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RECEIVED 07 November 2024
ACCEPTED 18 December 2024
PUBLISHED 07 January 2025

CITATION

Raphela TD and Matsididi M (2025) The causes and impacts of flood risks in South Africa.
Front. Water 6:1524533.
doi: 10.3389/frwa.2024.1524533

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The causes and impacts of flood risks in South Africa

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Introduction: Floods are classified as one of the hydrological hazards affecting many countries worldwide. With most weather-related disasters occurring in developing countries, demographics and socioeconomic pattern changes have contributed to many losses relating to water-related disasters such as floods. South Africa is among the developing countries most frequently affected by natural disasters, particularly floods. Thus, this study assessed the causes and impact of floods on the communities of Bronville and Hani-park in Welkom in the Free State Province in South Africa.

Methods: The study adopted a quantitative approach, using a structured questionnaire to collect the data. The study used an R statistical package to analyze the data and applied descriptive statistics and a series of Generalized linear models to examine the impacts of floods in the community.

Results: The findings reveal a community-wide concern about flooding impacts. There was a statistically significant difference between whether floods affected your physical structure as an outcome variable and how the flooding affected participants (Wald $\chi^2 = 30.364$; $p = 0.001$). Also, a significant difference was found regarding how floods affect the water quality in your community (Wald $\chi^2 = 1.496$; $p = 0.030$). The subjective perception of flood impacts on households has been reported to be aligned with observed damage to physical structures, underscoring the direct influence of floods on various household elements. The study also emphasises the costly nature of flood recovery and the potential strain on household resources due to flooding. Respondents indicated floods adversely affect vegetation, soil stability, and ecological dynamics. The study also, reveals that while some residents affected by flooding reach out to their municipalities for support, many do not seek or receive financial assistance.

Discussion: The study concludes that floods have a considerable socioeconomic impact on households and communities, particularly regarding repair costs for flood-related damages. In addition, the study concludes that floods have significant implications for drinking water quality in the community, with statistical evidence supporting the claim that floods contribute to water quality degradation. The findings of flood preparedness suggest a clear gap in early warning dissemination and evacuation planning tailored to the study community's needs. The findings of this study underscore the urgent need for comprehensive and sustainable flood mitigation strategies in vulnerable communities like Bronville and Hani-park.

KEYWORDS

vulnerability, township, sewage, groundwater flooding, disaster risk, resilience

1 Introduction

Worldwide, an average of 205 million individuals have been reported to be affected annually by flood disasters, accounting for almost 47% of water-related disasters (Wahistrom and Guha-Sapir, 2015). Floods are classified as one of the hydrological hazards affecting many countries worldwide (Wahistrom and Guha-Sapir, 2015). The world has experienced flooding disasters that accounted for approximately 56% of weather-related disasters, including several significant flood events that took place in 2016 in countries like Romania, Germany, China, Ukraine, Paris-France, the United States, Russia, and Belgium, the UAE and South Africa (Rowe and Smithers, 2018).

The EM-DAT 2023 reported that flood disasters affected over 93 million humans and caused a total economic loss of almost US \$202.7 billion globally, with floods contributing significantly. The impacts of floods combined with inadequate levels of disaster preparedness in countries, especially developing countries, may contribute to higher socioeconomic, physical, and environmental vulnerability levels (Abunyawah et al., 2018). Flood-related disasters have caused about 6.8 million fatalities globally in the 20th Century (Doocy et al., 2013). Psychological impacts and survivors suffering from distress of post floods are also reported by several studies (Alderman et al., 2012; Bei et al., 2013; Doocy et al., 2013).

Floods have also been reported by Aznar-Crespo et al. (2021) to have affected about 1.65 billion people and killed around 122,000 people while causing damages of about 563 billion US dollars all over the world between 2000 and 2019. However, studies of how floods affect the environment are neglected, especially in developing countries. Floods have been reported to change access to fresh water for communities that depend on groundwater for survival, alter crop production, cause violence within areas with limited environmental resources, and reduce production in aquatic ecosystems due to ocean acidification (Lieber et al., 2020). These are some of the negligible issues in the literature.

Several scholars reported floods to be commonly caused by heavy rainfalls. Other factors that play a significant role connected to flooding are poorly planned and constructed dwellings in low and middle-income areas (Pharoah, 2014; Istomina and Dobrovoski, 2014; Spilsbury and Spilsbury, 2017; Van Niekerk, 2011; Dahri and Abida, 2020). Heavy rainfall as a source of floods has become one of the traumatising events affecting lives and livelihoods (Elalem and Pal, 2015). The rainfall characteristics that determine the rate and scale of floods are the duration, area, depth, and measure of storm rainfall (Yang et al., 2019). Flooding, characterised by heavy rain, harms communities, especially township communities in South Africa (Haug et al., 2016). The higher the rainfall intensity, the greater it will result in floods (Jha et al., 2012). Most water-related disasters occur in developing countries (Wahistrom and Guha-Sapir, 2015). Demographics and socioeconomic pattern changes in these countries have significantly contributed to many losses when it comes to floods (Elalem and Pal, 2015). Furthermore, Fiorillo et al. (2018:2) argue that the increase in population growth and rapid urbanisation in these townships results in more vulnerability since urban areas or new settlements are likely to be established or are mostly to be expanded in flood-prone areas where land is free. According to De Silva and Kawasaki (2018), people reside in unsafe areas that make them vulnerable to water-related disasters such as floods to access resources.

