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Original Article

Preparedness and Response to Flooding Risks by Kenya Wildlife Service in Hells Gate National Park, Nakuru County, Kenya

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ABSTRACT

Floods are short-lived events that occur abruptly with little to no warning and are among the most dangerous disasters relating to weather due to the hazardous conditions caused for people, the destruction of property and the loss of life as well. Thus, minimizing flooding impacts timely and passing accurate information is critical in flood preparedness and response. Previous studies have focused on the probability of floods occurring and their magnitude, therefore leaving a knowledge gap on preparedness and response to flooding risks in national parks by government agencies in Kenya. Hell's Gate National Park experiences significant flash flooding; therefore, it provided a good venue to study the levels of preparation and response mechanisms available in Kenyan national parks. The objectives of the study were to understand the level of preparedness and mechanisms to respond to flooding events by Kenya Wildlife Service in Hells Gate National Park. The study was guided by a descriptive research design which involved collecting quantitative and qualitative data from 118 park users and other key informants. The study found that the Kenya Wildlife Service plays a crucial role in flood preparedness and response, but there is room for improvement in early warning systems, hazard map distribution, and user education because only 36.6% of the respondents were aware of escape routes to be used during floods. In terms of recommendations, the study found that it is crucial to enhance the existing flood preparedness and response mechanisms within the park including investing in advanced technology for early warning systems, conducting regular drills, and fostering community engagement and partnerships, continuous improvement of flood preparedness and response plans, along with a robust communication strategy.

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INTRODUCTION

In the twentieth century, flood events have increased worldwide, causing major impacts on human activities, the environment and socioeconomic life (Kiptum, 2019). Disasters related to floods are on the rise and in the past decade more than 140 million people on average have been affected each year with a mortality rate of 25, 000 annually (Nyakundi, 2010). To increase preparedness in the future for flood events, an integrated approach that builds the resilience of a floods-affected community and enhances emergency preparedness based on reliable data is critical.

Hashim, et al., 2021 have identified the factors affecting engagement in disaster preparedness activities as follows (1) hazard knowledge, (2) risk perception, (3) previous experience, business owner's or decision maker's characteristics (age, gender, and race); and (4) business organization characteristics (annual income, age of business, sector, company's size and two-floor premise).

Additionally, according to Alam and Muzzammil, (2011), it is not possible to completely avoid flood disasters, but the associated with flood-related disasters can be minimized by creating proper awareness of the likely floods and their impact by developing suitable early warning systems, flood preparedness and management of flood disasters through the application of information technology tools.

In Germany, locals prepare for floods using some precautionary measures e.g. since they have more experience with floods and have knowledge of being at risk (Thieken et al., 2007). These measures include (1) gathering information about floods by participating in neighborhood development and (ii) floodproofing and insuring their property against flood damage. For instance, the German government has an emergency funding system that is issued for reconstruction as well as the provision of insurance through compensation for the rapid recovery of residents from floods (The Federal Ministry of Finance, 2021).

For example, its National Environmental Management Authority works hand in hand with the Hydrological Services Agency and the Nigerian Metropolitan Agency to develop an updated plan for preparedness and response (Adelekan & Asiyanbi, 2016). To strengthen the early warning system for early detection community members are trained to conduct community-based surveillance which strengthens the early warning system. Platforms such as the media public service announcements are used to inform locals of prevention and mitigation measures to reduce flood-related risks.

On the other hand, Iguda-Ladan, and Saulawa, (2021) report that flood response includes the search

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and rescue of victims, survey and assessment of flood disaster impacts and needs, evacuation of victims and mass care for a large number of people affected by the flood disaster. Further risk perception has been defined by Lechowska, (2018) as an assessment of the probability of hazard and the probability of the results (most often—the negative consequences) perceived by the society and thus understanding how society perceives flood risk is of crucial importance.

Kenya is prepared for flood events through an early warning system (Kiptum, 2019). This involves timely communication of a flood event and mapping out flood hazard areas. Locals rely on information from the Kenya Meteorological Department, media and NGOs (Rono, 2017). Communities prone to floods use early warning systems to warn the wider community on approaching floods as well as participating in drills prepared to alert locals on how to respond in case of a flood event (Kiptum, 2024).

As disasters related to water continue to increase due to factors such as climatic variability it is therefore important to design actions to reinforce the resilience of the Kenya Wildlife Service (Few et al., 2004). Further, in Kenya, disaster preparedness is fragmented, whereby in most cases it is reactive rather than taking proactive actions (Rono, 2017).

