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Assessment of flood incidents, damages, and mitigation efforts in Danglag, Consolacion, Cebu, Philippines

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Abstract

Flooding, a natural phenomenon with far-reaching consequences, has been a perennial challenge for communities worldwide. Its impacts on lives, livelihoods, and infrastructure are profound. Despite recent efforts to reduce flooding, Barangay Danglag in Consolacion, Cebu, remains vulnerable to flooding. This study examines the causes, effects, and mitigation efforts of flooding in Barangay Danglag, Consolacion, Cebu. Data collected from 29 households near Danglag-Laray Creek revealed that majority of the residents are living in a residential area with a lot smaller than 100 square meters. Most residents experienced flooding in the past decade up to the second floor of the residential properties, primarily due to heavy rainstorms and nearby water bodies overflowing. Additionally, the downspout connections that is revealed to be flown directly to lawns and ground surface that added to water level. The impacts included significant non-monetary losses such as time off work for clean-up and stress. The study reveals that most properties experienced some form of flooding damage over 1 to 3 times for the past 10 years, reporting minimal damage to yards and experiencing damage to lawns, trees, and shrubs. Crop damage was noted and reported damage to fences and auxiliary structures. This study shows that clean, safe supplies of drinking water is highly important as it as crucial, suggesting it is a top priority and likely essential for achieving goals or maintaining standards. Flooding effect mitigation efforts by residents included planting native vegetation, including Mahogany Trees and Madre de Cacao, and using permeable paving. The study underscores the critical need for tailored flood mitigation strategies to enhance community resilience against future flooding events.

Keywords: Flood effects; Flood mitigation; Flood risk; Property impact

1. Introduction

Barangay Danglag is located at Consolacion, Cebu where the area is characterized by a mix of urban and rural landscapes, with bustling commercial centers alongside agricultural fields and residential communities. The barangay is susceptible to flooding, primarily due to its proximity to water bodies such as the Danglag, Cansaga, and Tapulco rivers. Despite recent efforts, including the construction of a flood control structure along the Cansaga River in 2023 by the Department of Public Works and Highways (DPWH) [1], flooding remains a persistent threat. Heavy rainfall regularly overwhelms drainage systems, leading to substantial property damage and disruptions to daily life. These ongoing challenges raise serious concerns about the well-being of the community.

The causes of flooding in Danglag are likely multifaceted. Inadequate drainage systems, a common issue in urbanizing areas across the Philippines (ReliefWeb) [2], could be overwhelmed by Danglag's growing population. Clogged waterways due to increased waste and rising sea levels impacting coastal areas like Cebu (Kulp & Strauss) [3] Kulp might further exacerbate the problem. Additionally, Danglag's specific topography, such as proximity to rivers or low-lying areas, could contribute to its vulnerability (Joseph et al.) [4].

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According to research of (Joseph et al.) [4], these recurring floods have devastating consequences for the community. Residents face substantial financial burdens from repairs and lost belongings. Standing water creates health risks, especially for vulnerable populations. Floods disrupt daily routines, hindering education, work, and essential services. The uncertainty and anxiety associated with flooding events can also lead to psychological distress.

While this study focused on gathering fresh data, historical records highlight the recurring nature of the problem. A report of ReliefWeb [2] documented flooding and landslides in Cebu caused by heavy rains, impacting areas like Consolacion, including Barangay Danglag. These events not only cause immediate damage but also contribute to long-term issues like erosion and decreased property values.

Beyond anecdotal evidence, research suggests a connection between urbanization and increased flooding risks. An article by Klippe [5] points towards inadequate drainage systems and clogged waterways due to rapid urbanization as key factors contributing to flooding in Cebu City, a trend likely affecting nearby areas such as Danglag in Consolacion. Likewise, a study published in ISPRS Annals by Lasco et al. [6] emphasizes the importance of proper urban planning and rainwater retention strategies in mitigating flood risks in highly urbanized areas (Lasco et al.) [6].

Recent studies further emphasize the urgency of addressing flooding in the Philippines. A 2019 study by Kulp and Strauss in Nature Communications [3] warns that parts of Cebu City, including areas potentially near Consolacion, could be submerged by 2050 due to rising sea levels (Kulp & Strauss). This highlights the need for long-term solutions alongside immediate mitigation efforts. Similarly, a study by Cayamanda et al. [7] in the International Review of Social Sciences Research examines communities' social vulnerability to floods in the Philippines. Understanding these vulnerabilities is crucial for developing effective flood risk reduction strategies that consider the social and economic impacts on residents (Cayamanda et. al) [7].

This research aimed to provide a comprehensive understanding of the flooding problem in Danglag, Consolacion, Cebu. The gathered information is invaluable for local authorities, residents, and disaster risk reduction agencies to develop targeted solutions for protecting the community from future flooding events. The study addressed several key inquiries regarding the profile and challenges faced by Barangay Danglag. Firstly, it characterized the area in terms of property types and the frequency of flooding over the past decade. Additionally, it assessed the extent and causes of flooding, along with the resultant effects, including both non-monetary and monetary impacts, as well as severity. Furthermore, it explored practical measures for mitigating flooding risks, such as optimizing eaves outlets and property enhancements. Lastly, it evaluated the significance of various water-related issues, including access to clean drinking water, flood prevention strategies, recreational water bodies, and watershed health. Thus, there is a need to study this research in order to protect communities from flooding events.

