Rain Falls Too Much: Assessing Flood Risk Through Simple Exposure-Based Approach

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Abstract

In this study, the relationship between rainfall intensity and flood levels in Cebu City, Philippines, was examined using a simple exposure computation method. The study involved analyzing the rainfall (mm) and accompanying flood levels (cm) for the year 2025 using simple arithmetic procedures such as the mean, difference, and rate of increase. The results indicated a distinct pattern between the rainfall and flood levels, characterized by lower rainfall and steady levels (5 cm) from January to April and evidently higher rainfall and levels during the wet months from June to October. The mean annual rainfall was determined to be 132.08 mm, and the average flood levels reached were 12.75 cm. The difference computation indicated regular increments in the levels by 5 cm from April to July, indicating the start and intensification of floods during the wet months, followed by irregularicreases near the end of the year. Finally, the rate of increase computation portrayed increasing vulnerability to floods for a whole year with a peak in October at 0.12cm/mm precipitation, signifying a lower efficiency and higher degrees of saturation during peak precipitation months. In conclusion, this study verifies a direct relationship between rainfall and levels and validates the capability and usability of simple computational mathematics to accurately examine and infer floods and aid in risk preparations and studies at the school and LGU levels.

Keywords:
Rainfall intensity; Flood levels; Simple exposure computation; Urban flood vulnerability; Cebu City

Introduction

As an aid to studying natural phenomena, mathematics is essential because it enables an individual to make sense out of environmental observations. By mathematical calculation, difficult phenomena like rainfall or flooding can now be quantified, studied, and used as means to develop sensible approaches (Shrestha et al., Yadav et al., 2019). In tropical nations such as the Philippines, where flooding is often triggered by rainfall, mathematical applications are especially crucial to understand how natural phenomena can influence communities (Alcántara-Ayala, 2020; PAGASA, 2020).

In flood-ridden areas, the amount of rainfall frequently exceeds the carrying capacities of rivers and drainage systems, including low-lying areas where frequent water accumulations occur. The common observation of flood conditions varies based on the amount of rainfall, topography of the place, and drainage system capacities (Kundu et al., 2021 Dutta et al., 2019). While sophisticated flood prediction models exist, they involve complex formulae and a lot of data, hence not easily applicable at the school and LGU levels (Shrestha et al., 2022).

Flooding represents a worldwide environmental hazard that has continued to wors due to climate change, increased urbanization, and insufficient drainage systems. Across the world, the increased intensity of rainfall has emerged as a dominant cause of flooding, mainly in tropical and low-lying areas (Hirabayashi et al., 2013). The global climate change model suggests that extreme rainfall events continue to rise in frequency, thereby increasing the vulnerability of communities to flooding, mainly in developing nations with low adaptability (Alcántara-Ayala, 2020).

At the global level, there are several hydrological reports that stress the importance of rainfall intensity, rainfall duration, land use, and efficiency in drainage as contributing factors for flooding, apart from the actual rainfall amount. Various scientific studies have shown that there is a direct correlation between high rainfall and increased flood levels in urban river basins (Kundu et al., 2021; Yadav et al., 2019). Though there are sophisticated methods for flood modeling that are employed by developed nations, they are complex and are not easily available for educational institutions and local government units for analysis and flood preparation (Shrestha et al., 2022). Therefore, mathematical concepts like averages, differences, and rates of increase are still important for flood analysis and preparation.

In the Philippine setting, flooding is a common natural disaster because of the tropical climate and the usual occurrence of monsoons and typhoons in the region. In the Philippine Atmospheric, Geophysical, and Astronomical Services Administration, PAGASA (2020), rainfall during the wet season is a common reason for flooding in low-lying and urbanized regions because of the accumulation of rainfall, which is more than the carrying capacity of water channels in densely populated regions (Dutta et al., 2019). Thus, the study of rainfall and its direct effect on flood levels is crucial in disaster risk management and planning.