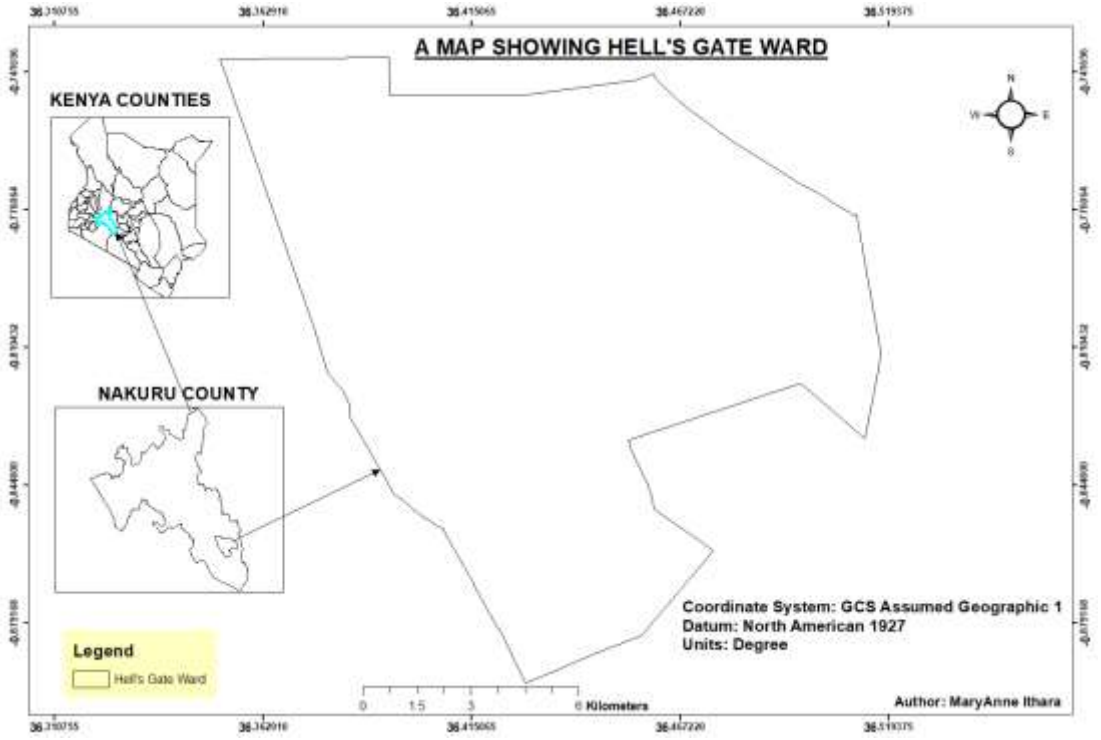
These studies, therefore, focus on the preparedness and response mechanisms that KWS has put in place and are important in designing a comprehensive understanding of the vulnerability and the processes that play a vital role in shaping the capacities of coping with floods.

RESEARCH METHODS

Study Area

Hell's Gate National Park is located in Naivasha Sub County in Hell's Gate ward and has a population of 44,297 people with a growth rate of 3.05% (Nakuru County Government, 2018). The area of study is situated south of Lake Naivasha and northwest of Nairobi.

Figure 1: Hell's Gate Location Map



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The climatic condition of the study area is influenced by the Lake Naivasha basin (Onywere, 2005). The rainfall pattern is bi-modal with the long rain season occurring between April- June and the short rain season occurring between October-November. The area receives rainfall of approximately 600mm annually. The highest temperature is recorded in March while the coldest temperature is recorded in July (KWS, 2010). Tourism is the main economic activity in the study area (Scoon, 2020). Hell's Gate National Park attracts tourists both locally and internationally due to its proximity to Nairobi, many hotels, and campsites, the extent of the birds and wildlife, and the area's beauty. Vegetation in the park ranges from rocky to swampy but is dominated by shrubs and short trees which include euphorbia and acacia. The vegetation is as a result of the topography (Onywere, 2005).

Research Design

The study preferred the descriptive research design because it involved collecting qualitative and quantitative data on the park users' perception and KWS preparedness and response to flooding in the event of a flood hazard in Hell's Gate National Park.

Sample Size and Sampling Procedure

The sample size was determined by using Creative Research Systems (CRS) (2009) tools since there is no admission data or census enrollment of the park users. The sample size for the study was 118 park users. The purposive sampling technique was used to identify institutions with key information on floods in Hell's Gate to analyze perceptions and responses from the perspective of decision-makers. The key informants were 3 KWS, 2 Kenya Red Cross and 2 KENGEN officers. Thus, the sample size was 125. Simple random sampling was used for the users of the park, with each member of the population given an equal chance to participate.