2. Materials and Methods

A quantitative study was conducted to investigate the flooding experiences of 29 households living near Danglag-Laray Creek in Danglag Consolacion, Cebu. Data collection relied on a structured ready-made questionnaire from the American Bottom Watershed Plan in [8]. The survey questionnaire was distributed through an online survey platform. Targeting twenty-nine (29) residential households, the survey explored various aspects of flooding. The survey will rely on descriptive statistics like frequency tables and percentages to understand the prevalence of property types, flood frequency, floodwater depth, and how often residents experience flood effects. Residents will use ranking to prioritize causes of flooding and property improvements. For importance of reoccurring water issues, this research utilized scoring procedure, then calculated the weighted mean by multiplying the frequency of each rating by its corresponding numerical value, summing these products, and dividing by the total number of respondents (29). This method provided a weighted mean score that reflects the overall importance assigned to each issue by the respondents. Finally, a weighted mean will summarize the overall severity of flooding and residents' water-related priorities. This comprehensive approach aimed to provide a clear picture of the flooding situation in Danglag Consolacion, Cebu.

2.1. Scoring Procedures

Table 1 Scoring Procedure for Water Issues

Weighted Mean	Category	Description
4.21-5.00	Very High Importance	This water issue indicates that the item is considered extremely important. Respondents consistently rated it as crucial, suggesting it is a top priority and likely essential for achieving goals or maintaining standards.
3.41- 4.20	High Importance	This water issue are regarded as important, though slightly less critical than those in the very high importance range. These items are still highly valued and play a significant role in overall success or performance.
2.61-3.40	No Opinion	This water issue represents items for which respondents did not have a strong opinion. The neutral rating suggests that these items are neither particularly important nor unimportant, possibly due to lack of relevance or sufficient information.
1.81-2.60	Low Importance	This water issure are considered of low importance. Respondents generally perceive these items as having minimal impact or relevance, and they are not prioritized in decision-making processes.
1.00-1.80	Very Low Importance	This water issue deemed very low in importance. These are the least significant items, viewed as having negligible or no impact on outcomes or goals, and are often ignored or deprioritized.

3. Results and Discussions

3.1. Barangay Profile

The profile of the barangay Danglag were presented in Figure [1] in terms of type of property and Figure [2] in terms of the frequency of flooding in the past 10 years.

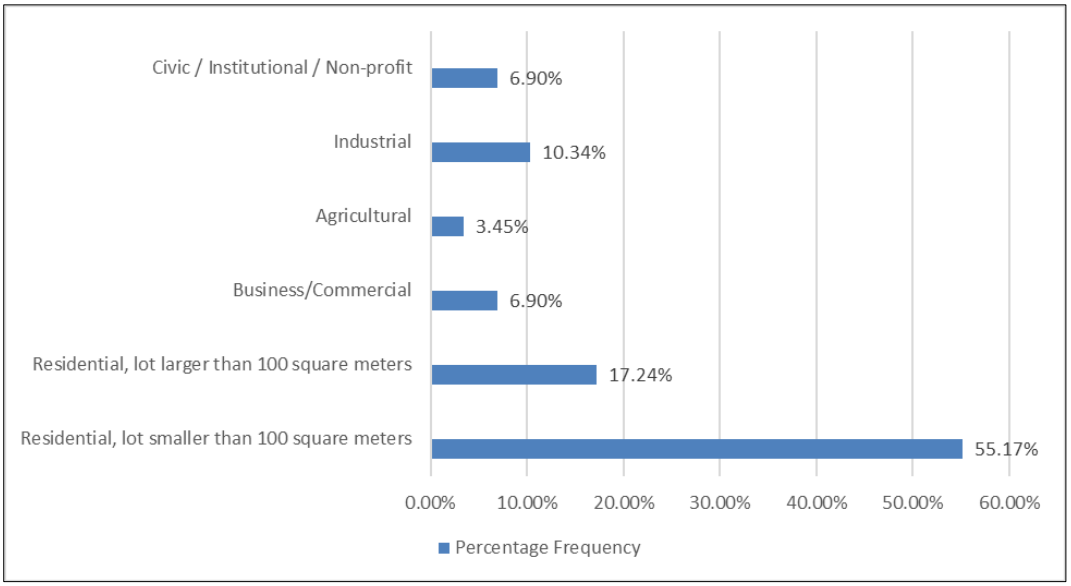

Figure 1 Property houses located

Figure [1] provides information on the types of properties at a particular address, broken down by category and represented in percentage frequency terms. The data presents the types of properties at surveyed addresses, revealing that the majority of respondents (55.17%) live in residential properties with lots smaller than 100 square meters.

