27%	27%	23%

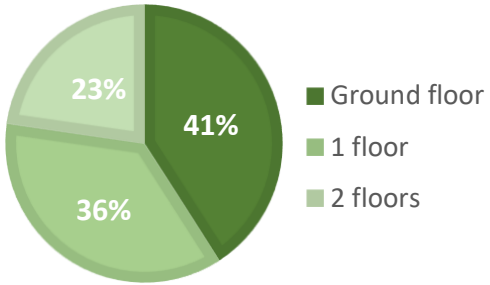
Gender and age
From a total of 22 respondents, 5 respondents are male, and 17 respondents are women. There is a great variety of age differences from the respondents. But no one has the age of 65+ years.

Marital status
32% of the respondents stated to have vulnerable people (children, elderly etc.) in their households. With almost half of these respondents unmarried women, affected by flash floods and with households of 3 - 5 or more people.

Monthly income
36% have stated they earn less than 20.000 esc. Which is approximately around of equal to €180, - per month. assuming they earn respectively more than the minimum wage. 41% of the respondents didn't feel comfortable sharing their monthly income.



AMOUNT OF FLOORS IN THE HOUSE



House floors

Approximately 60% of the resident's homes have one or more than 1 floor.
Assuming they can escape a floor higher during flash floods and the other 40% can't.

Durance of stay

To validate people's ability to give information about their experience of floods, the mean of people living in Safende is approximately 13 years.

Respondent reaction:

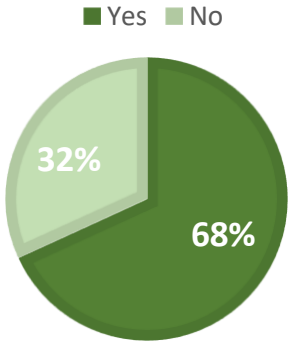
"If flash floods intend to worsen, I would consider moving to another safe area in Safende or elsewhere".

Respondent reaction:

"Since 2020 many people I know have moved outside Safende-low because of the flood issue."

5.1.2. Respondents personally affected by floods

RESPONDENTS PERSONALLY AFFECTED BY FLOODS

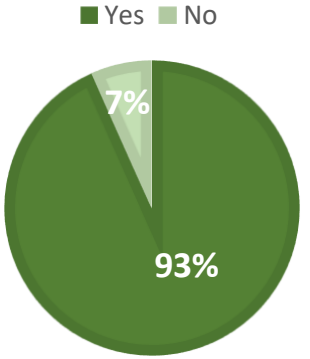


15 out of the 22 residents questioned, have been personally affected by the flash floods in 2020.

From 15 respondents 93.3% believe **living in a flood-risk area**. This is mostly due to:

- living in the **geographical location** of Safende (the many hills).
- the **current state** of drainage canals.
- the houses being **too close** to the Safende river.

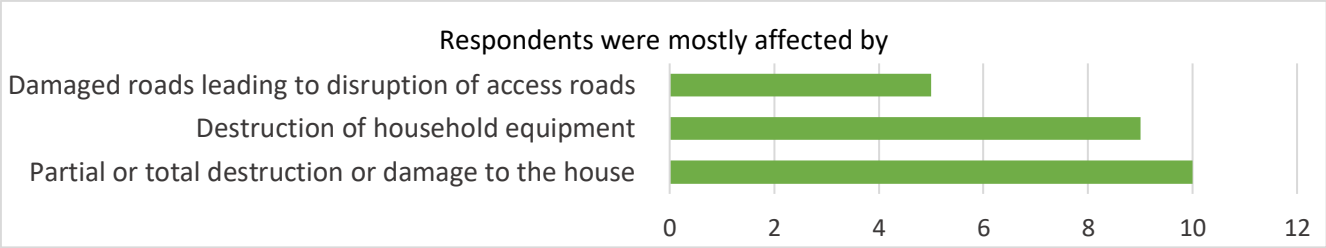
BELIEVING TO LIVE IN FLOOD-RISK AREA



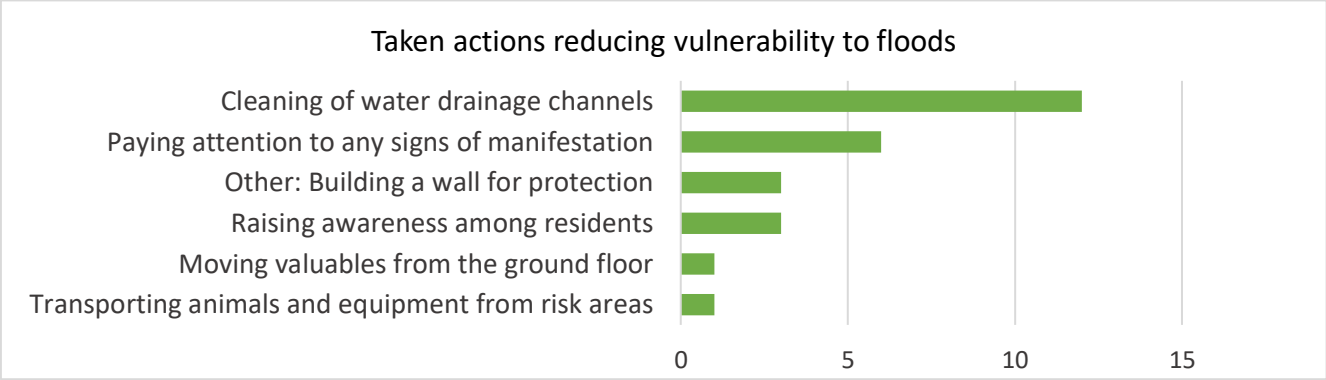
Respondent reaction:

"I heard that two children were carried away with the flood because water came into their house. Luckily a neighbour then pulled them out of the water".