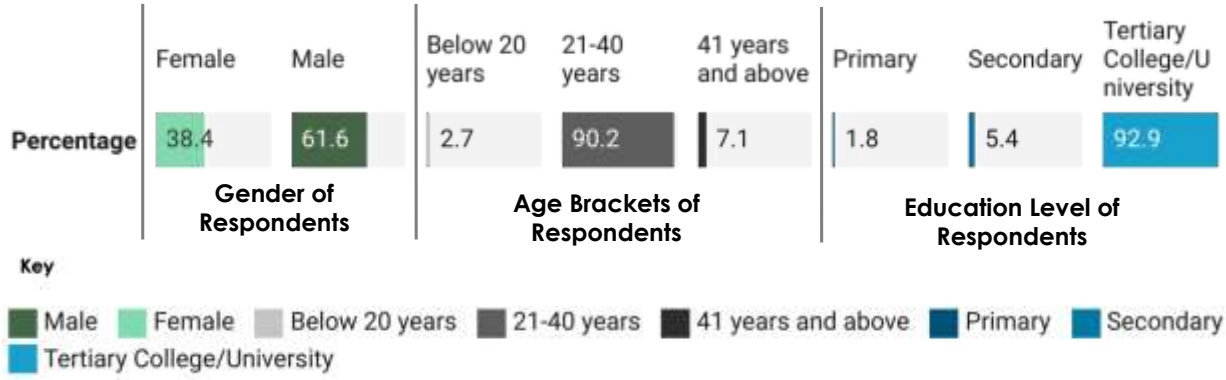
Data Analysis Methods

The study employed a mixed-methods approach to gather data. Primary data was collected through interviews, observations, focus groups, and questionnaires. Qualitative data from interviews and focus group discussions with key informants and park users were analyzed using content analysis to understand perceptions, preparedness levels, and experiences related to floods. Quantitative data from park users were analyzed using descriptive statistics and chi-square tests to determine associations between variables such as flood risk perception, safety perception, and preparedness level. Secondary data was obtained from published documents and online sources, providing contextual information and historical trends.

RESULTS

Respondents' characteristics

Figure 2: Respondents' General Information



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The study's results highlighted key demographic characteristics of respondents, showing a gender imbalance with 61.6% males and 38.4% females. This disparity suggests the need for more balanced gender representation in future studies to ensure diverse perspectives are captured, particularly in assessing perceptions of flood preparedness. However, this imbalance can be attributed to the number of male visitors to the park during the data collection period. The age distribution was heavily skewed towards respondents aged 21-40, who made up 90.2% of the sample, with only 7.1% aged 41-60 and 2.7% under 20. This concentration of responses from the 21-40 age group implies that flood preparedness strategies in Hell's Gate National Park may be overly focused on this demographic, potentially overlooking the needs of younger and older visitors. This trend may be because most park visitors typically fall within the 21-40 age range, as they are more likely to be physically able to visit the park and have disposable income.

Additionally, the study found that the vast majority of respondents, 92.9%, had tertiary education, with only 5.4% having completed secondary education and 1.8% primary education. This suggests that current flood management strategies may be unintentionally tailored to a highly educated audience, which could lead to communication barriers for those with lower educational levels. To ensure inclusivity, the park needs to diversify its communication strategies, making them accessible to people with varying educational backgrounds, thereby improving overall preparedness and response efforts.

Flood **preparedness and response mechanisms used by Kenya Wildlife Service**

Figure 3: Percentage Knowledge of Flood preparedness and response mechanisms

The study's findings regarding park users' awareness of evacuation procedures and safe areas during flood events reveal a significant gap in preparedness. According to Figure 3, only 36.6% of respondents are aware of escape routes in the event of a flood, while a majority, 63.4%, are not familiar with such routes. This suggests that many park visitors may be at risk during a flood event due to a lack of knowledge about how to evacuate safely. The findings emphasize the need for improved communication and education about evacuation routes to enhance the overall safety of visitors during flood emergencies. In addition to evacuation routes, the study also examined park users' knowledge of safe areas for shelters during floods. The study also found that 59.8% of respondents are aware of designated safe areas, while 40.2% are not. Although it is encouraging that the majority have some knowledge of these safe zones, the significant minority who are unaware of them indicates a need for ongoing efforts to raise awareness. Ensuring that all visitors are informed about safe shelter locations is crucial for their safety during flood events.

Further analysis, presented in Figure 3, looked at respondents' awareness of secure elevated areas within the park, which are impervious to water infiltration and suitable for seeking shelter during a flood. The results reveal that 55.4% of respondents know about such safe elevated areas, while 44.6% do not. This highlights a concerning knowledge gap that could leave nearly half of the park's visitors vulnerable during a flood. To address this, the park

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should focus on educating visitors about these critical refuge points to ensure their safety in an emergency. The study also explored respondents' understanding of the capacity of safe raised grounds within the park. The responses varied widely, with nearly half of the respondents (49.1%) unsure about the capacity of these safe areas. This uncertainty suggests that the availability and size of these refuge areas might differ across the park, which could lead to confusion during an emergency. Clear communication regarding the capacity and locations of safe raised grounds is essential to ensure visitors can effectively use these areas during flood events.