Additionally, smaller percentages of respondents are associated with residential properties with larger lots (17.24%), industrial properties (10.34%), and business/commercial properties (6.90%).

Bañados et. al, [9] study likely provides insights that urbanization often prompts the development of compact housing arrangements due to increased population density and land scarcity, aligning with the prevalence of smaller residential lots. Moreover, residential properties with larger lots reflects the diversity of housing preferences within urban environments.

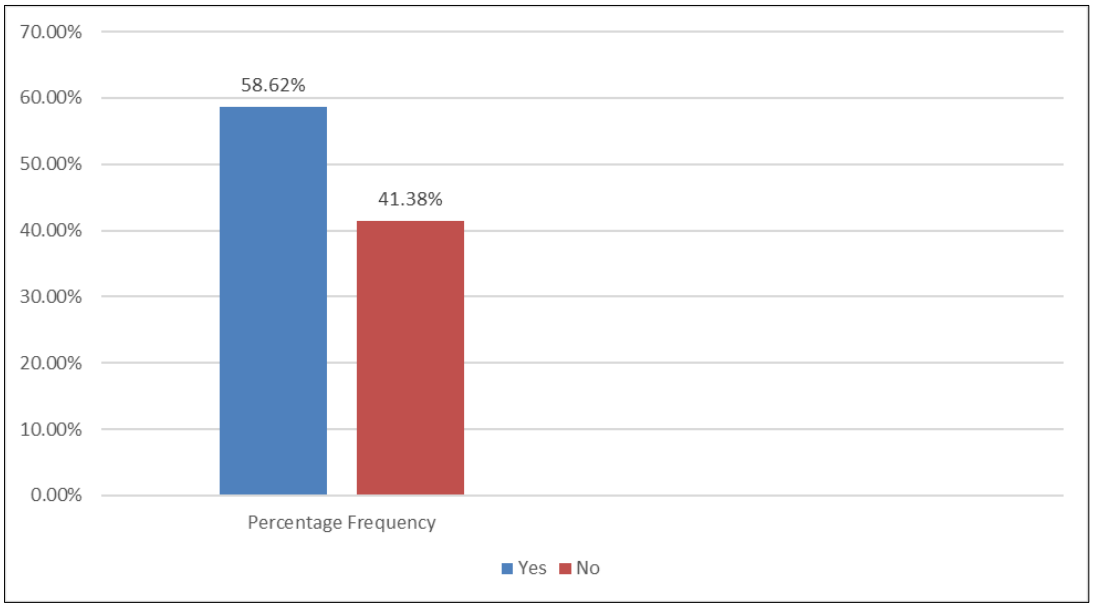

Figure 2 Houses being flooded in the last 10 years

Based on the data presented in Figure [2], it appears that over half (58.62%) of the properties included in the study have experienced flooding within the last decade. Conversely, nearly half (41.38%) have not encountered flooding during this period. This suggests a fairly balanced distribution, with a slight majority of properties being spared from flooding in the specified timeframe. Such findings could prompt further investigation into factors contributing to flood vulnerability or resilience among these properties.

A study by Chang, Heejun, and Pallathadka, Arun, et al. [10] highlights the escalating risk of climate change-induced extreme events as global populations surge into the 21st century. With population growth accelerating, the study projects an increase in the number of people vulnerable to the impacts of extreme weather phenomena. This finding underscores the urgent need for proactive measures to mitigate the adverse effects of climate change and enhance resilience in vulnerable communities.

3.2. Level of flooding in the area

The extent to where the flood occurs at the house/property were presented in Table [3].