The personally affected respondents mostly affected by:



80% of the respondents personally affected by flash floods have taken action to reduce their vulnerability.



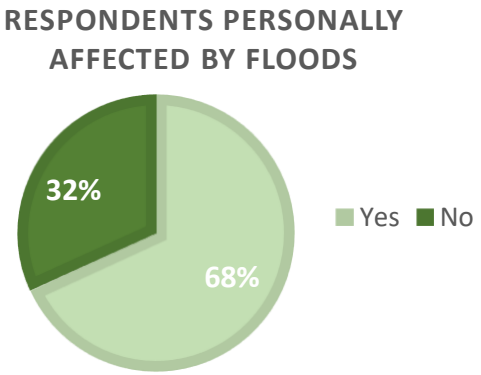
Respondents' reaction:

"From the hills next to the house, rainwater poured into the house where two rooms were flooded with mud, along with other things. Therefore, we have built this wall in 2020 and we are no longer affected by intruding water".

73.3% respondents have scored their home's exposure from 'High' to 'Very high':

Respondents score for home's exposure to flash floods				
1	2	3	4	5
Very Low	Low	Average	High	Very High
27%			73%	

5.1.3. Not affected by floods

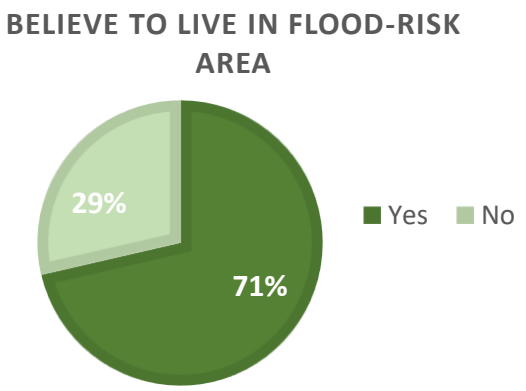


7 out of the 22 residents questioned, have not been personally affected by the flash floods in 2020.

From analysing their justification, the following reasons were concluded. The respondents:

- Have taking measures in own hands and are building walls to protect themselves.
- Live higher in the valley.
- Live above the ground floor/have a home with more floors.

71.4% (5 respondents) of the households not affected by flash floods do believe they live in a flood-risk area.



71.4% have stated their home's exposure from very low to average.
71.4% of not affected respondents have taken actions to reduce their vulnerability to flash floods, assuming they have been affected by floods before 2020 and have taken measures before this time. These actions are:

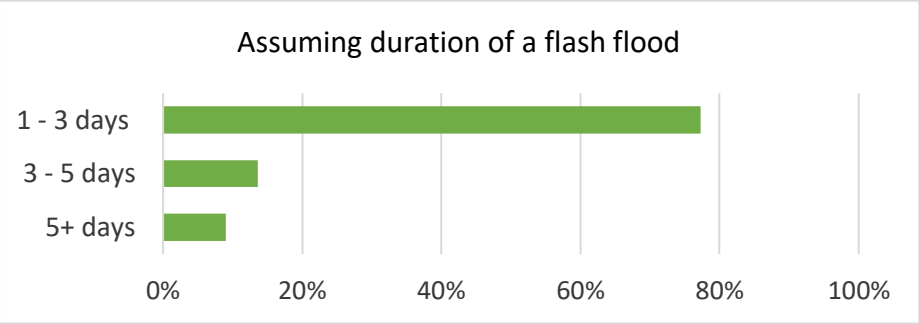
- cleaning of water drainage channels.
- transporting of animals and equipment from risk areas.
- moving valuables from the ground floor.
- building a wall for protection.

Respondents score for home's exposure to flash floods				
1	2	3	4	5
Very Low	Low	Average	High	Very High
71%			**29%**	

5.1.4. Results from all respondents

The following results address the results` from all 22 respondents.

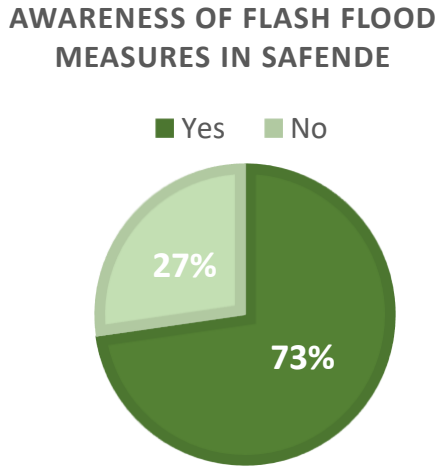
Flash floods and measures
77.3% of the residents stated that every flash flood lasts between 1-3 days.