Urban developments create land use changes, leading to increased flood disasters. Changes to water stream channels are likely to limit drainage of water flow during heavy rainfall, causing flash floods

(Eduardo and Eliane, 2013). In most areas, flood damages increase because of inadequate drainage facilities, more so in developing countries (Fiorillo et al., 2018:2). This study, therefore, seeks to assess the causes and impacts of floods in two townships in South Africa by looking at the causes, the physical, socioeconomic and environmental effects of these flood disasters. In addition, the study will gauge the interventions of municipalities to assist the communities in dealing with these floods. The study will also assess the study communities' preparedness for flood disasters. The study will contribute uniquely to the body of knowledge as it uncovers differences in the causes, impacts, and responses to floods in specific geographic (township) and socioeconomic contexts. The study's findings could also highlight localised factors influencing vulnerability and resilience, which might not be evident in broader regional and national studies.

2 Materials and methods

This study used a purely quantitative research approach to achieve the study's objectives, which assessed the impacts of flood risks in Bronville and Hani-park townships in Welkom in the Free State Province of South Africa. These townships experienced flood disasters in 2019, making them a target population.

A purely quantitative study that is purposive was selected for this study as a specific population that met the predetermined answers from the quantitative questions was targeted. This approach is intentional and strategic, ensuring that the sample directly aligns with the study's research objectives. Primary data was collected using a structured questionnaire with close-ended questions and predetermined responses. The authors developed and cross-referenced the questionnaire with seven questionnaires in the literature that investigated the impacts and causes of floods in other world regions. The reliability of the questionnaire was tested using the Cronbach Alpha in R software, and the value of 78% for the test was returned. In addition, the study was polluted with 10% of the selected population before actual data was collected. To test the validity of the questionnaire, a comprehensive literature review was conducted, and the review confirmed that the questions aligned with existing theories and frameworks.

Before data was collected, the authors explained the study's critical ethical considerations underpinning the survey to the respondents. This study obtained ethical clearance from the University of the Free State General Human Ethics Research Committee (GHREC) under protocol UFS-HSD2020/1833/251.

2.1 Study sampling

According to Statistics South Africa (2022), the census of Bronville was 9,966, whereas that of Hai Park was 4,400, with a total population of 14,366 across the two communities in 2022. This study, as it is quantitative, calculated the sample size of the two study areas using Taro Yamane's formula with a known population as follows:

$$n = \frac{N * Z^2 * P * (1 - P)}{e^2 * (N - 1) + Z^2 * P * (1 - P)}$$

Where n is the sample size, N is the population size, Z = 1.96 (at 95% confidence level), p = 0.5 estimated population proportion, e is

the margin of error set at 0.05. Accordingly, the sample settled at a 5% significant level ($\alpha = 0.05$) at a confidence level of 95%. The calculated sample size for the two communities was 374. However, since the study was purposive and targeted households within the communities that were affected by floods, the study further obtained the database of the floods-affected households from the National Disaster Management Centre Database and came to a sample size of 201 and the study was methodologically limited to this sample size across the two communities and only 127 households participated in the study. Data for this study was analysed for the 127 households that participated.

2.2 Data and statistical analysis

Data for this study was analysed using the R statistical Program version 4.4.0 (2024-04-24). All the figures for this study were produced using this software, whereas the tables were produced using Microsoft Excel. Data for this study was not normally distributed and statistical tests were non-pragmatic two-tailed. The significance level was set at $p \leq 0.05$ at a 95% confidence interval for all models applied for this study.

Firstly, the study gauged the socio-demographic characteristics of the participants to put the study in perspective by applying descriptive statistics. The study further assessed the community's experiences and causes of floods by running a Generalised Linear Model (GLZ) with a Poisson distribution. The Poisson distribution was selected as a family for all the models applied because this distribution is used to count data, representing the number of times an event occurred. The study aimed to quantify the impacts and causes of floods. The question "What do you think causes flooding in your community" was set as a response variable, whereas the questions of (1) How often do you experience flooding in your community? (2) do you believe that flooding is a problem in your community? (3) how would you rate the flooding problem? (4) do you believe that your home is at risk of flooding? and (5) do you experience flooding in your community? The variables mentioned above were set as predictor variables.

In addition, the impacts of floods were determined by running a series of separate Generalised linear models (GLZ) to first look at the (1) physical, (2) Socioeconomic, and (3) environmental impacts of floods in the study communities, furthermore, we assessed flood risks by gauging preparedness and response by running a GLZ model.

All participants ($n = 127$) reported not having house or home contents insurance and were unsure if their community had a flood management plan. Therefore, this study applied a GLZ to assess the relationship between floods' impact on recovery, preparedness, and response. Have you managed to recover ever since you have experienced floods? The preceding question was set as the outcome variable for the model, and the questions were: (1) Do you usually receive early flood warnings? (2) How do you receive early flood warnings? (3) Were you ever evacuated during the floods? and (4) selection of the possible reasons why the participants were evacuated were set as predictor variables. Indeed, early warnings form part of preparedness (Goniewicz and Burkle, 2019), whereas evacuation forms part of Disaster Response (Forsberg et al., 2019).

All GLM models applied for this study were run with a Poisson distribution because the number of responses for each selected response variable across all models was set as outcome variables.

3 Results

This study investigated the causes of the flood disaster and its holistic impact on the Bronville and Hani Park townships of Matjhabeng District Municipality in the Free State province of South Africa. Structured questionnaires were administered to flood-affected households in the two communities. Basic inferential statistics was applied to find the relationships between variables of importance to this study. Table 1 shows the demographic characteristics of the respondents; even though this is a water-focused study, understanding the demographics of the study participants is crucial in most impact studies as impacts happen to people and communities in the disaster Management context.