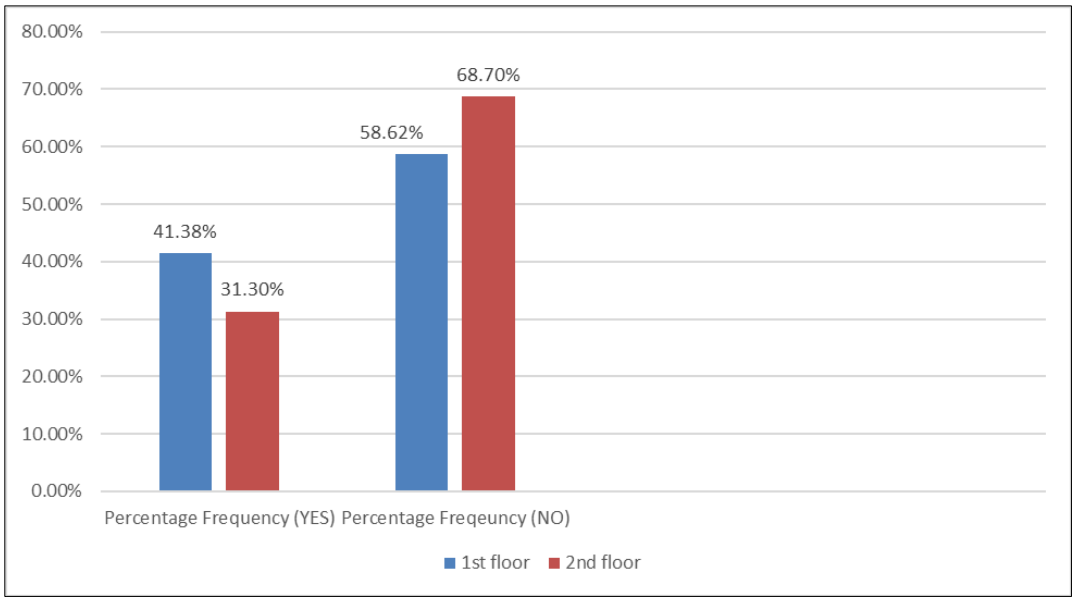

Figure 3 The extent to flood damage in property

The data from the Figure [3] highlights the impact of flooding on surveyed properties, indicating that 41.38% experienced flood damage on the 1st floor while 31.03% reported damage on the 2nd floor. Conversely, the majority of properties, 58.62% on the 1st floor and 68.97% on the 2nd floor, remained unaffected by flooding. These findings suggest varying degrees of flood vulnerability among the surveyed properties, with a significant portion experiencing damage on both floors but a majority remaining resilient, particularly on the 2nd floor.

According to Marvi, Morteza [11], floods pose a substantial threat to buildings, making them a critical component of flood-risk analysis. The study emphasizes the extensive damage that floods can inflict on built structures, highlighting the importance of assessing building vulnerabilities in flood-prone areas. This finding underscores the need for comprehensive flood-risk management strategies that prioritize building resilience and mitigation measures.

3.3. Causes of the property affected by the flood

The causes of the property affected by flood were presented in Figure [4].

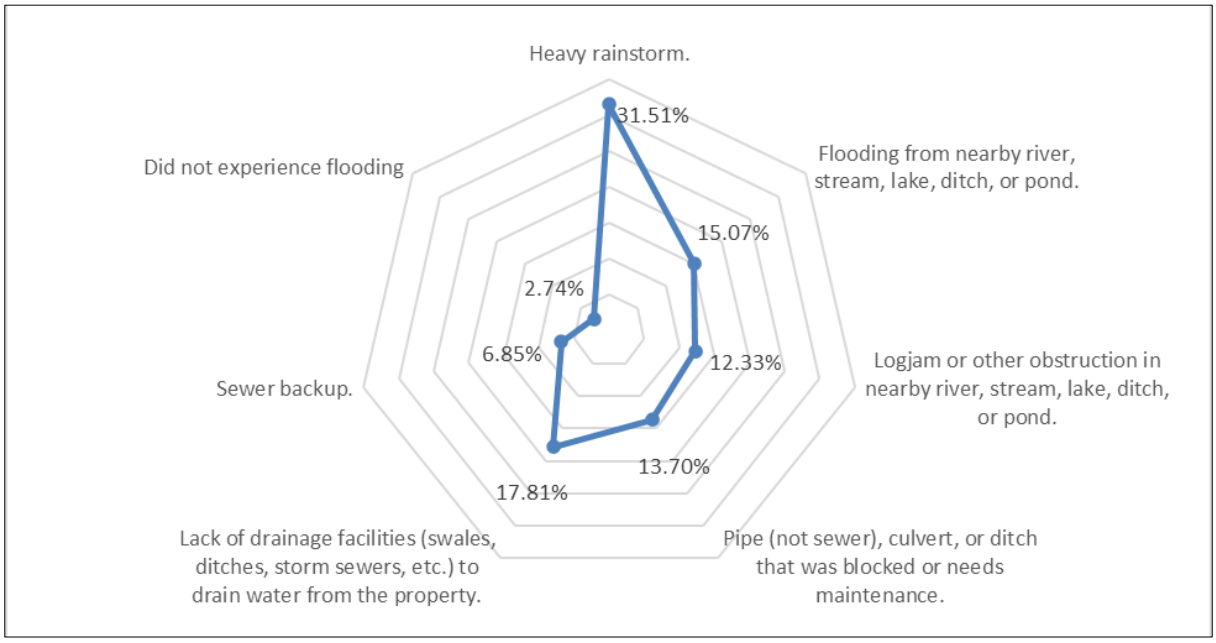

Figure 4 Causes of property affected by flood

Figure [4] provides information on the causes of flooding that affected respondents' properties. The most common cause reported is heavy rainstorms, accounting for 31.51% of responses, followed by flooding from nearby bodies of water such as rivers, streams, lakes, ditches, or ponds (15.07%). Other significant causes include logjams or obstructions in nearby waterways (12.33%), blocked or poorly maintained pipes, culverts, or ditches (13.7%), and lack of drainage facilities (17.81%). A smaller percentage of respondents reported sewer backups (6.85%), while a few did not experience flooding (2.74%).