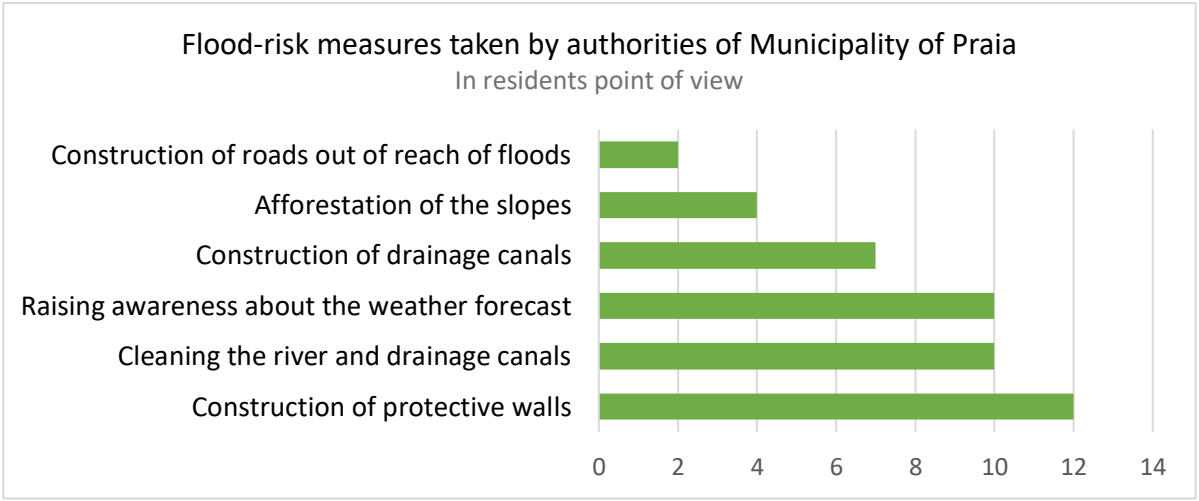


Respondents' reaction:
"The authorities came to construct the drainage and did not communicate with us. One day they came to measure and immediately started digging the next day and left. Now, I have a drainage canal against my house."

Respondent reaction:
"The government built this wall, without communicating with us, in 2019. My house was protected during the floods of 2020, but the wall created a curve in the stream and my neighbour got a lot of rainwater in her house."

72.7% of the respondents are **aware of flood-risk measures** implemented in Safende by the Municipality of Praia:





Scaling the satisfaction of these implemented measures above, 95.4% of the respondents feel 'very unsatisfied' to 'unsatisfied' with these measures:

Respondents score for satisfaction of implemented measures by Municipality of Praia				
1	2	3	4	5
Very Dissatisfied	Dissatisfied	Reasonable	Satisfied	Very Satisfied
95,4%		**4,6%%**		

Respondents score of insecurity with their safety to floods				
1	2	3	4	5
Very Insecure	Insecure	Reasonable	Secure	Very Insecure
77,3%		**28,6%**		

Furthermore, 77.3% feel 'very insecure' to 'insecure' with their safety to flash floods:

At last, 72.7% stated the vulnerability of nearby infrastructure (including paved/unpaved roads, bridges etc.) at 'high' to 'very high' vulnerability to flash floods.

22.7% of the respondents had no access to the roads nearby, during flash floods.

Respondents score of nearby infrastructure's vulnerability to flash floods				
1	2	3	4	5
Very High	High	Reasonable	Low	Very Low
77,3%		**28,6%**		

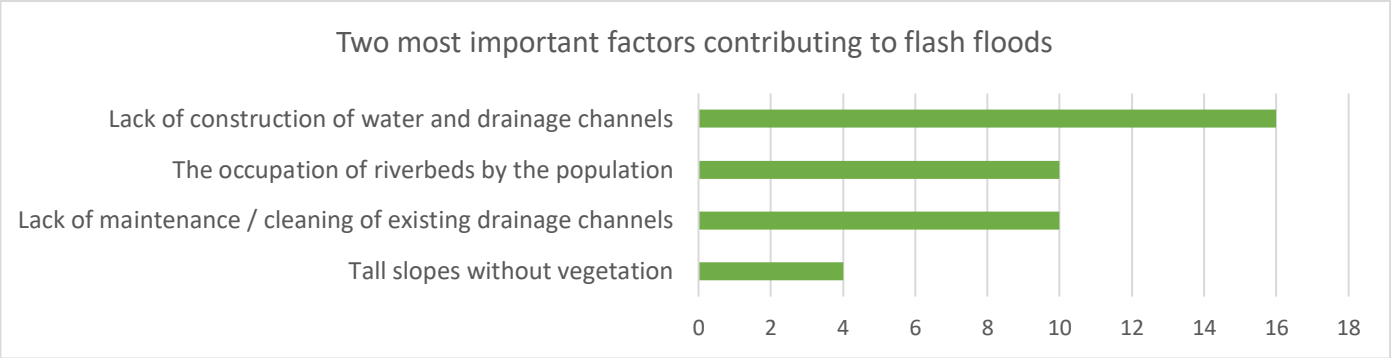
Respondents' reaction:

"We are really disappointed in how the government deals with us in times of flash floods. The rain is very intense, and we are not helped."