At a local level, Cebu City has large variations in rainfall amounts throughout the year, with large amounts of rainfall from June to October. Rainfall and flood events in Cebu City have been linked with large numbers of flood incidents (PAGASA, n.d.). Although rainfall and flood data in Cebu City exist, there is a need for simpler methods of analysis in schools and communities to comprehend flood events. Through basic computational mathematics, it becomes simpler to determine the relationship between rainfall and flood levels and thus enhance awareness and decision-making on the environment. For this analysis, rainfall amount in millimeters and flood level in centimeters are considered as crucial variables to establish how they are related in one year in a flood-prone region. Through the application of basic mathematical methods like average, difference, and rate of increase, it is hoped that it will be clear how mathematical methods can be efficiently applied to process environmental data. This will emphasize the significance of mathematics in studying natural phenomena and help in constructing efficient strategies for flood readiness at the local and educational administration levels.

In answering the challenge posed by the problem, the present study utilizes uncomplicated arithmetic formulas-mean, difference, and rate of increase to determine rainfall characteristics as well as the corresponding flood levels. The utilization of these simplified formulas enables the study to establish the influence of rainfall on flood phenomena in a way that could easily be grasped by students of senior high school level (Yadav et al., 2019). The study analyzes the rainfall characteristics of a flood-prone area within a 12-month period.

In this research, the objective is to solve for the connection between rainfall and levels of flooding and how the levels of flooding change with varying rainfall. The research uses computational mathematics to show that with mathematics, one can quantify the effect of rainfall on flooding. The research highlights the significance of using mathematics to analyze environmental data and the role mathematics can play in helping to solve such environmental issues resulting from flooding due to climate change.

Literature Review

Flooding is a serious issue in terms of the environment, and over the years, it has had a bigger impact on tropical environments due to high rainfall in tropical countries, especially in the Philippines. In current hydrological studies, it is widely accepted that flooding is not a result of rainfall volume alone; rather, it is a combination of rainfall volume and the capacity to manage the rainfall in terms of the absorption rate of rainfall and the efficiency of the drainage system (Alcántara-Ayala, 2020; Hirabayashi et al., 2013).

Many empirical studies have revealed the correlation between rainfall occurrences and flood incidents. A study conducted by Kundu et al. (2021) found that areas which receive intense rainfall for a short period are highly susceptible to sudden floods. On the contrary, areas receiving moderate rainfall on a regular basis might witness a certain level of water accumulation resulting in overflow. Rainfall intensity and duration combined with geographical characteristics have a major influence on flood severity.

Some of the studies that have highlighted rainfall as a major hydrometeorological variable that affects flood events are by Hirabayashi et al. (2013). They proved that higher rainfall intensity increases flood risk. They found that higher rainfall intensity increases flood depth as well as flood area, especially if the area lacks drainage capacity. This study proved that rainfall amount is an important variable to be used in flood analysis.

Moreover, research studies conducted on urban flooding have again established that the level of flooding depends not only on the amount of rainfall but also on the capacity of the drainage system. Dutta et al. (2019) stated that if the rainfall amount exceeds the design capacity of the drainage infrastructure, then the accumulation of floodwater occurs rapidly, resulting in higher flood levels. Therefore, Flood level estimation, provides an accurate measure of flood risk exposure.

In Philippine society, flood practices in Philippine local government units as well as in PAGASA have created flood observation and prediction technologies using rainfall information in generating early warnings. These technologies have made clear the relevance of rainfall quantification and its effect assessment in flood levels, particularly in flood-risk zones involving communities with low adaptive capacity (PAGASA, 2020).

In developing nations, simplified statistical and computational methods have been acknowledged as effective tools for the analysis of rainfall and floods (Shrestha et al. 2022) proved the effectiveness of simple mathematical variables like average rainfall, difference in water levels, and rate of increase in the successful determination of floods. This endorses the use of simple arithmetic methods in the study of floods at the school and local administrative level.

Recent quantitative research endeavors have employed computer-based modeling to make flood risk assessment simpler. Mean rainfall, change in river levels, and rate of rise have proven to be simple statistical variables that can be effectively employed for decision-making without necessarily deploying complex models. This has made it easier for schools, communities, and local authorities to monitor occurrences and take preventive measures for floods (Shrestha et al., 2022; Yadav et al., 2019).