According to Glago, Frank [12], flood disasters, initially triggered by natural phenomena, have seen heightened occurrences and impacts due to human actions and inactions. Over time, the practice of flood disaster management has transitioned from traditional ad-hoc response measures to integrated approaches incorporating technologically advanced tools. These modern strategies encompass flood disaster awareness, preparedness, and response measures, indicating a shift towards proactive and comprehensive approaches to mitigate flood risks.

3.4. Effects of flooding

The effects of the flood were presented in Figure [5] in terms of non-monetary loss, Figure [6] monetary loss, and in Table [2] the severity of the flood.

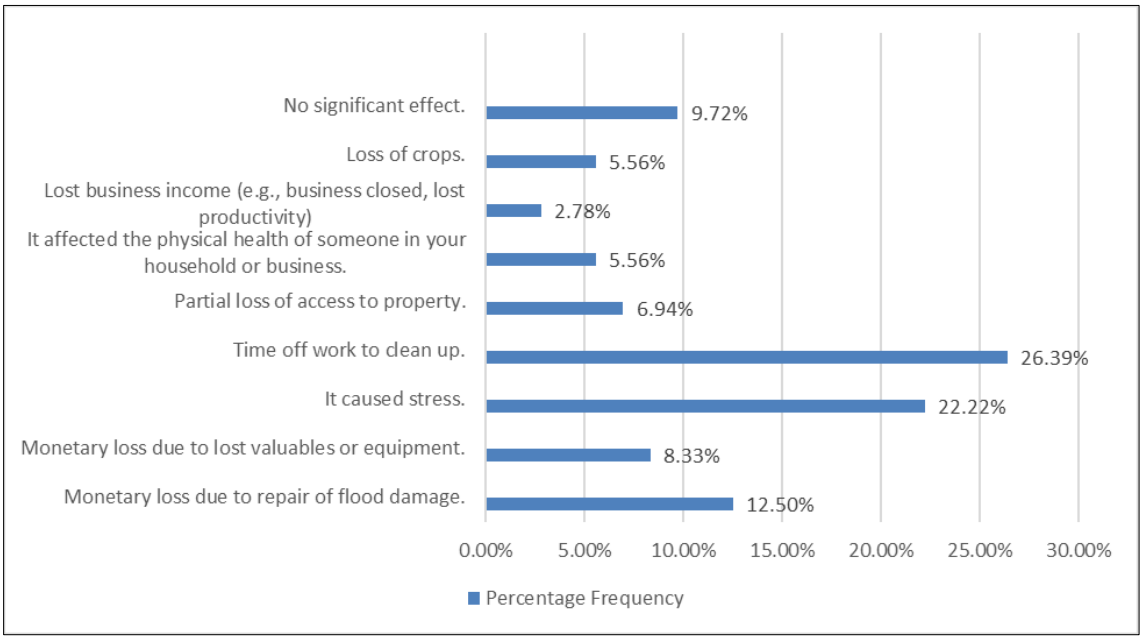

Figure 5 Non-monetary loss as an effect of flooding

Figure [5] reveals that time off work to clean up was the most prevalent effect, affecting 26.39% of respondents. Stress closely followed, with 22.22% of respondents reporting its impact due to flooding. Additionally, 12.5% of respondents experienced monetary loss from repairing flood damage, while 8.33% incurred losses from lost valuables or equipment. Partial loss of property access was reported by 6.94% of respondents. Adverse effects on physical health, loss of crops, and no significant effect were each reported by approximately 5-6% of respondents. Lost business income affected only 2.78% of respondents, and a small percentage (1.39%) did not experience flooding. lost business income (2.78%). A few respondents stated that flooding had no significant effect on them (9.72%).

Aldardasawai, A. F. M. and Eren, B. [13] stated that floods pose significant threats not only to individuals' lives but also lead to long-term devastation across multiple domains, including the economy, environment, and psychological well-being of affected individuals. This emphasizes the comprehensive impact of flooding beyond immediate physical damage, highlighting the far-reaching consequences on communities and societies.