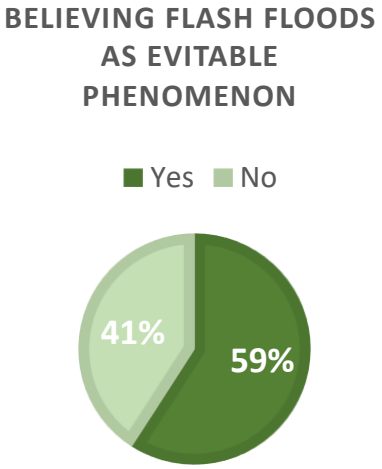
Perception to flash floods

The respondents have stated their two most important factors contributing to flash floods.
Other factors named were:

- Government does no fieldwork to choose the right location for flood protection.
- Construction material is put in the river instead of being thrown away.
- Trash scattered throughout the neighbourhood.

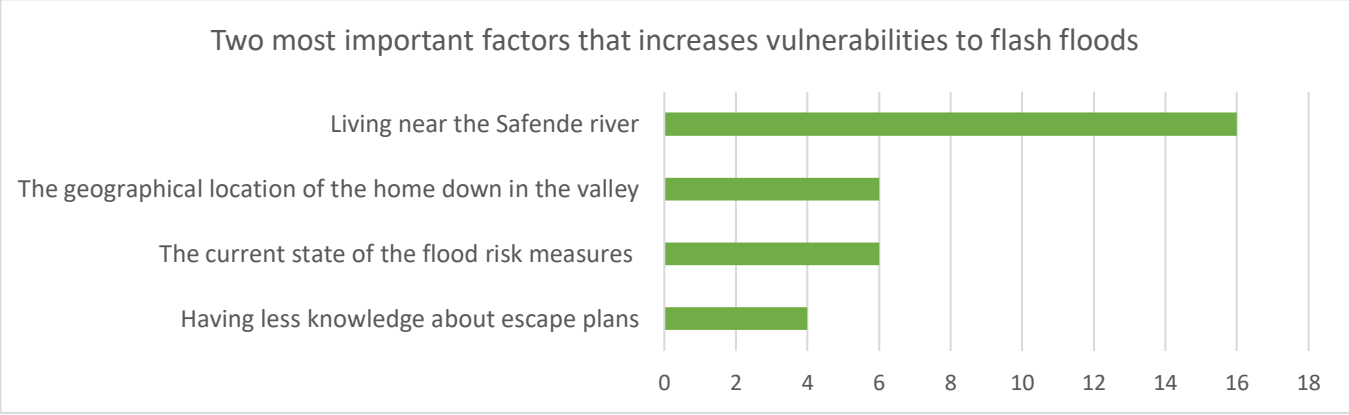


59% have stated that they believe the flash floods in Safende are an **evitable phenomenon**.



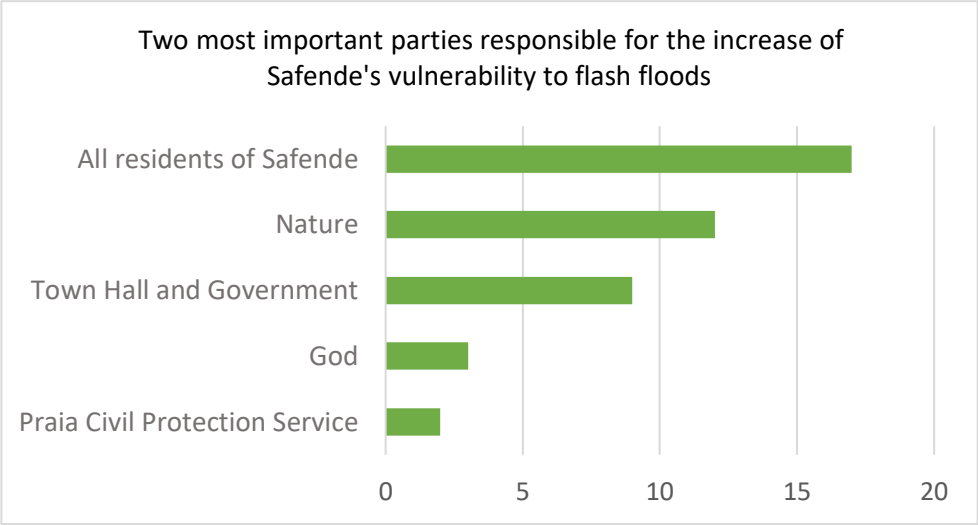
The respondents have stated their two most important factors increasing their vulnerability to flash floods.
Other factors named were:

- It depends on the intensity of the rain.
- A lot of trees get stuck in the canal.