Lastly, the study assessed the sufficiency and reliability of the park's communication systems for flood warnings, as illustrated in Figure 3. The results indicate significant dissatisfaction, with 74.1% of respondents believing that the current equipment and mechanisms for receiving warnings are insufficient, and 70.6% expressing doubts about the reliability of the communication system. These findings underscore the urgent need for the park to enhance its warning infrastructure and communication channels to ensure timely and effective dissemination of flood warnings, thereby improving visitor safety during emergencies.

Awareness of Flooding

The study examined the effectiveness of disaster preparedness and response mechanisms within Hell's Gate National Park, with a particular focus on flood forecasting, warning dissemination, and awareness among park visitors. Drawing on insights from key informants representing the Kenya Wildlife Service, the Kenya Red Cross, and KENGEN, the discussion highlighted the current practices and challenges in flood preparedness. The study also explored the sources of initial flood awareness among park users, the frequency and methods of flood warnings, and the critical need for localized and timely flood forecasting systems to enhance safety within the park.

Table 1: Initial awareness of flooding.

	Percent
By use of the guides from the Maasai community living within the park	5.4
Do not know/not sure	11.6
Form own judgment	14.3
Heard of people that drowned	0.9
Media	0.9
Official flood warning	30.4
Past experiences	0.9
Tour guides	0.9
Unofficial or informal flood detection and warning process	34.8
Total	100

Table 1 provides insights into the initial sources of awareness about flooding among park visitors. The percentages indicate how different channels contribute to visitors' knowledge of flood risks in the park. A significant portion of respondents, 34.8%, mentioned "Unofficial or informal flood detection and warning processes" as their source of initial awareness. This suggests that some visitors rely on informal sources or community knowledge within the park to become aware of potential flood risks. This finding underscores the role of local communities and their traditional knowledge in raising awareness among park visitors. Another notable source is "Official flood warning" at 30.4%. This suggests that park authorities play a role in informing visitors about flood risks through official channels. It's positive to see that a substantial portion of visitors receive information through official means.

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Additionally, "Form own judgment" (14.3%) and "Do not know/not sure" (11.6%) indicate that some visitors may not have a clear source of flood awareness, and some rely on their observations or judgments. This suggests room for improvement in providing structured and reliable flood awareness information to all visitors. The relatively low percentages for other sources such as "Tour guides" (0.9%), "Heard of people that drowned" (0.9%), and "Media" (0.9%) suggest that these sources have limited influence on visitors' initial awareness of flooding in the park. Thus, the findings highlight the diversity of sources contributing to visitors' initial awareness of flooding, with both formal and informal channels playing a role. This information can guide park authorities in developing comprehensive and effective flood awareness programs that incorporate community knowledge while also ensuring official warnings reach all visitors.

The interviews with key informants from the Kenya Wildlife Service, the Kenya Red Cross, and KENGEN have shed light on the absence of a dedicated flood forecasting system in Hell's Gate National Park and its implications for flood preparedness and response provided the following findings.

According to a key informant from KWS:

> *"Hell's Gate National Park has faced flooding events in the past, and without a dedicated forecasting system, we rely on external agencies for weather and river level data" (KWS, 2022). This reliance on external sources poses challenges in providing timely and site-specific flood warnings to park visitors and residents.*

Another key informant from KENGEN emphasized the need for a localized approach, stating:

> *"The park's unique topography and hydrology require a specialized forecasting system that can monitor local rainfall patterns and river levels" (KENGEN, 2022). This sentiment highlights the limitations of relying solely on broader weather forecasts issued by national agencies, which may not capture the specific conditions within the park. The absence of an internal forecasting system also impacts the park's ability to proactively mitigate flood risks.*

A representative from the Kenya Red Cross noted:

> *"During floods, every minute counts. Without real-time data, we may not be able to make timely decisions on park closures or evacuations" (Kenya Red Cross, 2022). This underscores the importance of having access to accurate and up-to-date information for flood preparedness and response.*

To address this issue, key informants stressed the importance of collaboration between Hell's Gate National Park and external meteorological and hydrological agencies. A KWS representative mentioned:

> *"We are in constant communication with these agencies to receive weather and river level data, but establishing a closer partnership could enhance our flood preparedness efforts" (KWS, 2022). This collaborative approach could help bridge the gap in flood forecasting capabilities. The insights from key informants highlight the critical need for a dedicated flood forecasting system tailored to Hell's Gate National Park. The absence of such a system poses risks to human safety and conservation efforts. Establishing a localized forecasting mechanism and strengthening partnerships with external agencies are essential steps toward enhancing flood preparedness and response within this unique natural habitat.*

The frequency of flood forecasts produced for Hell's Gate National Park is a crucial aspect of flood preparedness and response. Key informants, including representatives from the Kenya Wildlife Service (KWS), the Kenya Red Cross, and KENGEN, provided valuable insights into the

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current practices related to flood forecasting in the park. One key informant from KWS mentioned that flood forecasts for Hell's Gate National Park are typically produced on a seasonal basis:

> *"We receive seasonal forecasts from national meteorological agencies, which provide an overview of expected weather patterns, including the likelihood of heavy rainfall and potential flooding," noted the KWS representative (KWS, 2022).*

This suggests that the park relies on broader, less frequent forecasts that may not capture sudden changes in local conditions. However, the interview with the Kenya Red Cross representative revealed that in the event of imminent flood threats, there is an effort to provide more frequent updates:

> *"When we receive information about an impending flood event, we try to issue updates as frequently as possible, especially as the event unfolds," stated the Kenya Red Cross representative (Kenya Red Cross, 2022).*

This indicates that the frequency of forecasts can vary depending on the urgency of the situation. The key informant from KENGEN emphasized the importance of having a more regular and localized forecasting system:

> *"Ideally, we should have real-time data and forecasts specific to the park's microclimate. This would require more frequent updates, possibly daily," suggested the KENGEN representative (KENGEN, 2022).*

This perspective underscores the need for a dedicated and frequent flood forecasting system tailored to the park's unique conditions. In summary, the frequency of flood forecasts for Hell's Gate National Park currently varies from seasonal forecasts to more frequent updates during imminent flood threats. However, there is a clear consensus among key informants that a more localized and regular forecasting system would significantly enhance flood preparedness and response within the park's specific context.

The main receivers of flood warnings in Hell's Gate National Park, according to insights from key informants including representatives from the Kenya Wildlife Service, the Kenya Red Cross, and KENGEN, vary based on the sources and dissemination channels of these warnings. One primary receiver of flood warnings is the Kenya Wildlife Service itself. As a responsible authority for park management and visitor safety, KWS actively monitors weather forecasts and flood warnings provided by national meteorological agencies:

> *"We have a direct line of communication with meteorological services, and we receive official flood warnings, which are then disseminated to our staff within the park" (KWS, 2022).*

This underscores the role of KWS in receiving and disseminating critical information to park stakeholders. Another key recipient of flood warnings within the park is the Kenya Red Cross, which plays a vital role in disaster response and management. They are often alerted to flood warnings through official channels and are actively involved in assisting with flood events:

> *"When we receive flood warnings, we mobilize our teams and resources for possible response activities," explained a representative from the Kenya Red Cross (Kenya Red Cross, 2022).*

Park visitors, especially those who have registered with park authorities, are also important receivers of flood warnings:

> *"We make efforts to inform registered visitors about potential flood risks, especially during the rainy seasons, and advise them on safety measures" (KWS, 2022).*

This indicates that visitors who have engaged with park authorities directly receive warnings and guidance to ensure their safety. It's important to note

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that while these key informants mentioned official channels and park authorities as receivers of flood warnings, the broader public and visitors may receive warnings indirectly through media broadcasts, mobile alerts, and community networks. The exact dissemination methods and their reach may vary, but the park's management and relevant organizations work to ensure that critical flood warnings reach those who need them most.

The frequency of flood warnings produced in Hell's Gate National Park varies depending on several factors, as indicated by insights from key informants, including representatives from the Kenya Wildlife Service, the Kenya Red Cross, and KENGEN. Flood warnings are typically generated in response to specific weather conditions and forecasts:

> *"Flood warnings are not produced on a regular schedule but rather in response to meteorological data and forecasts indicating conditions conducive to flooding" (KWS, 2022).*

This suggests that flood warnings are issued when there is a significant risk of flooding based on meteorological information. The frequency of flood warnings can be influenced by seasonal patterns, particularly during the rainy seasons when the risk of flooding is higher:

> *"During the long rains and short rains seasons, the frequency of flood warnings tends to be higher due to increased rainfall and the potential for flash floods" (KENGEN, 2022).*

Additionally, the frequency of flood warnings may increase during periods of extreme weather events, such as cyclones or heavy storms. These events can trigger rapid changes in weather conditions and may lead to more frequent issuance of warnings. It is important to note that while flood warnings are not produced on a fixed schedule, the park's management and relevant authorities are vigilant in monitoring weather conditions and responding promptly to emerging flood risks. This approach ensures that warnings are issued when necessary to protect the safety of park visitors and staff. In summary, the frequency of flood warnings produced in Hell's Gate National Park is not on a regular schedule but is determined by specific weather conditions, seasonal patterns, and the potential for extreme weather events. The primary goal is to issue warnings when there is a substantial risk of flooding based on meteorological data and forecasts.