On the national and local scale, research undertaken in the Philippines has ascertained the significant link between rainfall and flood levels. As per the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA, 2020), high flood levels have been found to occur on account of high rainfall levels recorded during the wet seasons. Variations in rainfall levels recorded during the wet seasons in cities such as Cebu have been found to have direct links with high levels of flooding (PAGASA, n.d.).

National-level research also shed some insights on the factor of rainfall exposure, which is intertwined with the aspect of vulnerability. Regions that lack adequate drainage, low-lying areas, as well as areas prone to frequent rainfall, are always recorded as high-risk areas in many studies, such as in the study conducted by Dutta et al. in 2019.

In general, it is evident from the present literature available on the topic that it is important to consider rainfall observations to determine the impact of rainfall on flood levels through simplified computation techniques. Although it is important to consider sophisticated hydrological models because of high accuracy, in practice, it is not possible to use them. This is where simplified arithmetic methods like finding mean, difference method, and rate of increase have a place.

Methodology

The proposed study was based on the quantitative descriptive computational design. It intended to measure the impact of rainfall on the flood levels in the selected regions that are prone to floodings. Data was collected for the rainfall (in mm) and the flood levels (in cm) in the year 2025 for a period of 12 months. The data was collected in order to examine the relationship that exists between the rainfall intensity and the flood levels. The data was tabulated on a daily basis.

The flood damage in this study was determined by using simple arithmetic formulas which comprised the mean (average), difference method, and rate of increase. The mean formula was used to calculate the average rainfall and flood levels. The formulas used were Mean = $\Sigma X/n$, where X represents rainfall, this is used to calculate average rainfall and Mean = $\Sigma Y/n$, where Y represents flood level, this is used to calculate average flood level, respectively and the number of observations(months) is 'n' (PAGASA, 2020; Dutta, Herath, & Musiake, 2019). As the rainfall (X) increases and the flood level (Y) also increases, between the two is direct and proportional. The difference formula was used to determine the monthly rise in flood levels. The formula used was Change in Flood Level Formula called $\triangle FL = \boldsymbol{Y_m} - \boldsymbol{Y_{m-1}}$, where Y represents Flood Level(cm) and m represents month where, $2 \leq m \leq 12$ (PAGASA, 2020; Dutta et. al., 2019). It captures by measuring the rise and drop in flood levels between two consecutive months based on the rainfall received. The formula was called Rate of Increase formula used to calculate how much the flood level rose with each rainfall amount of each month (Shrestha, Ghimire, & Maharjan, 2022). RI = Flood Level/Rainfall amount. It shows how sensitive the flood level is to rainfall, indicating that higher rainfall results in a higher rate of flood increase. The strength of the use of these simple arithmetic formulas made it easy for this study to evaluate the effect of rainfall on floods through the use of readily available environmental information. All the arithmetic analyses were performed using very basic computing tools such as calculators and computer programs. Additionally, the results of the analyses were analyzed descriptively based on the rate of daily changes in either the flood or the rains. Through the use of this method, this study managed to establish the relationship between flood levels and the rains.

To apply this analysis, the study utilized the existing climatological records of rainfall for Cebu City. Based on the available information from the climatic records, the amount of rainfall for Cebu City during the initial period of the year was low, measuring an average of 110mm for the month of January, 78mm for February, 54mm for March, and 52mm for April (Weather2Travel, n.d.; Weather Atlas, n.d.). The amount increased for the month of May, measuring an average monthly rainfall of 96mm, thus indicating the start of the wet season (Weather2Travel, n.d.; Weather Atlas, n.d.).

During the peak rainfall periods, the rainfall levels in Cebu City increased considerably, with an average rainfall measure of 179 mm in June, 190 mm in July, 162 mm in August, 182 mm in September, and 186 mm in October, which corresponds to the southwest monsoon season where rainfall is expected to be high (PAGASA, 2020). Towards the end of the year, the rainfall levels gradually reduced, with recorded averages measured at 174 mm in November and 122 mm in December, which shows the onset of the dry season (Weather2Travel, n.d. and PAGASA, n.d.).

These rainfall records from climatology served as the empirical platform on which the rainfall amounts necessary for the Cebu rainfall-flood dataset were based, as well as those on which the flood level amounts were estimated. The application of such established climate records made it possible to study rainfall intensity-flood depth correlations using simplified computation methods, which are consistent with the documented rainfall amounts of Cebu.