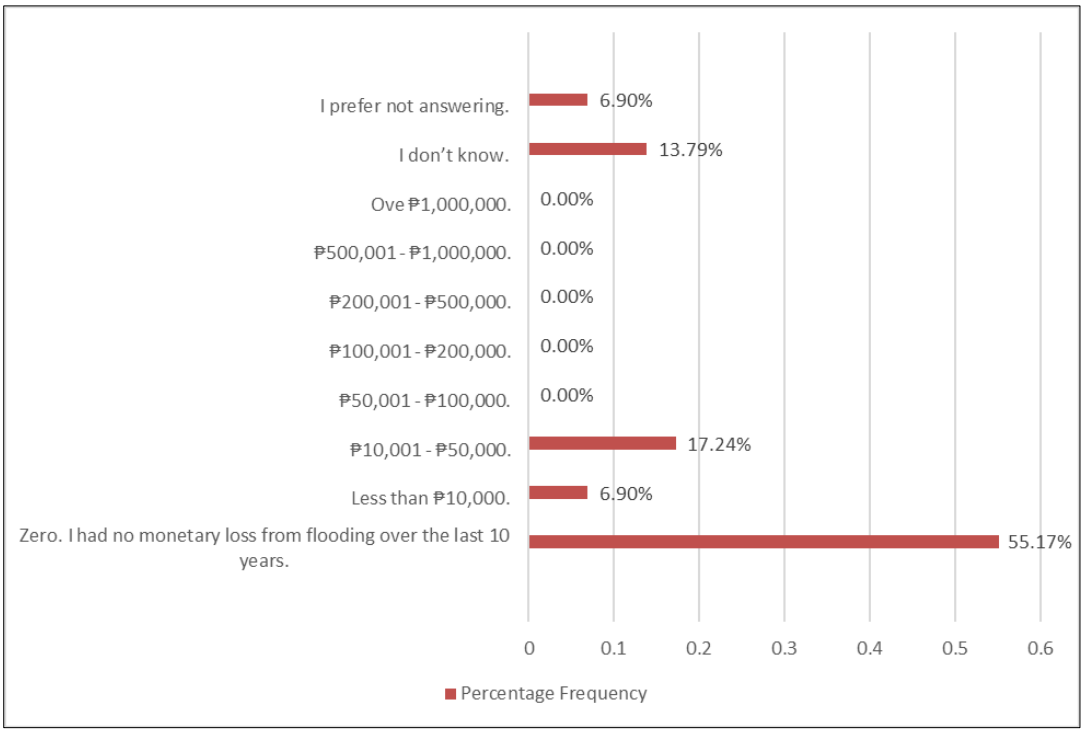

Figure 6 Monetary Loss as an effect of flooding

Figure [6] provides data on the monetary losses suffered by respondents due to flooding over the last 10 years, represented in Philippine Peso (PHP). The majority of respondents (55.17%) reported zero monetary loss from flooding during this period, while smaller percentages reported losses ranging from less than ₱10,000 (6.90%) to ₱10,001 - ₱50,000 (17.24%). Additionally, some respondents indicated uncertainty about their losses (13.79%), while a few preferred not to answer (6.90%).

According to Allaire, Maura [14], the financial toll of extreme flooding events is escalating globally, underscoring the urgent need for effective mitigation measures. Allaire emphasizes that mitigating flood risks necessitates thorough comprehension of the societal impacts of such disasters. This highlights the importance of not only understanding the economic costs but also the broader social, psychological, and environmental consequences of flooding.

Table 2 The severity effect of the flooding

Extent/Type of Flood Damage	**Number of times flooded over the last 10 years**				
	1-3 times	**4-6 times**	**7-9 times**	**10-49 (1-4.9 times per year)**	**50 or more (at least 5 times per year)**
Yard/Open green space was flooded, with little/no damage	72.41%	6.90%	10.34%	6.90%	3.45%
Yard/Green space was flooded, with damage to lawn, trees, and shrubs	82.76%	0.00%	10.34%	3.45%	3.45%
Crops were damaged	72.41%	13.79%	6.90%	3.45%	3.45%
Fences, auxiliary buildings (sheds, etc.), or other structures were damaged	79.31%	6.90%	6.90%	3.45%	3.45%
Primary home/business was damaged	75.86%	6.90%	10.34%	3.45%	3.45%

The data in Table [2] indicates that most properties experienced flood damage when flooding occurred 1-3 times over the past 10 years, with the highest percentages of minimal yard flooding (72.41%), moderate yard damage (82.76%),

crop damage (72.41%), structural damage to auxiliary buildings (79.31%), and primary home/business damage (75.86%) falling within this frequency range. As flooding frequency increases, the incidence of reported damage generally decreases across all categories, suggesting that properties flooded more frequently may have implemented effective protective measures or that there might be variability in reporting. This pattern highlights that even infrequent flooding events can cause significant damage, emphasizing the importance of flood preparedness and mitigation strategies.

According to Wang, L. and Chui, S., et al. [15], the combined effects of climate change and socioeconomic developments are exacerbating the frequency and severity of floods. This underscores the intricate interplay between environmental factors and human activities in shaping flood risk.

3.5. Outlet connection

Outlet connections, or downspouts, are essential parts of a building's gutter system. These vertical pipes attached to the building's exterior channel rainwater from the roof gutters to the ground, directing it away from the foundation to prevent water damage, erosion, and flooding. The outlet connection of the eaves was presented in Figure [8].