3.1 Socio-demographic characteristics

This study investigated the causes of the flood disaster and its holistic impact on the Bronville and Hani Park townships of Matjhabeng District Municipality in the Free State province of South Africa. Semi-structured questionnaires were administered to flood-affected households in the two communities. The researchers used descriptions with themes by quoting the responses with quotation marks and explaining the implications of the responses for the open-ended questions to address the qualitative component of this study. Furthermore, basic inferential statistics was applied to find the relationships between variables of importance to this study. Tables, figures, and photographs were used to visualise the study results. Table 1 shows the demographic characteristics of the respondents; even though this is a water-focused study, understanding the demographics of the study participants is crucial in most social impact studies.

3.2 Flood experiences and causes

A statistically significant difference was found for the questions: What causes flooding in your community (Wald $\chi^2 = 4.246$; $p = 0.001$); How often do you experience flooding in your community (Wald $\chi^2 = 2.307$; $p = 0.004$)? However, there were no statistically significant differences found for the questions about whether the participants believe that flooding is a problem in their community (Wald $\chi^2 = 21.412$; $p = 0.587$), how the participants rate the flooding problem in their community (Wald $\chi^2 = 27.416$; $p = 0.587$) and whether the participants believe that their home is at risk of flooding (Wald $\chi^2 = 26.781$; $p = 0.587$) with the response variable "what do you think causes flooding in your community?"

In addition, most respondents reported experiencing floods in their community every time it rains. Furthermore, many respondents reported floods as problematic in their community, and they rated floods as a significant problem (Figure 1). Moreover, most respondents reported their homes as at risk of flooding, and most of the five predictor variables reported the causes of floods in their communities to be a lack of drainage systems.

TABLE 1 Demographic characteristics of the respondents.

Parameters	Frequency	Percent (%)
Age groups		
18–25	4	3.1
26–35	26	20.5
36–45	45	35.4
46–55	23	18.1
56–65	14	11.0
Above 65	15	11.8
Total	127	100.0
Gender		
Female	69	54.3
Male	58	45.7
Total	127	100.0
Home language		
Afrikaans	23	18.1
Other	1	0.8
Sepedi	1	0.8
Sesotho	42	33.1
Tsonga	1	0.8
Tswana	4	3.1
Venda	1	0.8
Xhosa	45	35.4
Zulu	9	7.1
Total	127	100.0
Marital status		
Cohabiting	19	15.0
Divorced	1	0.8
Married	42	33.1
Separated	2	1.6
Single, never married	56	44.1
Widowed	7	5.5
Total	127	100.0
Children per household		
One child	29	22.8
2–4 Children	71	55.9
4–6 Children	14	11.0
None	13	10.2
Total	127	100.0
Born in the area		
No	81	63.8
Yes	46	36.2
Total	127	100.0
Years living in the area		
Fifteen years and above	55	43.3
Five to ten years	8	6.3

(Continued)

TABLE 1 (Continued)

N/A	44	34.6
One to five years	8	6.3
Ten to fifteen years	12	9.4
Total	127	100.0
Educational level		
No schooling	5	3.9
Primary Schooling	24	18.9
Secondary Schooling	80	63.0
Tertiary	18	14.2
Total	127	100.0
Employment status		
Employed	39	30.7
Part-time jobs	10	7.9
Pensioners	12	9.4
Self-employed	17	13.4
Students	2	1.6
Unemployed	47	37.0
Total	127	100.0

3.3 Impacts of floods on the community

The study determined the physical, socioeconomic, and environmental impacts of floods and reported the following results.

3.3.1 Physical impacts

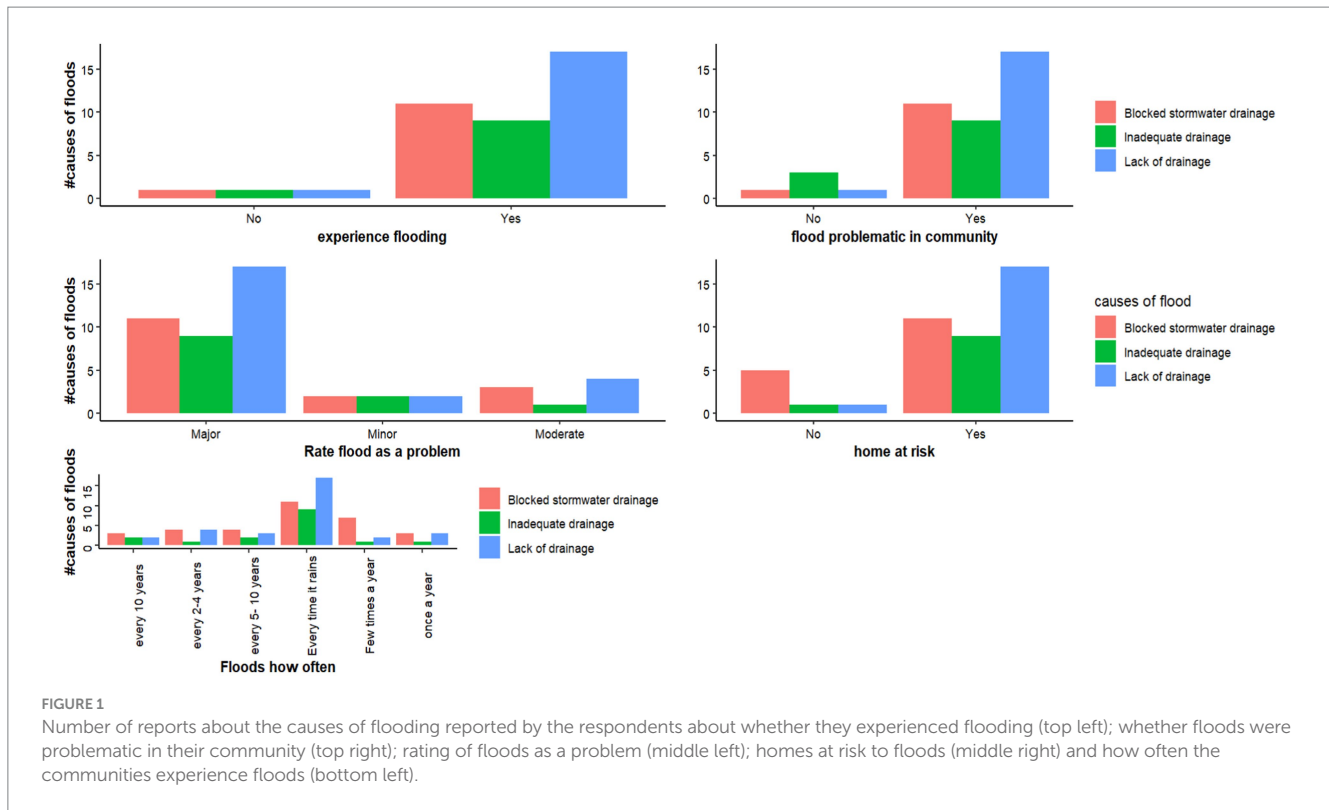
There was a statistically significant difference between whether floods affected your physical structure as an outcome variable and how the flooding affected participants' community/households (Wald $\chi^2 = 30.364$; $p = 0.001$). However, no statistically significant difference was found for the questions of What physical structure has floods damaged in your house (Wald $\chi^2 = 11.716$; $p = 0.110$).

