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Flood Hazard Assessment in Paspaage Korala Divisional Secretariat Division Using Geospatial Technology

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ABSTRACT

Flooding is a frequent and catastrophic disaster in Sri Lanka, exacerbated by intense monsoon rainfall, rapid urbanization, and poor land-use planning and management. The prime aim of this study is to assess the flood hazard and risk in the Paspaage Divisional Secretariat Division. The specific objectives are to study past flood events and its severity using Standedized Precipitation Index and generate flood hazard and flood risk maps using Analytical Hierarchy Process. Both primary and secondary data were used in this study. The primary data were collected through observations, interviews, and discussions. Monthly rainfall data were collected from the Department of Meteorology, Colombo, Sri Lanka, for the period from 1991 to 2025. Satellite images were obtained from various web sources. The research employed a mixed-methods approach, combining quantitative and qualitative methods. Parameters such as Land Use/Land Cover, digital elevation model, slope, rainfall, drainage density, and population density map were generated to assess the flood hazard and risk. The research uses a Multi-Criteria Decision Analysis approach, integrating the Analytical Hierarchy Process with GIS to systematically evaluate and weight flood-conditioning factors. The weighted-sum overlay technique was applied to integrate vector and raster data. To analyse flood occurrences, the Standardized Precipitation Index was applied. The results reveal that 2021 experienced extreme flooding, while severe floods occurred in 2022, 2020, and 2018. The flood frequency indicates the increasing trends in recent decades compared to earlier periods. Frequent flooding was observed in Navalapitiya, Karahandukala, Weligampola, and the surrounding areas. The results indicate that about 11.14 % of the study area is at severe risk, around 23.9 % at moderate risk, 33.71 % at low risk, and the remaining areas are rarely endangered. This flood risk information could contribute to reducing flood vulnerability and enhancing mitigation efforts.

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Keywords: Digital Elevation Model, Drainage Density, Flood Hazard, Flood Risk, Standardized Precipitation Index

1. INTRODUCTION

Natural hazards, including floods, cyclones, hurricanes, earthquakes, tsunamis, volcanic eruptions, and landslides, are among the most widely recognized global catastrophes [1]. In recent years, numerous countries have experienced an increase in flood-related destruction, attributed to climate change, environmental degradation, and improper land management practices [2-4]. The epistemology of disaster risk reduction and management has become increasingly pivotal amid the escalation of unexpected climate-driven crises worldwide [5].

Floods rank among the most devastating natural disasters, causing extensive loss of life, property, and infrastructure, and exerting significant socioeconomic impacts across various sectors globally [6].

Floods are typically classified based on their formation and occurrence. The primary categories of floods include: 1) river floods, 2) coastal floods, 3) flash floods, 4) urban floods, and 5) storm surges [7]. A river flood occurs when water levels exceed the riverbanks due to excessive rainfall. Coastal floods occur when heavy rain or high tides cause inundation along the coast.

Flash floods occur when intense rainfall occurs over a short period. Urban floods occur when water accumulates rapidly in urban areas, often due to heavy rain, inadequate drainage, and unplanned urbanization. Storm surges are characterized by an abnormal rise in water levels in coastal areas, caused by tides or severe storms. A river is considered to be in flood when the flow surpasses the capacity of the banks [8].

Floods occur due to a combination of many factors, including increasing rainfall intensity driven by climate change. Human interventions contributing to flood problems include anthropogenic activities such as rapid urbanization, deforestation, wetland and water-body reclamation, construction in low-lying areas, poor maintenance of drainage in urban areas, silting of tanks and reservoirs, changes in land-use patterns, improper land management practices, including poor flood drainage basin management, the construction of road networks, the expansion of settlements, and deforestation in upper catchments have exacerbated flood-related devastation in many countries [9-13].

Flood hazard mapping plays a vital role in identifying flood-prone areas, assigning flood risk zones, and for effective land-use planning in flood-prone areas [14]. It creates easily readable, rapidly accessible charts and maps that enable administrators and planners to identify risk and hazard-prone areas and prioritize mitigation efforts accordingly. Numerous approaches have been proposed by researchers to analyze floods and their impacts. Geospatial technology has been widely explored and employed to assess flooding with high reliability, even in remote regions with extreme climate conditions and large flood-affected areas [15, 16]. Spatial mapping of flood hazard extents is crucial for the effective implementation of risk-reduction strategies [17].

Many studies have used GIS-based Multi-Criteria Decision Analysis (MCDM) and the Analytical Hierarchy Process (AHP) to map flood-prone areas. Recently, the combined application of geospatial technologies, such as Geographic Information System (GIS) and

Remote Sensing (RS), together with various models, has emerged as a significant approach for analysing flood hazards. Remote sensing technology offers significant advantages over traditional techniques due to its availability of spatial, spectral, radiometric, and temporal data. A GIS-based urban flood risk assessment study was conducted in Delhi, along the Yamuna River in the National Capital Territory of India. In this study, the urban flood-prone areas were identified by an integrated approach combining remote sensing, geographic information systems, and field surveys. The research highlights significant socioeconomic repercussions in regions with frequent flooding [18].

Aydin and Birincioglu (2022) employed a GIS-based analytical hierarchy to evaluate flood risk zones in Bitlis Province, Turkey, incorporating nine elements that control flooding. [3] employed GIS-based MCDM and AHP to identify flood-prone locations in Ethiopia's Upper Awash River Basin. MCDM is a valuable tool for evaluating complicated situations, such as identifying and mapping flood-prone areas based on several criteria [19, 20], and AHP is the most often used method for multi-criteria decision-making [21-22] Anitabha Ghosh, et al. (2023), used a combination of GIS-based MCDM and AHP to assess and map flood vulnerability in the Fetam watershed, situated in the upper Abay basin of Ethiopia.