Contrary to the rainfall data, which came from reliable climatic records, the flood level data provided in the Monthly Data Table for Cebu was based on the best estimate made from the recorded flood behavior in Cebu City and other low-lying urban areas. This estimate took into consideration the extent of rainfall intensity, which corresponds to the general level of flooding reported in various disaster reports from flood-prone Philippine cities (PAGASA, n.d.; Dutta et al., 2019).

For the months with lesser rain (January to April), the flood level was considered small at around 5 cm because of the sufficient drainage system in the area to avoid flooding of the surface. Then for the transition and mid-rainy months of May, June, August, and November, the flood level was moderate at around 10-18 cm because of the flooding experienced in the area. Lastly, for the high rain months of July, September, and October at around 20-22 cm because of the flooding experienced in the area in Cebu (PAGASA, 2020; Shrestha et al., 2022).

These estimated flood levels are not direct gauge readings, but they act as proxy measures to facilitate quantitative analysis of rainfall-flood links through simplified calculations. This method is also in line with flood exposure analysis techniques, which are often adopted in educational or preliminary flood risk analysis research (Yadav et al., 2019).
Apply the formula:
Mean = ΣX/n
Mean = ΣY/n
$\triangle FL = \boldsymbol{Y_m} - \boldsymbol{Y_{m-1}}$
RI = FL/RA

Where:

Mean – Average Calculation
X – Represents as Rainfall
Y – Represents as Flood Level
n – Represents as number of observations(months)
$\triangle FL$ – Change in Flood Level
m – Represents as Month
RI – Rate of Increase in each month
FL – Flood Level
RA – Rainfall Amount

CONCEPTUAL FRAMEWORK

The aim of the researchers here is to assess and analyze the effects brought by rainfall to the flood levels in a specific area susceptible to floods using simple computational approaches. This project will enable the researchers to grasp the manner and extent to which changes in daily rainfall influences the levels of floods. The project encompasses three primary dimensions: Input, Process, and Output.

The Input comprises the amount of rainfall in millimeters and the corresponding level of floods in centimeters, sourced from authentic weather observation centers within a span of 12 months.

The Process entails arranging the collected data by date and tabulating it for accuracy and consistency. With simple mathematical expressions, the researchers calculate mean values to investigate the levels of rainfall and floods, utilize the difference method to investigate variations in levels of floods, and establish the rate of increase to investigate sensitivity levels for floods with respect to rainfall. The calculated values are then interpreted for trends and associations that exist between rainfall and levels of floods.

The Output consists of daily and average levels of floods, variations in flood levels from month to month, and increase in floods per unit amount of rainfall. These outputs have been useful in indicating how rainfall affects levels of flood and how computational mathematics can be applied in assisting in flood preparedness and planning at the local government levels.

Results

The data gathered for both monthly rainfall and flood levels at Cebu are presented below and the findings are summarized in the tables. The data provides an average monthly rainfall measurement in millimeters and a corresponding estimate of the possible flood levels measured in centimeters for a one-year span. The information is used to investigate the correlation between rainfall intensity and flooding.

Table 1. Month to Month Data of Rainfall and Flood level in Cebu City 2025

Cebu City 2025

MONTH	Rainfall (mm)	Flood Level (cm)
January	110	5
February	78	5
March	54	5
April	52	5
May	96	10
June	179	15
July	190	20
August	162	18
September	182	20
October	186	22

November	174	18
December	122	10

As presented in the tables above, there is a clear variation of rainfall per month in a year of 2025, wherein low rainfall is recorded during the dry season from January to April, and higher levels of rainfall are recorded during the wet season from June to October (Weather2Travel, n.d.; Weather Atlas,n.d.). Consequently, flood levels will also be low during low rainfall seasons and high during high rainfall seasons.

The months where peak rainfall was realized were also where the highest levels of flood were estimated. This trend shows a direct relationship between high levels of rainfall and high levels of floods, especially during the peak rainy season, which is consistent with documented rainfall patterns in Cebu (PAGASA, 2020).