The ways of disseminating warnings to park users in the event of a flood in Hell's Gate National Park encompass a variety of methods and strategies, as outlined by key informants including representatives from the Kenya Wildlife Service, the Kenya Red Cross, and KENGEN. One primary method of disseminating flood warnings is using technology and communication systems:

> *"We utilize mobile phone networks and SMS alerts to reach out to park users. When a flood warning is issued, text messages are sent to registered park visitors who have provided their contact information" (KWS, 2022).*

This approach leverages the ubiquity of mobile phones to quickly reach a broad audience. Another effective means of warning dissemination is through the park's official website and social media channels:

> *"Our website and social media accounts are crucial for sharing real-time updates, especially during periods of heightened flood risk" (KWS, 2022).*

In addition to digital channels, park management also employs more traditional methods for disseminating flood warnings. According to a representative from the Kenya Red Cross:

> *"We work closely with local communities, including the Maasai living near the park. Community leaders and elders play a vital role in relaying flood warnings to park users" (Kenya Red Cross, 2022).*

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This community-based approach ensures that warnings reach even those without access to modern communication technology.

Furthermore, the park employs on-site signage and information boards strategically placed at key locations within the park. These signs provide clear instructions and warnings about flood risks and safety measures. As explained by a KWS representative:

> *Visual aids, such as signs and boards, are valuable tools for conveying flood warnings to park visitors, especially those who may not have access to digital platforms (KWS, 2022).*

To ensure a comprehensive approach to warning dissemination, park management also conducts regular awareness campaigns and workshops. These initiatives educate park users about flood risks, safety procedures, and the importance of heeding warnings. According to KENGEN:

> *"Workshops and awareness campaigns are essential for equipping park users with the knowledge they need to respond effectively to flood warnings" (KENGEN, 2022).*

In conclusion, the effectiveness of KWS's disaster preparedness and response mechanisms in Hell's Gate National Park is influenced by various factors, including resource allocation, coordination, training, communication, and community engagement. While there are positive aspects, such as collaborative efforts and training programs, there are areas that need further attention, especially in adapting to changing flood patterns, improving communication, and enhancing community awareness. Continuous monitoring and evaluation, as suggested by respondents, will be key to making these mechanisms more effective in the future.

Cross-tabulation of variables

The study did a cross-tabulation of variables to determine the safety of the park and preparedness level. The cross-tabulation analysis was conducted to investigate the association between specific variables related to flood preparedness and safety perceptions among park users. This analysis aimed to understand how certain factors are interconnected and whether there are significant relationships between them. The results from these cross-tabulations indicated whether there were statistically significant relationships between the variables being examined. In cases where the p-value was less than a predetermined significance level (usually 0.05), it was concluded that there was a significant association between the variables. This information is valuable for understanding how park users' knowledge and perceptions relate to their preparedness for flood events and their safety within the park. Ultimately, the cross-tabulation analysis provides insights into the factors that influence park users' preparedness and safety awareness in the context of flooding, helping to inform future flood management strategies and safety measures in the park.

Table 2: Association between knowledge of escape routes and perceived adequacy of warning mechanisms in flood events in parks

	Value	Asymp. Sig. (2-sided)
Pearson Chi-Square	40.764a	0.000
Likelihood Ratio	25.152	0.000

The study sought to explore the correlation between park users' knowledge of escape routes and their perception of the adequacy of warning mechanisms during flood events within parks. The results, as presented in Table 2, indicate a statistically significant association between these two variables. Both the Pearson Chi-Square and Likelihood Ratio tests yielded p-values of 0.000, signifying a strong association. This suggests that individuals with better knowledge of escape routes are more likely to

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perceive the warning mechanisms as adequate, emphasizing the importance of preparedness and awareness in flood risk mitigation within parks.

Table 3: Effectiveness of escape routes and communication systems for flood safety in parks

	Value	Asymp. Sig. (2-sided)
Pearson Chi-Square	30.227	0.000
Likelihood Ratio	14.871	0.005

Table 3 presents the results of an analysis that aimed to explore the relationship between park users' knowledge of escape routes during a flood event and their perception of the reliability of the communication system for flood warning dissemination. The statistical tests conducted, including Pearson Chi-Square and Likelihood Ratio, yielded significant findings with p-values of 0.000 and 0.005, respectively. These results indicate a significant association between these two variables. Specifically, individuals who reported knowing escape routes were more likely to perceive the communication system as reliable for flood warning dissemination. This underscores the importance of both awareness of evacuation routes and the effectiveness of communication systems in enhancing flood preparedness and response within the park.

Table 4: Availability and adequacy of shelters and warning systems

	Value	Asymp. Sig. (2-sided)
Pearson Chi-Square	51.417a	0.000
Likelihood Ratio	21.771	0.000

Table 4 presents the results of an analysis examining the association between the availability of selected safe areas for shelters in the park during floods and the sufficiency of equipment or mechanisms to receive flood warnings while in the park. The statistical tests conducted, including Pearson Chi-Square and Likelihood Ratio, both yielded highly significant findings with p-values of 0.000. These results indicate a strong and significant association between the presence of safe shelter areas and the sufficiency of equipment or mechanisms for receiving flood warnings. In other words, park users who reported the existence of safe shelter areas were more likely to perceive the equipment and mechanisms for receiving flood warnings as sufficient. Conversely, those who did not know of safe shelter areas were less likely to perceive the equipment as sufficient. This association suggests that the availability of safe shelter areas in the park is linked to park users' perceptions of the sufficiency of equipment or mechanisms for flood warnings, highlighting the importance of both factors in flood preparedness and response within the park.