Responsibilities and involvement

The respondents stated their two most important parties responsible for the increase of the area's vulnerability to flash floods as the following:



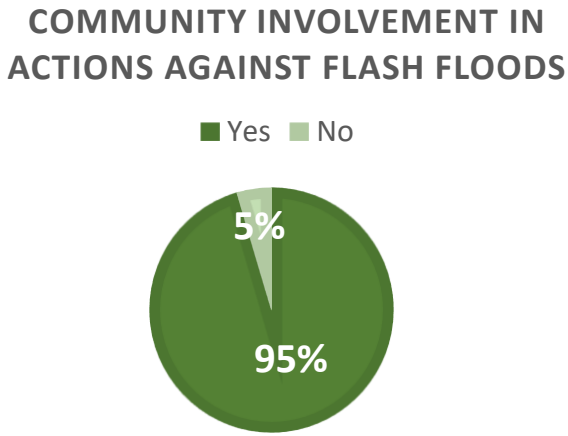
Respondents' reaction:
"If we take measures, we cannot avoid it, but we can reduce the damage done by flash floods. At least, that is what we hope."

Community involvement in actions against flash floods is rated with 95.5% by the respondents.

From which 54.5% state that the whole community is involved in participating in these actions (see actions in 'affected by floods.

Actions mostly done community-wise are the following:

- Cleaning trash from the Safende river and from the drainage canals.



Alerts and needs

63.6% of the respondent's state that they receive warning on national and local television about weather forecast and the risk of an occurrence of flash floods. Other respondents have no access to these warnings and are therefore not warned.

All the respondents have stated they do find being alerted to flash floods important and would like more information about their vulnerabilities to flash floods to understand more about how they can protect themselves.

Respondents' reaction:

"On national tv the government promises to make sure everyone will be as safe as possible during the rainfall. But during flash floods, no one comes to take measures."

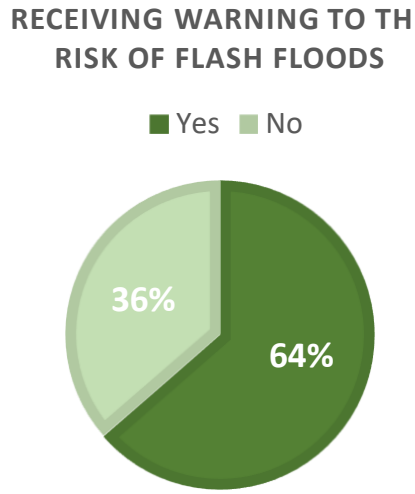
In addition to the respondents needs, some have stated the following:

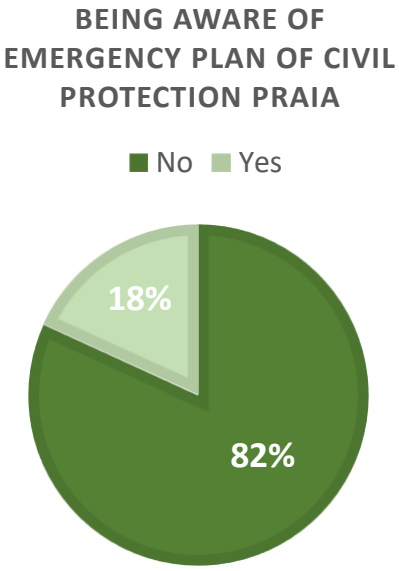
- Authorities need to do more projects and training in Safende to reduce our vulnerability to flash floods.
- Authorities need to finish the drainage systems.
- Authorities need to give more clear information about the vulnerability of Safende to flash floods.
- Authorities need to give more knowledge about the works of flash floods to understand the occurrence better.
- Authorities need to be more sensible with the residents of Safende about the flash floods situation.

As last, only 18.2% of the residents are aware of an emergency plan from Civil Protection Praia.

Respondents' reaction:

"The government only comes to talk about flash floods for their votes".





5.2. Conclusion

The following sub-conclusion is addressed to answer the following sub-question:

What is the social impact of the flash floods on the community in the Safende district?

In terms of the respondent's gender there were a minimal number of men who participated in the interview. Observed from the interviews this could be due to several factors such as, not being interested to participate or that most men were working at the time of the interview.
Approximately 32% of the total respondents are living with children and elderly in their households which makes them more vulnerable to flash floods. With half of them being unmarried women. Regarding the monthly income rate, it's difficult to conclude, since over 40% of the residents didn't feel comfortable sharing.
A key finding of the survey was that 15 out of 22 respondents questioned had been personally affected by flash floods in 2020 and believe to live in a flood-risk area. More than 70% of the respondents are aware of the flood-risk measures taken by the Municipality of Praia and with 95% of the respondents stating their dissatisfaction on these measures following several comments of the disappointment from residents it can be assumed their trust in the Municipality of Praia seems low referring to providing effective flood-risk measures.

Respondent's reaction: "We are really disappointed in how the government deals with us in times of flash floods. The rain is very intense, and we are not helped."

Similarly, a significant percentage of 77,3% of the respondents felt 'Very insecure or 'Insecure' about their safety to flash floods and the same on the vulnerability to flash floods of nearby infrastructure. With some individual not being able to use the roads for days.
With more than 40% of people living on one floor it could mean that in the occurrence of a high intensity flash floods residents would not be able to escape to a higher floor. On the other hand, 7 out of 22 respondents had not been personally affected by the floods in 2020 due to different factors. They attributed their safety to taking measures in their own hands by building walls and building their homes higher in the valley and are also living in an apartment building which doesn't increase their vulnerability to flash floods directly.