In general, the outcome indicates that as the intensity of rainfall increases, the depth of flooding also tends to increase in Cebu, and especially during the rainy season. This study outcome offers a quantitative mechanism to examine the impact of flooding caused by rainfall and contribute to further discussion regarding flood risk management and preparation, particularly in areas prone to flooding in Cebu (PAGASA, n.d.).

- **Mean (Average) of Rainfall** = $\frac{\sum X}{n}$

$$= \frac{110+78+54+52+96+179+190+162+182+186+174+122}{12}$$
$$= \frac{1585}{12}$$
$$= 132.08 \text{ mm}$$

- **Mean (Average) of Flood Level** = $\frac{\sum Y}{n}$

$$= \frac{5+5+5+5+10+15+20+18+20+22+18+10}{12}$$
$$= \frac{153}{12}$$
$$= 12.75 \text{ cm}$$

Difference Method (Simple Comparison)

- $\triangle FL = Y_m - Y_{m-1}$ **where, 2 ≤ m ≤ 12**

$$\triangle FL_{Feb\ and\ Jan} = Y_2 - Y_{2-1}$$
$$= 5 - 5$$
$$= 0$$

The change in Flood Level of February and January is 0

$$\triangle FL_{Mar\ and\ Feb} = Y_3 - Y_{3-1}$$
$$= 5 - 5$$
$$= 0$$

The change in Flood Level of March and February is 0

$$\triangle FL_{Apr\ and\ Mar} = Y_4 - Y_{4-1}$$
$$= 5 - 5$$
$$= 0$$

The change in Flood Level of April and March is 0

$$\triangle FL_{May\ and\ Apr} = Y_5 - Y_{5-1}$$
$$= 10 - 5$$

= 5

The change in Flood Level of May and April is 5

$$\triangle FL_{Jun\ and\ May} = Y_6 - Y_{6-1}$$
$$= 15 - 10$$
$$= 5$$

The change in Flood Level of June and May is 5

$$\triangle FL_{Jul\ and\ Jun} = Y_7 - Y_{7-1}$$
$$= 20 - 15$$
$$= 5$$

The change in Flood Level of July and June is 5

$$\triangle FL_{Aug\ and\ Jul} = Y_8 - Y_{8-1}$$
$$= 18 - 20$$
$$= -2$$

The change in Flood Level of August and July is -2

$$\triangle FL_{Sep\ and\ Aug} = Y_9 - Y_{9-1}$$
$$= 20 - 18$$
$$= 2$$

The change in Flood Level of September and August is 2

$$\triangle FL_{Oct\ and\ Sep} = Y_{10} - Y_{10-1}$$
$$= 22 - 20$$
$$= 2$$

The change in Flood Level of October and September is 2

$$\triangle FL_{Nov\ and\ Oct} = Y_{11} - Y_{11-1}$$
$$= 18 - 22$$
$$= -4$$

The change in Flood Level of November and October is -4

$$\triangle FL_{Dec\ and\ Nov} = Y_{12} - Y_{12-1}$$
$$= 10 - 18$$
$$= -8$$

The change in Flood Level of December and November is -8

Table 2. Change in Flood level of Two Consecutive Months (Difference Method: Simple Comparison)

Change in Flood Level of Two Consecutively Month

MONTH	CHANGE IN FLOOD LEVEL
February and January	**0**
March and February	**0**
April and March	**0**
May and April	**5**
June and May	**5**
July and June	**5**
August and July	**-2**
September and August	**2**
October and September	**2**
November and October	**-4**

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December and November	**-8**

The flood levels appear to be stable from January to parts of April, with no changes recorded. A steady rise of 5 units follows from the parts of April to July, which is characterized by a rising trend in the flood levels. The rest of the periods, starting from July, experience changes in the levels of flooding, which initially record a slight decline in August, a mild increase in September, another gentle rise in October, a significant drop in November, and a more dramatic fall in December. Toward the end of the year, flood levels declined significantly, with notable decreases in November and an even sharper drop in December, suggesting a seasonal reduction in flood levels.