Effectiveness of Disaster Preparedness and Response Mechanisms

Based on the findings from park users and other key informants, the assessment of the effectiveness of the disaster preparedness and response mechanisms used by Kenya Wildlife Service (KWS) in Hell's Gate National Park reveals a mixed picture, with several strengths but also notable areas for improvement.

The presence of early warning systems, including flood hazard maps and communication channels, received positive recognition from respondents. This suggests that KWS has made significant strides in establishing essential infrastructure for disaster preparedness. However, there were concerns expressed about the reliability of these systems during extreme conditions, implying that further investments may be needed to enhance their

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robustness. This finding highlights the importance of continuous improvement and maintenance to ensure that early warning mechanisms are effective in safeguarding park users and wildlife.

The respondents generally acknowledged that KWS allocates resources adequately for disaster preparedness and response. This suggests that the organization recognizes the importance of having the necessary tools and supplies on hand to respond effectively to flood events. Nevertheless, there were occasional mentions of shortages of essential supplies, indicating that further attention to resource management and distribution may be necessary. Park users' perceptions of resource adequacy are crucial, as they provide insight into the practical implementation of disaster management plans.

Moreover, the collaborative efforts of KWS with stakeholders such as the Kenya Red Cross and KENGEN received positive feedback from respondents. This indicated effective coordination in disaster response efforts, contributing to the overall effectiveness of the mechanisms in place. Such partnerships are essential for pooling resources and expertise in managing flood risks within the park. Further, training and drills conducted by KWS were perceived as beneficial, enhancing the readiness of their personnel. Respondents noted that these activities contributed to improved preparedness and response capabilities. However, there was also a suggestion that more frequent and realistic exercises could further enhance preparedness. This underscores the importance of continuous training and simulation exercises to keep staff well-prepared for various disaster scenarios.

Community engagement efforts by KWS were acknowledged by respondents. However, there were comments indicating that community awareness of flood risks could be further enhanced. This suggests that KWS should focus on refining its community engagement strategies to ensure that local residents and park users are well-informed about flood risks and the appropriate actions to take during flood events. Moreover, climate change considerations, while not explicitly addressed by respondents, are indirectly highlighted by the acknowledgement of changing flood patterns. This emphasizes the need for KWS to integrate climate change adaptation measures into its disaster management planning to effectively address evolving risks.

Furthermore, some respondents expressed concerns about communication, particularly in reaching park users during flood events. This highlights the importance of robust communication systems, including mobile networks, to ensure timely alerts and information dissemination. Effective communication is a critical component of disaster preparedness and response and should be a priority for KWS.

The increased frequency of flood events, as noted by both park users and key informants, emphasizes the need for ongoing evaluation and adaptation of preparedness measures to address the changing risk landscape. This suggests that KWS should adopt a proactive approach to disaster management, continuously monitoring and adjusting its strategies to meet the evolving challenges posed by climate change. Lastly, community awareness and education regarding flood risks were highlighted as areas where KWS could improve its efforts. Improved awareness can significantly contribute to more effective preparedness and response, as informed individuals are more likely to take appropriate actions during flood events.

In conclusion, the effectiveness of KWS's disaster preparedness and response mechanisms in Hell's Gate National Park is influenced by various factors, including resource allocation, coordination, training, communication, and community engagement. While there are positive aspects, such as collaborative efforts and training programs, there are areas that need further attention, especially in adapting to changing flood patterns, improving communication, and enhancing community awareness. Continuous monitoring and evaluation,

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as suggested by respondents, will be key to making these mechanisms more effective in the future.

DISCUSSION

This study on the Hell's Gate National Park highlights critical gaps and strengths in flood preparedness and response mechanisms. However, certain limitations must be acknowledged. One limitation of the study is the skewed demographic distribution of respondents, with the majority being male and aged between 21-40 years. This demographic imbalance may have influenced the findings, particularly regarding perceptions of flood preparedness, potentially overlooking the needs of older, younger, and female visitors. A more representative sample would have offered a comprehensive understanding of flood preparedness across different demographic groups.

Another limitation lies in the reliance on self-reported data, which may introduce bias or inaccuracies. Respondents might have overestimated their awareness or preparedness for floods, leading to discrepancies between perceived and actual readiness. Additionally, the study's focus on Hell's Gate National Park may limit the generalizability of the findings to other national parks or regions with different environmental and socio-economic contexts.

The results align with previous research on disaster preparedness, which emphasizes the importance of early warning systems, community engagement, and localized flood forecasting. Studies by Thieken et al. (2007) and Nyakundi et al. (2010) have similarly found that communities with higher flood awareness and preparedness tend to experience fewer casualties and damage. However, like these studies, the current research shows a significant knowledge gap, particularly concerning evacuation routes and shelter locations.