Another significant finding in the survey was that 17 out of 22 respondents had mentioned that the residents themselves are the most important party responsible for the increasing vulnerability, which can be confirmed with the high rate of people living near or in the Safende river and its branches.
on the other hand, there is a very high rate of 95.5% of the respondents stating they participate as a community by many clean ups in the neighbourhood after flash floods. Lastly, 63,6% of the respondents stated they can access national warnings about weather forecasts, where the other 36,3% lacked access to this information.
With these results it can be concluded that the residents need improving their flood-awareness.

6. Results reducing vulnerability

In the previous results of this study, the structural flood measures in Safende could have been more effective to flash floods with detailed planning of construction, maintenance and with participation from flood-affected residents. As shown earlier in this study, this has not been the case with the drainage channels and walls constructed by the authorities in 2019. The authorities' non-structural measures like, cleaning the drainage canals after-flood and raising awareness on national television, in the hope of reducing residents' vulnerability to flash floods are not most wanted by the respondents of this study.

Based on the information gathered on residents' needs, this chapter focuses on the non-structural measures. In the persuasion of reducing the vulnerability to flash floods by improving flood disaster awareness of the residents in Safende. Flood disaster awareness could be seen as a measure that does not intend to change the flood watercourse and is thereby a non-structural flood measure (Hossain, Rahman, & Bhattacharya, 2014).

First, the intended audience is proposed with the associated difficulties and appropriate requirements obtained from the questionnaire results and conclusion. Secondly, the suitable stakeholders that are willing to engage in flood awareness are presented following a strategical plan of solutions to enhance the participations between the suitable stakeholders.

6.1. Improving disaster awareness

To improve flood disaster awareness, understanding the intended audience is important when wanting to effectively share critical information about flash floods to imply a type of action. In addition to communicating on flood awareness there are two more factors playing an important role to successfully communicate flood awareness. The process should be done in an interactive exchange of information and the source of the message can influence the recipient's response to flash flood warnings. For example, the credibility, trustworthiness, and the degree of skill the recipients believe the source contains. The strategy for implementing flood disaster awareness for Safende is elaborated in table 6.

Table 6 The main vulnerabilities of the residents to flash floods and proposed non-structural requirements.

Main vulnerabilities	**Proposed non-structural based requirements**
Fears of water entering home during flash floods.	Reducing damages to homes and households' inventory.
40% of respondents not being alerted in an occurrence of flash floods.	Integrating local warnings between residents.
Not trusting promised flood-risk actions from the government.	Building trust between government agencies, local organisations, and residents.
Respondents are motivated to take own flood-risk measures but do not know how to improve their flood-awareness.	Educating about the occurrence of flash floods about increases flood preparedness.

6.2. Suitable stakeholders

6.2.1. NGO Tudora Safende

The NGO Tudora Safende was brought in this study's attention during the interviews with the residents of Safende. Through not-structured interviews the organisations ambitions and difficulties were obtained as the following:

The NGO Tudora is a volunteer organisation that is active as well as online as in public in Safende. It draws attention to underprivileged residents (young and old) who end up in urgent situations due to an illness and/or lack of financial resources. It stands for "the love of a neighbour" and has ambition to educate residents about the risks of flash floods and potential measures residents can implement by themselves to reduce their vulnerability to flash floods. The organisation is highly active online and is known as a reliable influence with sensitivity to the residents by two respondents interviewed in this study.
Taken actions:
Tudora did contribute with damage clean-ups in Safende after the flash floods in 2020 and are a recognised organisation with a large support base online to raise awareness to residents in Safende.
Knowledge gap:
Despite Tudora's ambitions for the Safende district, it lacks sufficient knowledge about the vulnerabilities to flash floods and tools to educate residents about how to prepare for flash floods how to react during flash floods.

6.2.2. Civil Protection of Praia

The Civil Protection of Praia was brought in this study's attention during conversations with experts in the field of flood-hazard mapping. Through not-structured interviews the organisations ambitions and difficulties were obtained as the following:

The Civil Protection and Fire department has a critical role in establishing guiding principles and applying them during Civil Protection emergency operations. Furthermore, defining the task, duties and responsibilities of various agents, bodies and entities involved and the relative rules of action. To guarantee that beneficial conditions are created to ensure available resources quickly and efficiently.
Taken actions: On behalf of the Municipality of Praia, Civil Protection of Praia created a National Emergency Plan for the City of Praia in times of natural hazards. This emergency plan Civil Protection Praia has stated its ambition to focus on the following objectives:

- Identify potentially natural hazard risk zones/neighbourhoods.
- Study and plan the necessary intervention tools in the occurrence of an emergency
- Develop and implement precautionary measures that allow, mitigate and/ or reduce factors of risks and vulnerability
- Ensure continued monitoring of natural hazards
- Ensure safety and tranquillity to the population during emergency situations
- Obtain and analyse all weather information

Speaking with a spokesman of Civil Protection Praia it was confirmed to start identifying potential risk zones in Praia, including Safende, to evaluate the current financial contents that could be vulnerable during floods and the amount of vulnerable people per household.