Furthermore, a higher number of respondents reported escape routes being flooded and damage to their furniture (Figure 2).

3.3.2 Socioeconomic impacts

The question of whether floods have affected the respondents and their community socially and economically was statistically significant to the question of estimation of how much it has caused the household to fix the flood damages (Wald $\chi^2 = 0.003$; $p = 0.001$). However, no statistically significant difference was found between whether floods have affected the respondents and their community socially and economically and the impacts the community faced during and after flood disasters (Wald $\chi^2 = 33.268$; $p = 0.172$). However, no statistically significant difference was found for whether floods have affected the respondents and their community socially and economically and whether floods affected the households (Wald $\chi^2 = 7.986$; $p = 0.392$).

Furthermore, an equal number of respondents (most of the respondents) reported that the cost of fixing the flood damage was R10 000 and > R15 000. Most respondents reported Electricity Cut-Off



(ECO) as the impact they faced due to floods. Moreover, most respondents reported that floods have affected their households. All these majority responses regard the socioeconomic effects of floods on households and communities as the outcome variable (Figure 3).

3.3.3 Environmental impacts

The study assessed the environmental impacts of floods and set the question of whether floods affect communities' environments as a response variable. A significant difference was found regarding how floods affect the water quality in your community (Wald $\chi^2 = 1.496$; $p = 0.030$). However, there was no statistically significant difference found for the questions of how flooding affects surrounding area by damaging vegetation (Wald $\chi^2 = 3.104$; $p = 0.078$), how repeated floods affect local wildlife and plant habitats (Wald $\chi^2 = 7.014$; $p = 0.071$) and what impact do floods have on the soil and agricultural land in the communities (Wald $\chi^2 = 4.092$; $p = 0.251$).

Furthermore, most respondents reported that floods damage the surrounding area by damaging vegetation, decreasing water quality, dispersing invasive species, and eroding topsoil (Figure 4).

3.4 Municipal interventions

The study further assessed the intervention of the municipality in flood disaster management by asking how the flooding affected respondents' households in terms of money as the outcome variable. A statistically significant difference was found for whether the respondents contacted their municipality

in the past about flood damages (Wald $\chi^2 = 0.395$; $p = 0.005$). However, there was no statistically significant difference found for the questions of whether the respondents have asked their municipality for reimbursement of the cost of the flood damage (Wald $\chi^2 = 0.037$; $p = 0.846$) and whether the respondents have received any reimbursement for flood damages from the municipality (Wald $\chi^2 = 1.172$; $p = 0.279$). Furthermore, the highest number of respondents did not report flood damages to the city and did not ask for reimbursement from the municipality, even though the majority reported floods costing them their savings money used to replace their furniture (SMLFR). Lastly, most respondents reported that they did not receive reimbursement from the municipality, and they also reported floods costing them their savings money used to replace their furniture (SMLFR; Figure 5).

3.5 Floods preparedness and response

There were statistically significant differences found between the response variable, "whether the respondents managed to recover from floods, and all the predictor variables as follows: Whether the respondents usually receive floods early warnings (Wald $\chi^2 = 2.544$; $p = 0.000$); how the respondents received floods Early warnings (Wald $\chi^2 = 19.710$; $p = 0.001$); Whether the respondents were ever evacuated because of the floods (Wald $\chi^2 = 8.970$; $p = 0.002$); the reason for evacuation (Wald $\chi^2 = 32.589$; $p = 0.001$). Furthermore, the highest number of respondents reported not receiving early flood warnings from social media and never evacuated due to flooding; they were evacuated because they had older people in their households (Figure 6).