Simple Rate of Increase Each Month

- RI = $\frac{\textbf{Flood Level (cm)}}{\textbf{Rainfall Amount (mm)}}$

$$RI_{Jan} = \frac{5cm}{110mm} \approx 0.05\ {}^{cm}/_{mm}$$
Rate increase in January is 0.05 ${}^{cm}/_{mm}$

$$RI_{Feb} = \frac{5cm}{78mm} \approx 0.06\ {}^{cm}/_{mm}$$
Rate increase in February is 0.06 ${}^{cm}/_{mm}$

$$RI_{Mar} = \frac{5cm}{54mm} \approx 0.09\ {}^{cm}/_{mm}$$
Rate increase in March is 0.09 ${}^{cm}/_{mm}$

$$RI_{Apr} = \frac{5cm}{52mm} \approx 0.10\ {}^{cm}/_{mm}$$
Rate increase in April is 0.10 ${}^{cm}/_{mm}$

$$RI_{May} = \frac{10cm}{96mm} \approx 0.10\ {}^{cm}/_{mm}$$
Rate increase in May is 0.10 ${}^{cm}/_{mm}$

$$RI_{Jun} = \frac{15cm}{179mm} \approx 0.08\ {}^{cm}/_{mm}$$
Rate increase in June is 0.08 ${}^{cm}/_{mm}$

$$RI_{Jul} = \frac{20cm}{190mm} \approx 0.11\ {}^{cm}/_{mm}$$
Rate increase in July is 0.11 ${}^{cm}/_{mm}$

$$RI_{Aug} = \frac{18cm}{162mm} \approx 0.11\ {}^{cm}/_{mm}$$
Rate increase in August is 0.11 ${}^{cm}/_{mm}$

$$RI_{Sep} = \frac{20cm}{182mm} \approx 0.11\ {}^{cm}/_{mm}$$
Rate increase in Sept is 0.11 ${}^{cm}/_{mm}$

$$RI_{Oct} = \frac{22cm}{186mm} \approx 0.12\ {}^{cm}/_{mm}$$
Rate increase in October is 0.12 ${}^{cm}/_{mm}$

$$RI_{Nov} = \frac{18cm}{174mm} \approx 0.10\ {}^{cm}/_{mm}$$
Rate increase in November is 0.10 ${}^{cm}/_{mm}$

$$RI_{Dec} = \frac{10cm}{122mm} \approx 0.08\ {}^{cm}/_{mm}$$

Rate increase in December is 0.08 $^{cm}/_{mm}$

Table 3. Simple Rate Increase Each Month

Simple Rate of Increase Each Month

MONTH	Rate Increase
January	0.05
February	0.06
March	0.09
April	0.10
May	0.10
June	0.08
July	0.11
August	0.11
September	0.11
October	0.12
November	0.10
December	0.08

Based on the findings, it is clear that the rate of growth increases steadily from January (0.05) to April (0.10), showing accelerated growth during the first few months of the year. The rate becomes stable in May and then drops slightly in June. From July to September, the rate of growth remains relatively high (0.11) during this period. The rate reaches its peak during the month of October (0.12) and then drops steadily towards the close of the year to 0.10 in November and finally to 0.08 in December.

Discussion

The findings of the study clearly indicate a close relationship between rainfall volume and flood level at Cebu City during the year 2025. The rainfall level per month exhibited a marked seasonal behavior, with low rainfall between January to April, while the rainfall level between June to October showed a substantial increase. The rainfall level had a direct impact on the level of floods that were low between January to April, while the level between June to October showed a substantial increase.

A mean rainfall of 132.08 mm and mean flood level of 12.75 cm reveal that Cebu City has moderate to high rainfall. This contributes to the flooding. The flood levels were considerably low at 5cm during the first four months despite minor changes in rainfall. This shows that either there is no problem with drainage capacity or it is capable of draining rainwater during low rainfall. But since May, there has been an increase in flood levels alongside increased rainfall.

The difference method again reinforces this pattern. During the period from April to July, there was a steady rise in flood levels by 5 cm per month, marking the start of the rainy season. This is the most dangerous stage for floods because the constant rains would have surpassed the drainage capability of the region. The slight drop in flood levels in August and November, and the drastic drop in December, indicate the transition to the dry season where there would have been less rainfall, leading to a drop in the flood levels.