Knowledge gap:
Despite annually revising the National Emergency Plan Praia and having the tools to execute above objectives, Civil Protection still has difficulties with its position to raise awareness to the residents in Safende.

6.3. Potential participation stakeholders

Addressing both ambitions and difficulties of the NGO Tudora Safende and the Civil Protection it can be concluded that both parties acknowledge the importance of flood awareness. With Tudora Safende not having the right knowledge and tools to advice residents on effective non-structural measures and with Civil Protection Praia not having the support base of residents in Safende to effectively warn and educate residents on potential flash flood risks.
The NGO Tudora Safende and the Civil Protection of Praia should form a collaborative partnership to combine their tools, knowledge, and expertise. This collaboration can enhance the efficiency of their actions and provide a unifying approach to reduce the resident's vulnerability to flash floods in Safende district (Hossain B. , 2020).
Within this collaboration the following actions are advised to be implemented:

1. Exchanging of knowledge and training:
The Civil Protection Praia can provide Tudora Safende with expertise's on flood hazard mapping and actions taken in emergency circumstances. On the other hand, the NGO Tudora Safende can share its competence of its communication skills by spreading awareness on a level that encourages residents in taking actions. The exchange of communication can be done by creating workshops and excursions in the field to enhance both parties' capacity with the appropriate tools to spread flood awareness within the community of Safende (Rehman, Sohaib, Asif, & Pradhan, 2019).

2. Community Awareness and Empowerment
Previous results in this study show that the community of Safende experiences difficulties in accessing online flood warnings. This study believes the NGO Tudora Safende, and the Civil Protection of Praia can collaborate in organising workshops and training sessions within the community of Safende. These activities include information about the occurrence of flash floods, preparations measures and recommendations on how to respond during a flash flood. Also, engaging residents in planning these activities by community gatherings or focus groups could empower residents to take responsibilities to reduce their vulnerability to flash floods (Crabbé, et al., 2016) (Rehman, Sohaib, Asif, & Pradhan, 2019).

3. Regular evaluation of actions
It is of great importance to Civil Protection Praia and to Tudora Safende to regularly evaluate their actions of spreading flood-hazard awareness and give each other feedback with recommendation to continue and improve reducing vulnerabilities to flash floods.

6.4. Conclusion

The current (non-) structural measures taken by the government agencies of Praia have made the respondents dissatisfied and feel unsafe in their neighbourhood regarding to the occurrences of flash floods. During this study the Civil Protection of Praia and the NGO Tudora Safende were approached to understand their ambitions and missing tools regarding spreading flood awareness in Safende.

Against the governments high dissatisfaction score, from the resident's point of view, the already involved NGO Tudora Safende could provide a more reliable message to the residents.

In the persuasion of reducing residents' vulnerability to flash floods this chapter indicates to start a collaborative partnership between both parties as the binding factor. With the objective to combine the strengths and weaknesses of both parties to address the requirements needed to reduce the vulnerabilities to flash floods of the residents in Safende.

7. Conclusion

Firstly, the objective of this study and the main question, to which it answers, are discussed in this chapter. This is followed by the sub-conclusions for each chapter and finally the conclusion is discussed.

The objective of this study was to understand the factors influencing the vulnerabilities of the Safende community to flash floods from this study's own observations and by approaching and interviewing the residents of Safende to propose a solution that can reduce the vulnerability to flash floods, considering the limited resources available.
The communities' interest by the occurrence of flash floods have been a defining and essential focus in this study's results. There were minimal actual studies found regarding flash floods in the Safende district and Praia's informal settlements in general. Hereby, it was important to physically evaluate the study area. Thus, the current deficiencies of the Safende rivers condition and its drainage channels could be identified. This data formed the base in approaching residents to ascertain what, from their perception, were important factors influencing their vulnerability to flash floods. For this purpose, the 2020 flash floods were chosen as a starting point and 22 respondents were asked about their experiences and taken actions during the flash floods. Furthermore, this study also examined respondent's needs from their perspective.
The engagement from the respondents in the survey has been decisive to the results in the search for a solution to the stated problems regarding flash floods in Safende. There is a desire within the interviewed respondents for measures that they can implement themselves and a party that can and is willing to provide this knowledge to the residents of Safende. For the attempt to realize these desires, research was conducted on parties operating within Safende and who carry a societal role. Hereby, the goals, ambitions and current difficulties of chosen parties, the Civil Protection Praia, and the NGO Safende Tudora, were examined. In which being able to spread flood awareness to reduce the vulnerability to flash floods of resident has been the guiding focus. All parts of the research have led to the answer to the main question:

"What are the key factors that influence the vulnerability to flash floods of the community in Safende?".