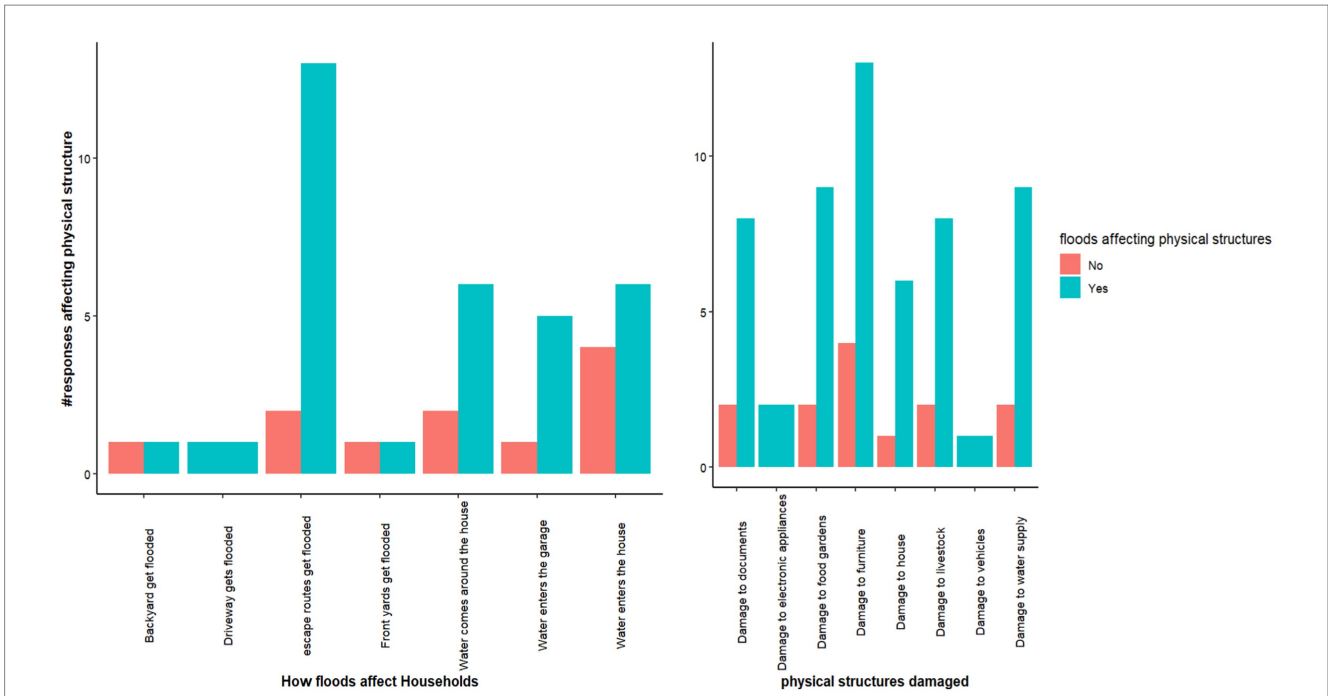


FIGURE 2 The number of reports about the physical impacts of floods reported by the respondents by how floods affect households (left) and the physical structure damaged by floods (right).

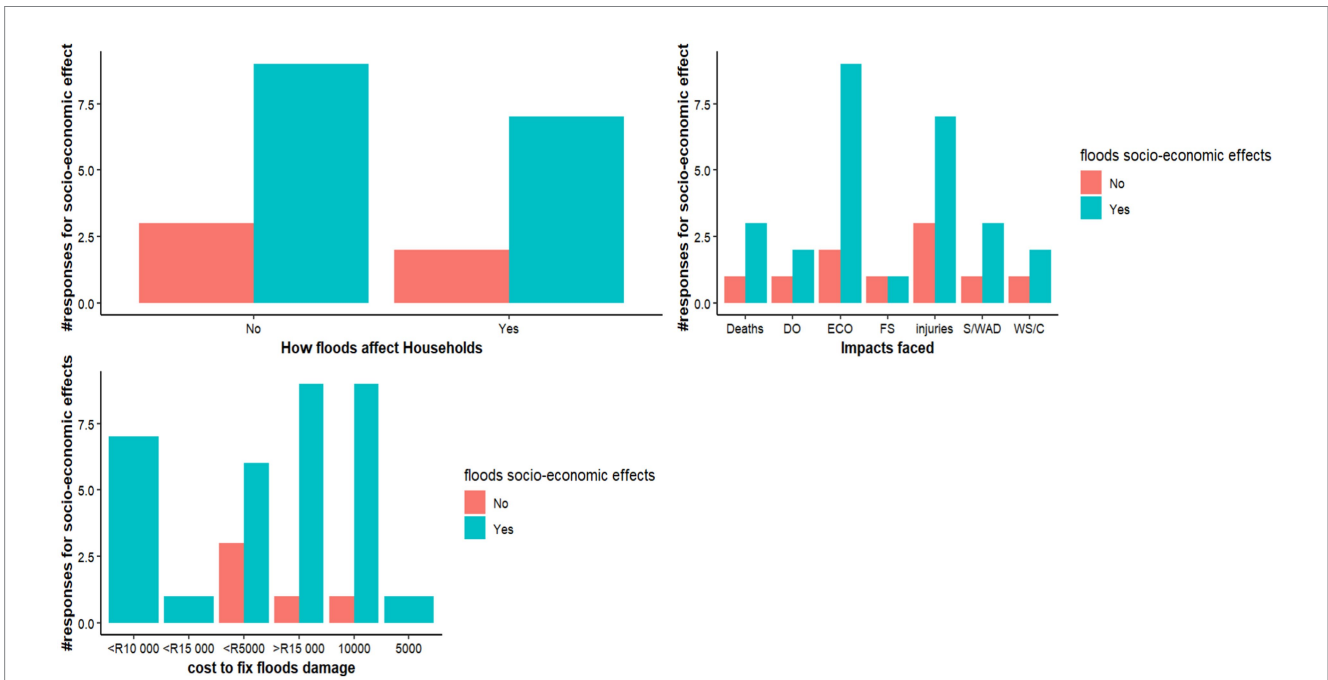


FIGURE 3 Number of reports about the socioeconomic effects of floods, including how floods affect households (top left), the impacts faced amidst floods (top right), and the cost of fixing flood damages (bottom left). DO, Disease Outbreaks; ECO, Electricity Cut-Offs; FS, Food Shortage; SW/AD, School/Work Attendance; WSC, Water Shortage and Contamination.