The theoretical implications of this study suggest that flood preparedness strategies need to incorporate both formal and informal communication channels, as well as community-based knowledge. This aligns with the disaster risk reduction framework that emphasizes resilience through community participation and local knowledge integration (Lechowska, 2018). Practically, the findings call for the KWS to invest in enhancing early warning systems, educational outreach, and infrastructure improvements, particularly in communication and shelter management. Implementing these measures would improve safety outcomes during flood events and promote a more inclusive approach to disaster preparedness.

CONCLUSION

The findings of the study offer a range of data from the demographic characteristics of the respondents to the levels of flood preparedness and response mechanisms by KWS in Hell's Gate National Park through cross-tabulations of key variables related to flood safety. Most of the respondents were male (61.6%), within the 21-40 years age bracket (90.2%) and had attained a tertiary/university level of education (92.9%). These demographic characteristics indicate that the existing flood preparedness in the park may be skewed towards young, educated, male audiences and unintentionally overlooking those who do not fit the stated demographic characteristics.

Concerning the levels of flood preparedness and response mechanisms, only 36.6% of the respondents were aware of escape routes to be used during floods. This statistic indicates a gap in a key aspect of flood preparedness amongst park users. However, more respondents were aware of designated safe areas (59.8%) and elevated sections (55.4%), indicating that despite there being a significant knowledge gap amongst park users it is still significantly higher than that of the escape routes. In addition to the knowledge gaps concerning escape routes, designated safe areas, and elevated areas, most park users expressed dissatisfaction with the sufficiency and reliability of communication systems for flood warnings, with 74.1% and 70.6% of respondents respectively

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expressing concerns. This highlights the need for improved communication infrastructure in the park.

Approximately 34.8% of respondents indicated that they acquired information on flooding in the park primarily from informal sources as opposed to 30.4% whose primary sources were official. This statistic indicates that KWS should incorporate informal channels and vernacular languages in its communication strategies. Additionally, key informants emphasized the lack of a localized forecasting system in Hell's Gate National Park, which relies instead on external sources that may not adequately address the park's unique conditions. This might also make it hard for KWS to circulate the information in informal and vernacular formats to park users.

The cross-tabulation analysis revealed significant associations between the assessed variables. There was a strong statistical association between respondents' knowledge of escape routes and their perception of the adequacy of warning mechanisms, supported by a p-value of 0.000. Another significant association was found between knowledge of escape routes and the reliability of communication systems for flood warnings, with p-values of 0.000 and 0.005. Additionally, a strong correlation was identified between the availability of safe shelter areas and the sufficiency of flood warning equipment, emphasizing the importance of both in ensuring visitor safety during flood events. Overall, the results suggest that while some measures are in place, significant improvements are needed in communication, education, and infrastructure to enhance flood preparedness and ensure the safety of all park visitors.

RECOMMENDATIONS

KWS should prioritize the enhancement of flood preparedness and response mechanisms in Hell's Gate National Park by addressing the identified knowledge gaps amongst park users and communication shortcomings. Firstly, KWS should implement targeted educational campaigns tailored to the diverse demographics of park visitors, particularly focusing on those who may be less educated or belong to underrepresented groups such as women, persons with disabilities, and those with low education levels. These campaigns should emphasize the importance of understanding evacuation procedures/channels, identifying designated safe areas, and recognizing flood risk patterns. Additionally, KWS should collaborate with local communities to integrate informal knowledge with official safety protocols, ensuring that all visitors, regardless of their background, are adequately informed and prepared in the event of a flood.

Furthermore, KWS must invest in upgrading the park's communication infrastructure to improve the reliability and effectiveness of flood warnings. This could include the installation of more robust and accessible communication systems, such as early warning sirens, mobile/social media alerts, radio/television announcements, and strategically placed information boards. The development of a localized flood forecasting system specific to Hell's Gate National Park is also crucial, as it would provide more accurate and timely warnings, allowing both visitors and park management to respond more effectively to impending flood threats. By addressing these key areas, KWS can significantly enhance visitor safety and mitigate the risks associated with flooding in the park.

Based on the conclusions, further areas of study should explore the effectiveness of different communication strategies in enhancing flood preparedness across various demographic groups, particularly focusing on underrepresented populations such as women and those with lower educational backgrounds. Research should also investigate the development and implementation of localized flood forecasting systems tailored to the unique conditions of Hell's Gate National Park. Additionally, studies could examine the integration of local and indigenous knowledge with official safety protocols to create a more inclusive and

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effective flood preparedness strategy. Finally, assessing the long-term impact of educational campaigns and infrastructure improvements on visitor safety during flood events would provide valuable insights for the continuous enhancement of flood response mechanisms.

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