The most important result from this study is as followed:

- Semedo's research has provided new insights on future flash floods targeting the Safende sub-basin. A T50 year return period prospect a water depth of 2.4 meters high and a return period of T100 years prospects a depth reaching 3.7 meters high. From my own observations, both the mainstream of the Safende river and both drainage channels are in a critical condition, assuming due to negligence during construction. Which has created a dangerous junction point in the entrance of the Safende district where flash floods get a free run. The disproportion of the drainage channels was well seen during the flash floods on September 12, 2020.
- In what way the residents have been personally affected by flash floods is evident through various findings. Firstly, a very a wide gender diversity van be seen in the results. Many female respondents feel responsible to protect their households from flash floods, with 36% of this group of respondents also stating that they live in a household vulnerable to flash floods. Residents are generally very conscious about the fact that living close to the Safende river increases their vulnerability to flash floods. Moreover, those residents who were not personally affected by flash floods in 2020 have taken measures to reduce their vulnerability. There is also a high dissatisfaction among residents on the current measures taken on behalf of the governmental agencies, with at least 77% feeling 'very insecure' to 'insecure' about their own safety to flash floods. Although,

residents do recognize that it is feasible to reduce their vulnerability to flash floods but are looking for guidance to be able to take these steps themselves as well.

- The potential collaboration between the Civil Protection of Praia and the NGO Safende Tudora could be of great importance to address their knowledge gaps, enhance flood-awareness and effectively educate residents about the risks of flash floods. This approach could contribute to the current dissatisfaction from within the respondents to the governmental agencies and could contribute to a more reliable message of spreading flood-awareness.

The professional product serves as an inspiration to look at a potential collaboration between the Civil Protection Praia and the NGO Safende Tudora. In the potentials and knowledge gaps of both parties are linked and an instruction is given on how both organisations can start educating residents about flood-awareness. The professional product also includes measures that residents themselves can apply to reduce their vulnerability about flash floods. By, among other thing, educating themselves about the occurrence of a flash flood in Praia, on how to prepare for a flash flood and how to react during flash floods.

8. Discussion

In this chapter the discussion is elaborated with the most important aspects of the study that could have influenced the result of this study. The elaboration also provides appropriate recommendations.

Survey

The survey results are based on the respondents who were addressed during the multi-day observations in the Safende neighbourhood. These have been momentary data, which means that when the interview is conducted again, other residents could be addressed and thus the survey results could differ from the current results.

Recommendation: the results still rather tentative. To a future study that is conducted with a similar objective it is the advice to question a larger and more diverse group of individuals.

In preparation of this study, it was decided to deal with the survey results upon return to the Netherlands. In doing so, it was concluded that there was a need to ask the same residents a set of additional questions. There was a need for results on whether the residents themselves or within their households had knowledge and the materials that would enable them to take their own measures to protect their homes from flash floods. The results also showed that question 30 and question 38 were very similar. It referred to important factors that would increase residents' vulnerability and to factors that would affect flash floods. Different options as answers were offered for both questions and could have been made too difficult for residents to understand the difference.

Observations

The reliability of the observations can also be debated. The observations were mostly conducted alone, together with two residents of the neighbourhood. The observations were based on what I felt was important to observe at the time, in the route that the two residents felt was safest to walk through. This means that particularly due to ensuring our safety, it was not possible to observe the entire Safende river and the neighbourhood. Due to this, other defects of the neighbourhood that may increase vulnerability against flash floods may not have been observed and not digitally recorded.
Although, all notes and images resulting from the observation were saved in SW-Maps so that the images could be indicated by exact locations on the map. Furthermore, the pictured defects of drainage channels were linked to images taken during the 2020 flash floods. Respondents in this study were also asked to confirm the defects from their own experience during the 2020 flash floods.

Recommendation: for this, the recommendation is to write an instruction in a follow-up study with what exactly should be observed in the neighbourhood. In addition, the recommendation to identify several residents who can help observe a larger area.

Review of hydraulic modelling

For this study, the ambition was to review the statistics from Semedo's study and visually compare this with all the observation from my research. Semedo's study on hydraulic modulation of flood-risk areas in the Safende sub-basin from 2021 was handed over after the observations in this study were done.

Semedo's study, like many others in Cape Verde, has not yet been published. This means that within the time scope of this study, it was not possible to replicate all the technical steps made in Semedo's study.

The consideration towards non-structural measures

In the preparation of this study, it was considered to look at both structural and non-structural measures that could be implemented in Safende district and could thereby reduce resident's vulnerability to flash floods. After reviewing the literature and discussions with ANAS and the respondents, it was considered to focus on the non-structural measures. This was mainly because insufficient evidence was retrieved in this study that if the focus was on structural measures, it was set to action by the governmental agencies of the Municipality of Praia.

For this justification, no detailed interviews were conducted with the Municipality of Praia, this was mainly because this research focused on the experience of residents. This judgement is also confirmed by the respondents from the survey and mentioned literature.

Recommendation: hereby, the recommendation to Civil Protection Praia and subsequently to the Municipality of Praia is the following. From the literature from independent experts who have already researched the vulnerabilities of the City of Praia and have studied possible solutions to flash floods and invite these experts to a brainstorm session. Particularly the professors of the Universidade de Cabo Verde who have done much research about the City of Praia. This brainstorm session can provide an opportunity to surface unpublished research and compare it with the structural plans from the Municipality of Praia. This could be decisive in naming the most promising structural measures that could reduce the vulnerability of the City of Praia to flash floods.

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