4 Discussions and conclusions

We assessed the causes and impacts of floods in two flood-prone areas in the Free State Province of South Africa, and two demographic

characteristics that stood out in the study were the respondents' level of education and employment status. Of the 127 respondents, the majority of the respondents, 63%, had secondary schooling. Most respondents, 47%, were unemployed and have significant implications for a study

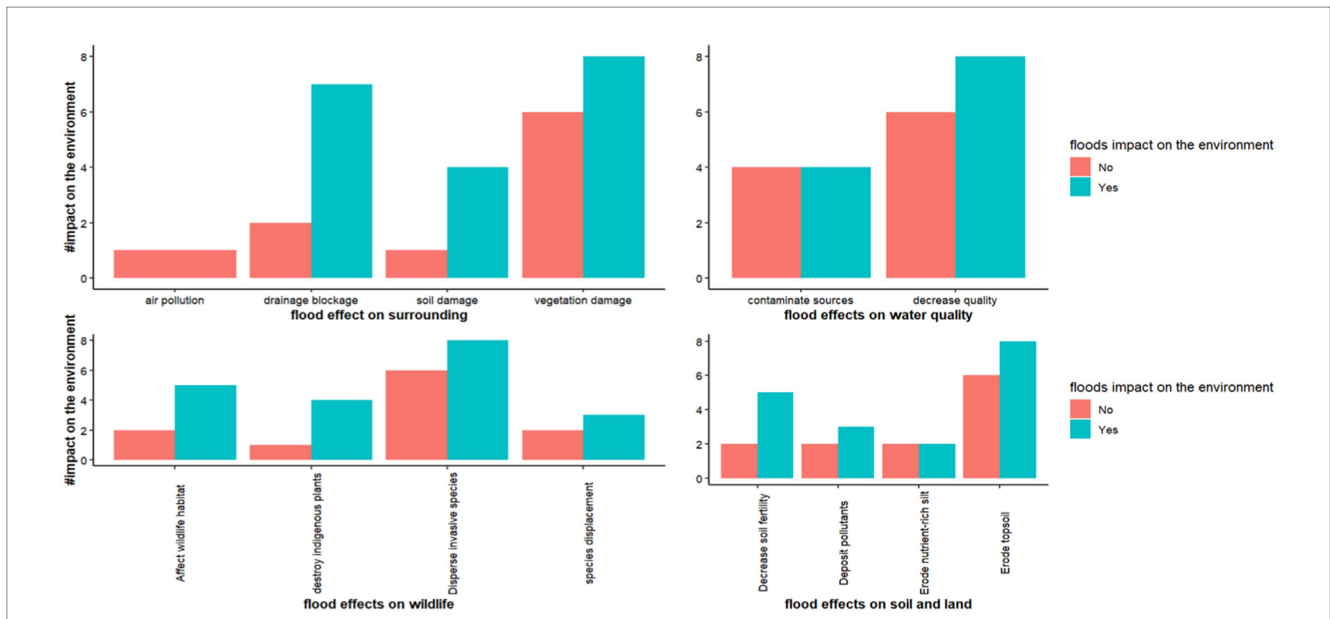


FIGURE 4 Number of reports about the environmental impacts of floods in the community by flood effects on the surroundings (top left), flood effects on water quality (top right), flood effects on wildlife (bottom left), and flood effects on soil and land (bottom right).