Figure 8 The percentage frequency of the downspouts' connections in the household

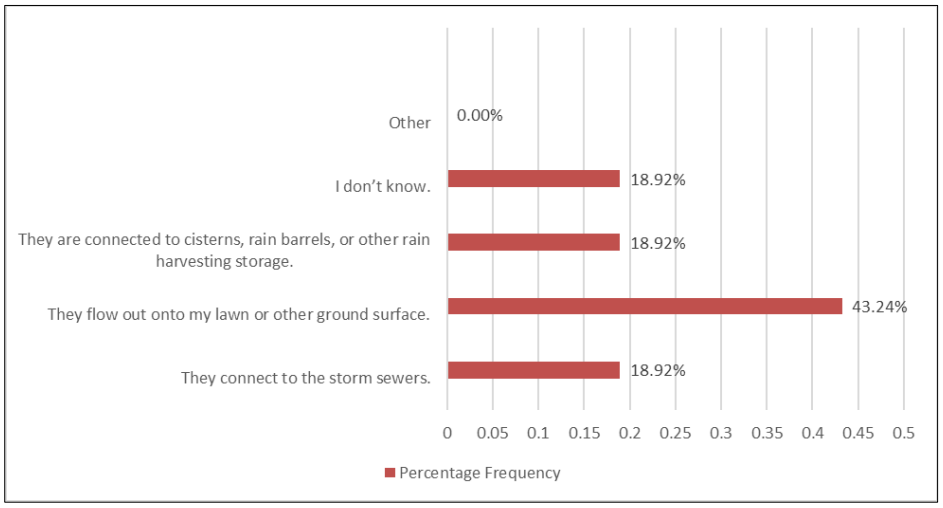

Figure 7 Downspouts' connection

The data in Figure [8] shows that 43.24% of respondents have their roof downspouts flowing onto their lawn or ground surface, making this the most common connection. Meanwhile, 18.92% each have downspouts connected to storm sewers, rain harvesting systems like cisterns or rain barrels, or are unsure of their downspout connections. No respondents reported using other unspecified methods for their downspouts. This distribution indicates a preference or common practice for discharging water onto lawns or ground surfaces.

The survey results show that while lawn discharge is the most common practice (43.24%), it may not be the most flood-resilient method. Studies recommend directing downspouts away from foundations to reduce erosion and basement flooding risks Alternative practices like storm sewer connections (18.92%) can be effective if properly designed to handle excess water without overwhelming the system [American Society of Civil Engineers] [16]. Rain harvesting (18.92%) offers a sustainable solution by capturing rainwater for later use, reducing stormwater runoff that can contribute to flooding.

3.6. Improvements to mitigate flooding

The improvement of the property to mitigate flooding in the area were presented in Figure [9].

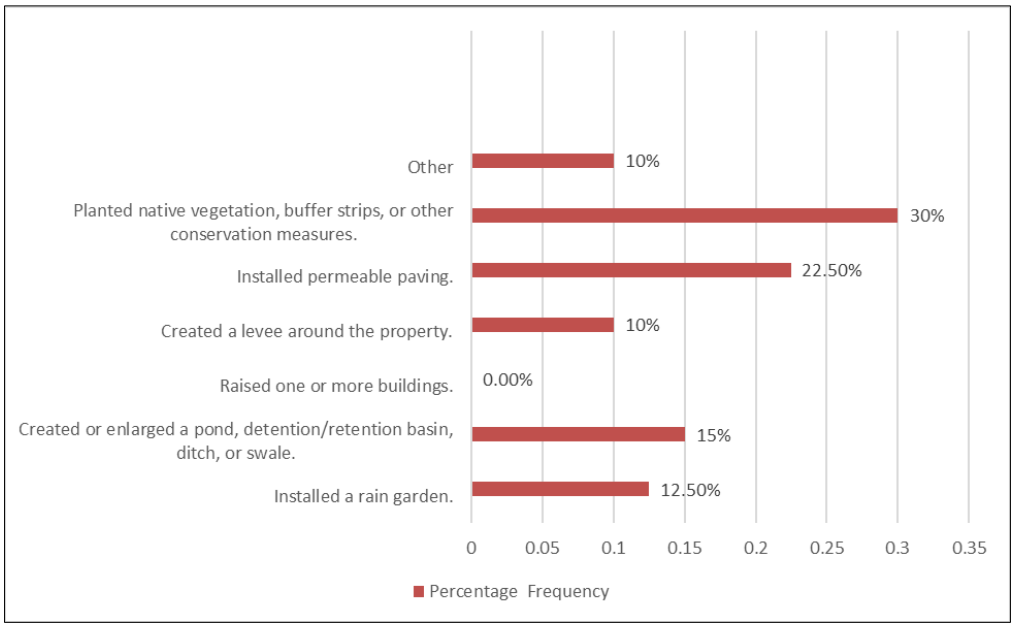

Figure 8 Improvements of the houses/properties in order to reduce flood impacts

The data from Figure [8] highlights various improvements made by respondents to reduce stormwater or flood impacts on their property. Planting native vegetation or using buffer strips is the most common improvement, with 30% of respondents adopting these measures. Permeable paving follows, utilized by 22.5% of respondents. Creating or enlarging ponds, detention/retention basins, ditches, or swales accounts for 15%, while installing rain gardens and creating levees each have adoption rates of 12.5% and 10%, respectively. Additionally, 10% of respondents have made other unspecified improvements, and no respondents reported raising buildings as a flood mitigation measure.