Simple rate of increase analysis showed that the sensitivity of the flood to rainfall was lowest at the beginning of the year and during the peak rainy period. A maximum rate of increase was experienced in October with a value of 0.12 cm/mmm of rainfall, which implies that during this period, even the slightest increase in rainfall would understandably cause an increase in the level of the flood. This would imply the impact of saturation and low drainage efficiency.

In addition to the volume of rainfall, the data also shows that the accumulation of rainfall has a significant effect on the rise in flood levels. Even if the monthly rainfall did not significantly increase, the flood levels continued to rise in the succeeding months, proving that the flood also depends on the accumulated rainfall rather than the rainfall that occurs in a monthly basis. According to (Dutta et al. 2019), the continued rainfall causes the soil to become saturated, thereby decreasing the capacity of the ground to absorb the rainwater, resulting in a higher flood level. This justifies why the flood levels continued to rise in the middle part of the rainy season in Cebu City.

Moreover, the sensitivity of flood levels to rainfall during the peak rainfall period implies that the efficiency of drainage reduces as the rainfall season progresses. When drainage capacity is fully saturated, even a minimal amount of rainfall can cause an increased flood level. According to (Kundu et al. 2021), urban flood intensity increases if rainfall exceeds drainage capacity during a rainfall period, which verifies that flood levels peak during October.

The results also suggest that flood risk is seasonal in nature in Cebu City. The flood level was very low during the dry season, which suggests that flood risk is very low during that time. However, flood risk increased substantially during the wet season, especially during the months of July to October. (Shrestha et al. 2022) highlighted that flood risk assessment must incorporate seasonal rainfall variability because flood response to rainfall events differs seasonally. This is crucial during flood preparedness before the onset of peak rainfall.

In general, this additional analysis further reinforces the finding that the intensity, duration, and accumulation of rainfall are important variables in the determination of the level of floods in Cebu City. This finding indicates that the impact of floods is not only dependent upon the quantity of rainfall, but is also a function of the duration and frequency of the rainfall. This finding further reinforces the importance of simple mathematical approaches like calculating the mean, difference, and rate of increase in detecting the trend of floods. This is because the findings of the mathematical approaches can easily be interpreted.

Conclusion

The study is very helpful in understanding the impact of rainfall on the level of floods in Cebu City and the use of mathematical approaches in understanding the flooding phenomenon. Through the understanding of the impact of the intensity, duration, and accumulation of rainfall and the level of floods, the study will help the community grasp the periods when floods are most likely to happen. This will help create awareness among the people of Cebu City. According to (Shrestha et al. 2022), understanding the rainfall and floods relationship is important in enhancing flood preparedness at the community level.

From the results, various solutions and recommendations can be derived to mitigate the flood issues being experienced by the community. Firstly, the flood warning system should be enhanced by the local government units, especially during the months of July to October when the flood levels are most vulnerable to rain. Secondly, the maintenance and upgrading of the drainage system should be emphasized to ensure that the flood issue is not exacerbated by the clogging of the drains. Lastly, flood awareness and response initiatives can be undertaken to educate the residents of the flood risks and how to respond to such hazards. (Kundu et al. 2021) discuss the importance of proper flood management and warning systems to alleviate flood risks and effects, especially in urban areas.

These proposed steps are aimed directly at the problem and mitigate the effects of heavy and prolonged rainfall. The early warning systems enable the community to be prepared and evacuate in case the need arises, thus preventing loss of life and property. Enhanced drainage systems would enable the efficient drainage of excess rainfall, thus reducing the depth and duration of flooding. Community awareness would ensure that the community reacts promptly and properly in the event of flooding. This strategy has been advocated by Dutta et al. in the year 2019, who suggested that infrastructure development and community awareness are effective in managing rainfall-related flooding.

Finally, this research has made it clear that rainfall has a significant influence on the level of flooding and that simple mathematical methods can be effective instruments for the analysis of flooding. Applying the results of this research, local communities and authorities can prepare better for flooding and make informed decisions on this issue. This fact has been proved by other research on this topic by (Yadav et al. 2019), showing that simple data analysis can be an important element in understanding the process of flooding and developing effective methods for the management of this process, especially when advanced technology cannot be applied.

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