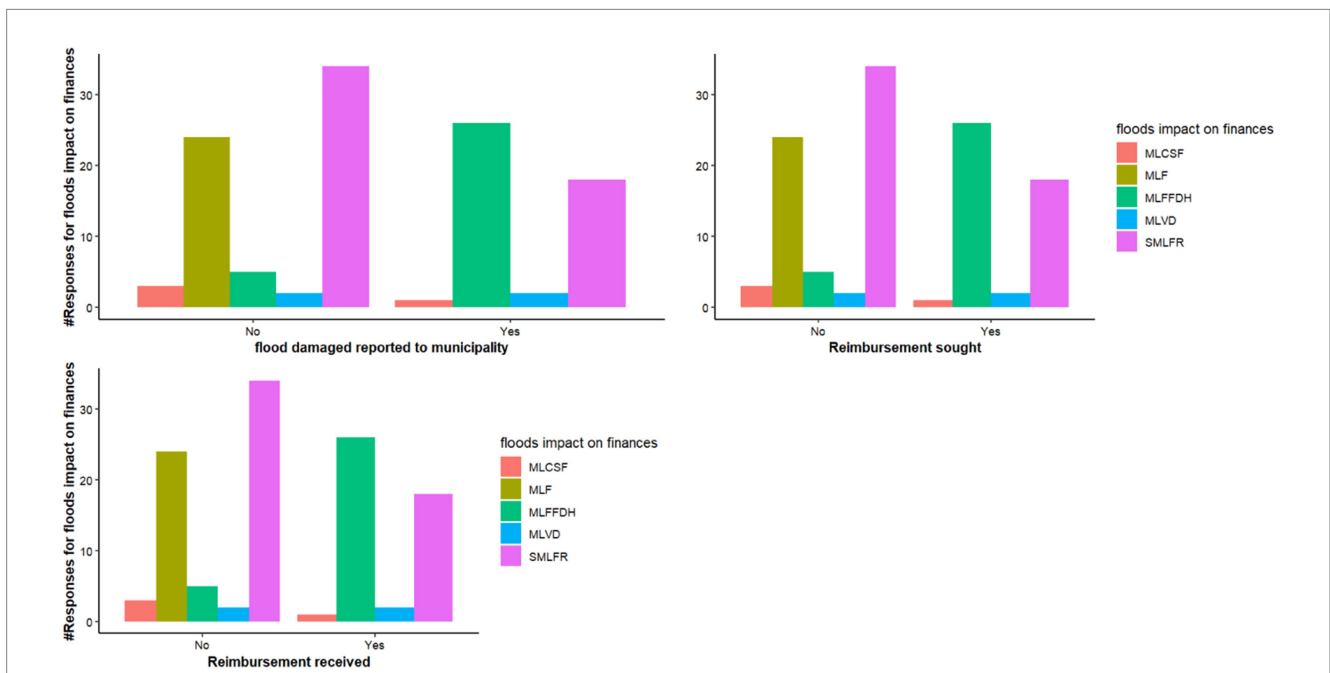
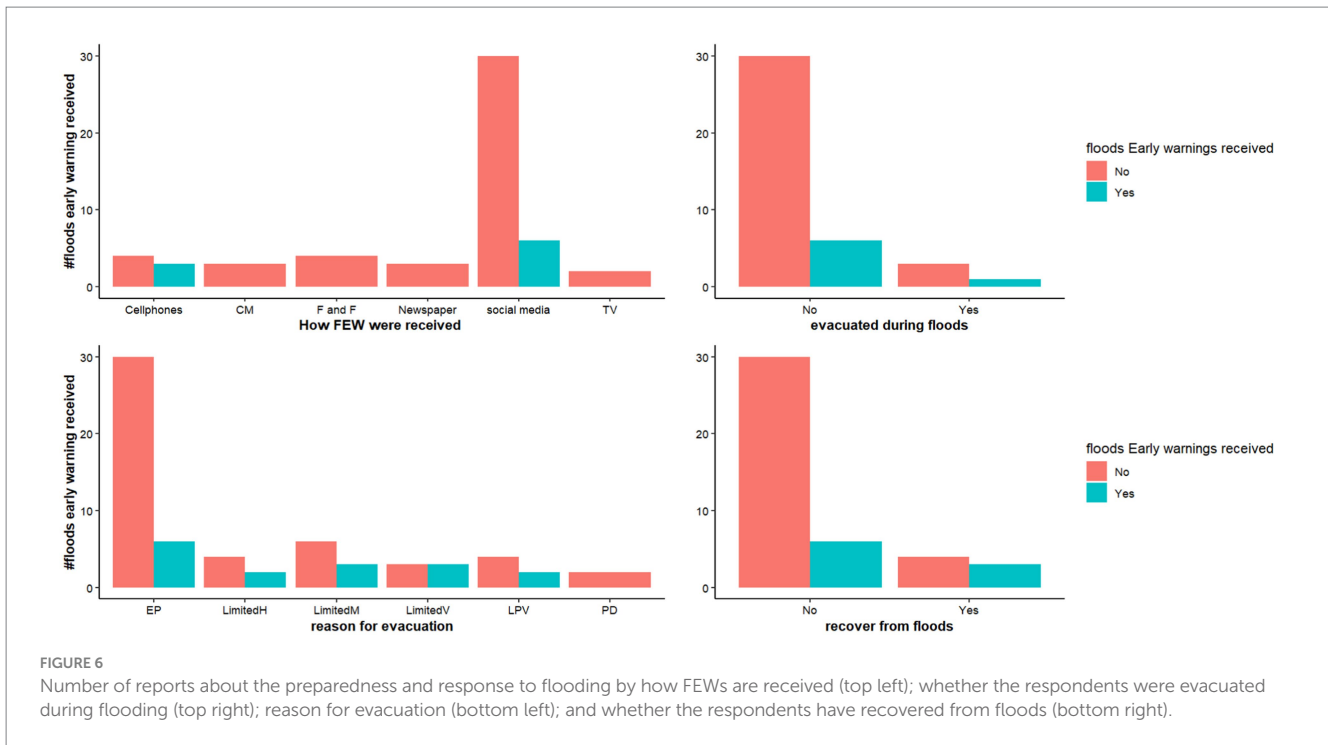


FIGURE 5 Number of reports about the municipality's intervention in flood disasters focussing on how the floods affect respondents' households in terms of money by flood damage reported to the city (top left); reimbursement sought from the municipality (top right); and reimbursement received from the city.

investigating the impacts and causes of floods in two townships, mainly when focusing on the physical, socioeconomic, and environmental effects, community preparedness, and municipal interventions. For example, most respondents with secondary schooling could influence their ability to understand and respond to flood risks as this is a moderate level of education. In addition, The interplay between educational attainment and unemployment highlights a dual

vulnerability in the studied communities. Addressing flood impacts requires technical and infrastructural solutions and targeted socioeconomic interventions. Empowering communities through education and economic opportunities can enhance their resilience and reduce dependence on municipal aid during flood disasters.

The study also found key insights into community perceptions and experiences of flooding. The findings suggest that flooding is a



common and recurring issue for many respondents. The study also highlights the importance of flood experiences, implying that these frequent flooding events may have noticeable impacts on daily life within the studied communities. Furthermore, the descriptive findings indicate that most respondents experience flooding each time it rains, and a significant proportion consider flooding a problem, rating it as a major issue in their community. Most report their homes as at risk, with inadequate drainage cited as the primary cause of flooding. The insights reveal the critical role of infrastructure deficiencies, such as drainage, in exacerbating flooding incidents.