The data suggests that property owners are implementing a variety of storm-water mitigation improvements, with planting native vegetation and using buffer strips being the most popular (30%). This aligns with previous studies on the effectiveness of native vegetation in storm-water management (Li & Davis,) [17]. Other common improvements include permeable paving (22.5%), ponds/basins (15%), rain gardens (12.5%), and levees (10%). Notably, raising buildings to mitigate flooding was not reported by any respondents, suggesting this method's unpopularity, likely due to the high cost and invasiveness of such measures. Permeable paving is another effective stormwater management technique, as evidenced by research (Liu et al.; Bhaskar et al.) [17] [18].

3.7. Level of Importance of Water issues

The level of importance of the following water issues are presented in Table [3].

Table 3 Weighted mean on water issues

Water Issues	Mean	Description
Clean, safe supplies of drinking water	4.79	The availability of clean and safe drinking water is very high importance. Respondents consistently rated it as crucial, suggesting it is a top priority and likely essential for achieving goals or maintaining standards.
Prevention of flood damage to homes, businesses, and property	4.66	This indicates that prevention of flood damage to homes, businesses, and property is considered extremely important. Respondents consistently rated it as crucial, suggesting it is a top priority and likely essential for achieving goals or maintaining standards.
Lakes, ponds, and streams suitable for recreation such as fishing, boating, and swimming	4.03	Recreational suitability of lakes, ponds, and streams is regarded as important, though slightly less critical than those in the very high importance range. These items are still highly valued and play a significant role in overall success or performance.

A healthy watershed that supports a wide variety of plant and animal life	4.72	Respondents consistently rated that maintaining a healthy watershed that supports diverse plant and animal life is very high importance it as crucial, suggesting it is a top priority and likely essential for achieving goals or maintaining standards.

The data in Table [3] reveals a strong consensus among respondents regarding the critical importance of ensuring clean, safe drinking water and preventing flood damage, with a mean score of 4.79 and 4.66, these issues are very high importance, suggesting it is a top priority and likely essential for achieving goals or maintaining standards. This aligns with existing research emphasizing the fundamental role of access to portable water for public health and the necessity for effective flood risk management strategies due to the devastating impact floods can have on communities and infrastructure (Eisenberg et al.; Merz et al.) [19] [20]. While opinions varied for the importance of lakes, ponds, and streams suitable for recreation, a substantial weighted mean of 4.03 still rated this aspect as very high importance, regarded as important, though slightly less critical than those in the very high importance range. This is still highly valued and play a significant role in overall success or performance, reflecting a strong desire for accessible recreational water bodies. Similarly, with a mean of 4.72 emphasized the importance of maintaining a healthy watershed to support biodiversity and ecosystem services, underlining the growing recognition of the ecological significance of intact and functioning watersheds (Bentley et al.; Muneepeerakul et al.) [21] [22]. Overall, the data highlights the interconnectedness of various water-related concerns and the shared priorities of ensuring clean water supplies, mitigating flood risks, preserving recreational opportunities, and safeguarding ecological integrity.

4. Conclusion

This research indicates that flooding is a prevalent concern in the area, with over half of the population having experienced flooding in the past decade. The most common causes of flooding reported were heavy rainstorms and overflow from nearby bodies of water. The most frequent effects of flooding were time off work to clean up and stress. While many individuals reported no monetary losses due to flooding, some experienced losses exceeding ₱50,000. The severity of flooding varied, with the highest impact on crops. Downspouts commonly drain onto lawns or ground surfaces, and many have implemented improvements like planting native vegetation or using permeable paving to mitigate storm-water or flood impacts. The importance of clean drinking water, flood prevention, healthy watersheds, and recreational water bodies is highlighted by the majority.

Recommendations

- Promote the Use of Native Vegetation and Buffer Strips

The data indicates that planting native vegetation such as Mahogany trees, Madre de Cacao or any other fruit trees, buffer strips, or other conservation measures is the most common method employed to mitigate flooding. These natural solutions should be promoted further as they are effective in reducing runoff, improving soil absorption, and enhancing the local ecosystem.

- Encourage the Installation of Permeable Paving

With a significant portion of the population installing permeable paving, this practice should be encouraged and possibly incentivized. Permeable paving reduces surface runoff by allowing water to infiltrate the ground, thereby decreasing the likelihood of flooding.

- Support the Creation of Levees and Raised Buildings

Although fewer individuals have created levees or raised buildings, these methods are crucial for properties in high-risk flood zones. Support and guidance should be provided to help more property owners implement these structural modifications.

- Expand the Use of Retention Basins, Ponds, and Swales

The creation or enlargement of ponds, detention/retention basins, ditches, or swales is another effective strategy observed in the data. These features help manage stormwater by temporarily holding and slowly releasing it, thereby mitigating flood risks. Local authorities should consider providing technical assistance and financial support for these projects.

- Promote the Installation of Rain Gardens

Rain gardens, though less commonly implemented, are effective in capturing and absorbing rainwater. Educational campaigns and incentives could increase their adoption, helping to reduce the volume of stormwater runoff.

Compliance with ethical standards

Acknowledgement

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Disclosure of conflict of interest

The authors declare no conflict of interest.

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