The findings exposed a gap between frequent exposure to flooding and individual perceptions of its severity or associated risks. This gap may imply a lack of awareness of potential long-term flood risks. In addition, the lack of drainage systems was identified as a significant contributing factor to the community's flooding challenges.

The study determined the physical, socioeconomic, and environmental impacts of floods and found that participants' experiences of flooding in their households are closely linked to the damage reported in physical structures. Flooded escape routes and damaged furniture were frequently reported, highlighting the direct and often unavoidable disruptions floods cause to essential household infrastructure. This finding supports previous research that shows households are particularly vulnerable to physical damage from floods (Pham et al., 2020; Shah et al., 2020; Ullah et al., 2021).

The study concludes that flooding significantly affects household structures more escape routes than other structures. The results suggest that interventions to mitigate flood damage should prioritize common household vulnerabilities while recognising the varying resilience among specific physical structures.

The significant socioeconomic impact of flooding on the respondents and their communities showed a notable perception of flood impact on households and communities and the financial burden required to repair flood-related damages. The findings suggest

that households experiencing more significant economic loss due to flood damages are more likely to report substantial socioeconomic challenges. The reported costs for repairing damages highlight the financial toll of floods, with a significant portion of households incurring expenses of R10,000 to over R15,000. This finding aligns with existing literature demonstrating that flood recovery can create substantial financial burdens, particularly for low-income families (Emrich et al., 2020; Rivera et al., 2022; Wilson et al., 2021).

Most respondents cited electricity cut-offs (ECO) as a prominent impact of flooding, reflecting the direct infrastructural impacts of floods and their effects on daily life. Electricity outages are critical as they disrupt economic productivity and social well-being, potentially leading to a cascading effect of vulnerabilities within the community. The widespread reporting of socioeconomic impacts suggests that floods challenge household stability and community resilience.

The study findings indicate a mixed impact of floods on the environment. However, the statistically significant result regarding water quality highlights that floods significantly affect drinking water quality within the community. This finding is consistent with a lot of studies that demonstrated how floods can lead to contamination of water sources through overflow of sewage systems (Hou et al., 2021), infiltration of pollutants (Cooper et al., 2019), and increased turbidity (Aldardasawi and Eren, 2021), all of which are detrimental to public health.

Additionally, the qualitative responses from participants suggest that the community associates flooding with environmental degradation through mechanisms such as vegetation loss, erosion, and the spread of invasive species.

The study further evaluated the role of municipal interventions during flooding in the study communities. The findings indicated that households are likelier to contact their municipality for assistance amidst flooding. However, the results suggest that, while many respondents experience considerable financial losses due to flooding,

they may not seek or expect financial aid or compensation from the municipality. This lack of engagement could reflect a lack of awareness about available resources, a lack of trust in municipal response efficacy, or a perception that municipal intervention is insufficient or inaccessible.

Interestingly, most respondents did not report flood damages to the municipality or request reimbursement despite reporting significant personal financial loss. This lack of reporting or request for reimbursement may suggest barriers to accessing municipal support, such as limited awareness of available support programs or the perceived complexity of the reimbursement process. Additionally, the finding that many households used personal savings to recover from flood damage points to an urgent need for proactive support from municipalities, particularly for at-risk families.

The study lastly assessed the community's preparedness for floods by evaluating factors associated with recovery from flooding events, examining the effectiveness and accessibility of early warning systems, and analyzing evacuation behaviors and motivations. The findings reveal that a significant proportion of respondents did not receive early flood warnings, and among those who did, social media was the most commonly cited source. This reliance on social media for warnings highlights a potential opportunity and vulnerability in the community's communication network. While social media provides rapid information dissemination, it may lack reliability and consistency, especially in remote or under-resourced areas with limited internet access. Additionally, respondents who had been evacuated often reported doing so due to the presence of vulnerable individuals, such as elderly family members, in their households. This underscores the importance of addressing specific community needs that could influence evacuation decisions and impact resilience and recovery.

The study concludes that flood preparedness within the community is influenced by several critical factors, with early warning systems, evacuation history, and household demographics playing central roles. The significant associations between these factors and the respondents' recovery outcomes indicate that better early warning systems and targeted evacuation support could significantly enhance community resilience to flooding. However, the lack of consistent early warning receipt across the population suggests that current communication strategies may be inadequate, with over-reliance on social media platforms posing risks for real-time response during emergencies.

4.1 Recommendations

This study would, therefore, recommend enhanced flood awareness campaigns within the study communities as well as infrastructure improvements and community flood preparedness Programs based on the findings of the first model. For the flood impacts on infrastructure, the study recommends targeted reinforcement of vulnerable structures, community-specific structural resilience programs, and educational outreach on flood-resistant household materials. For the socioeconomic implications of floods identified, the study recommends enhanced flood preparedness and mitigation Programs, Infrastructure resilience investments, and community-based insurance or support Mechanisms. This study recommends improved drinking water management and protection

measures and enhanced floodplain and vegetation management to mitigate the environmental effects of flooding. Flooding has a substantial economic impact on households, often depleting personal savings. Therefore, to circumvent the financial burden associated with flooding, this study recommends increased awareness and accessibility of support programs, enhanced financial support for flood-affected and flood-prone households, proactive flood prevention and risk reduction measures, and strengthening data collection and impact assessment on flood damages. Based on the preparedness level within the study communities, this study recommends enhanced flood early warning systems, community education and training, evacuation support for vulnerable households, social media integration with verified information channels, and regular community drills and simulations.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by University of the Free State General Human Ethics Committee. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

TR: Conceptualization, Formal analysis, Funding acquisition, Methodology, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing. MM: Conceptualization, Data curation, Investigation, Project administration, Resources, Validation, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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