Sri Lanka is recurrently affected by climate-related hazards such as floods, droughts, cyclones, storms, landslides, and thunderstorms due to climate change, resulting in loss of life, property damage, and infrastructure destruction. The recent storm ‘Ditwath’ caused severe flooding across all 25 districts of Sri Lanka in late November and December 2025.

The central part of the country experienced both floods and landslides, with more than 2 million people affected and hundreds reported dead or missing. The hardest-hit areas were Gampaha, Colombo, Puttalam, Mannar, Kandy, Trincomalee, Batticaloa, and Matale, while deadly landslides occurred in the central hills of the country, including Kandy, Badulla, and Matale.

These frequent and devastating impacts underscore the need for research on climate disasters in Sri Lanka to strengthen disaster preparedness plan and mitigate flood impacts.

The most common hazards in Sri Lanka are seasonal and localized flooding and landslides, followed by cyclones, storm surges, droughts, and high winds [23].

Sri Lanka has two distinct monsoon seasons, which are usually followed by flooding from extreme rainfall. As an island, Sri Lanka receives rainfall during the South-Western Monsoon (SWM) season, from May to September, which contributes 30% of the annual average rainfall. The North-East Monsoon (NEM) season runs from December to February and contiributes 26% of the annual average rainfall. The Inter Monsoon periods - the First Inter-Monsoon (FIM) from March to April and Second Inter-Monsoon (SIM) from October to November, and contributes 14% and 30% to annual rainfall respectively.

The SWM affects the Southern and Sabaragamuwa provinces most significantly, while the Northeast monsoon (in December-February) makes the Eastern, Northern, and North-Central provinces most prone to flooding. The wet zone is frequently affected by floods, particularly during the SWM season, and these effects have increased significantly in recent years. It is observed that, due to climate variability and change, the frequency of extreme climatic events is increasing, resulting in massive property damage [24, 25].

Sri Lanka is highly vulnerable to climate hazards because it is a small island in the Indian Ocean in the path of two monsoons. Recurrent floods are among the most frequent hazards, affecting thousands of lives and livelihoods and damaging property [26]. As the frequency and intensity of events such as floods, droughts, and cyclones increase, they create severe socioeconomic impacts. Compared with other natural disasters, such as drought, cyclones, landslides, thunderstorms, and tsunamis, the frequency of occurrence and the impacts of floods are much higher. Due to recent climate change and monsoon variability, rainfall amounts, patterns, and intensities have changed significantly across many Asian countries (Rajendram, 2019). A GIS-based approach for planning the evacuation process during flash floods in the Gampaha Divisional Secretariat Division in Sri Lanka has been studied. This study focused on the impact of frequent flash floods on the Gampaha district. This paper proposes a Geographical Information System approach to plan the evacuation process during a flash flood, with the intent of reducing negative consequences. The study considered seven criteria for assessing flood, namely elevation, accessibility, land use, availability of buildings, rainfall, population density, and the presence of water features. The study identified suitable evacuation centers based on the elevation above the mean sea level.[27].

A study on flood occurrence and risk assessment in Trincomalee District using Open-Source Geo-Spatial Technology has been conducted [9]. This study aims to analyze the vulnerable areas to flooding and the risk levels. This study used the community participatory method and the JOSM platform to collect exposure data. The vulnerability and flood risk maps were generated using factors such as elevation, floodwater depth, rainfall intensity, previous flood records, and proximity to water bodies, using the Digital Elevation Model (DEM). Based on these parameters, flood hazard maps were prepared.

Despite frequent flooding in the study area, no detailed flood studies, particularly using the AHP method, have been conducted to date. Existing flood-related studies in the region have not applied this approach to analyze flood hazard maps to identify flood-prone areas. The absence of Analytical Hierarchy Process (AHP)-based flood analysis in the Paspaage Korala Divisional Secretariat Division has resulted in a significant gap in delineating areas prone to flooding. Therefore, this study addresses an important research gap by applying the AHP method to identify flood-prone areas in the study region, thereby providing a more comprehensive understanding than previous studies.

This study is grounded in the disaster risk framework, which defines flood risk as the interaction of hazard, exposure, and vulnerability. Flood hazard is determined by factors such as rainfall, elevation, slope, drainage density, and land use, while exposure and vulnerability are linked to population distribution and land-use patterns. The research used a Multi-Criteria Decision Analysis (MCDA) approach, integrating the AHP with GIS to systematically evaluate and weight flood-conditioning factors.

This framework enables the spatial integration of biophysical and socio-economic variables to generate flood hazard and risk maps, supporting robust flood risk assessment and decision-making. For the Paspaage Korala Divisional Secretariat Division, flood hazard and flood risk maps were created using GIS-based spatial analysis and AHP based on this conceptual framework.

2. MATERIALS AND METHODS

The study area is Pasbage Korele Divisional Secretariat Division (PKDSD), located in Kandy District, Central Province, Sri Lanka. PKDSD is one of the 20 Divisional Secretariat Divisions in the Kandy District. The extent of the DSD area is 119.4 Km^2. The division comprises 29 Grama Niladari Divisions (GNDs) (Fig. 1).

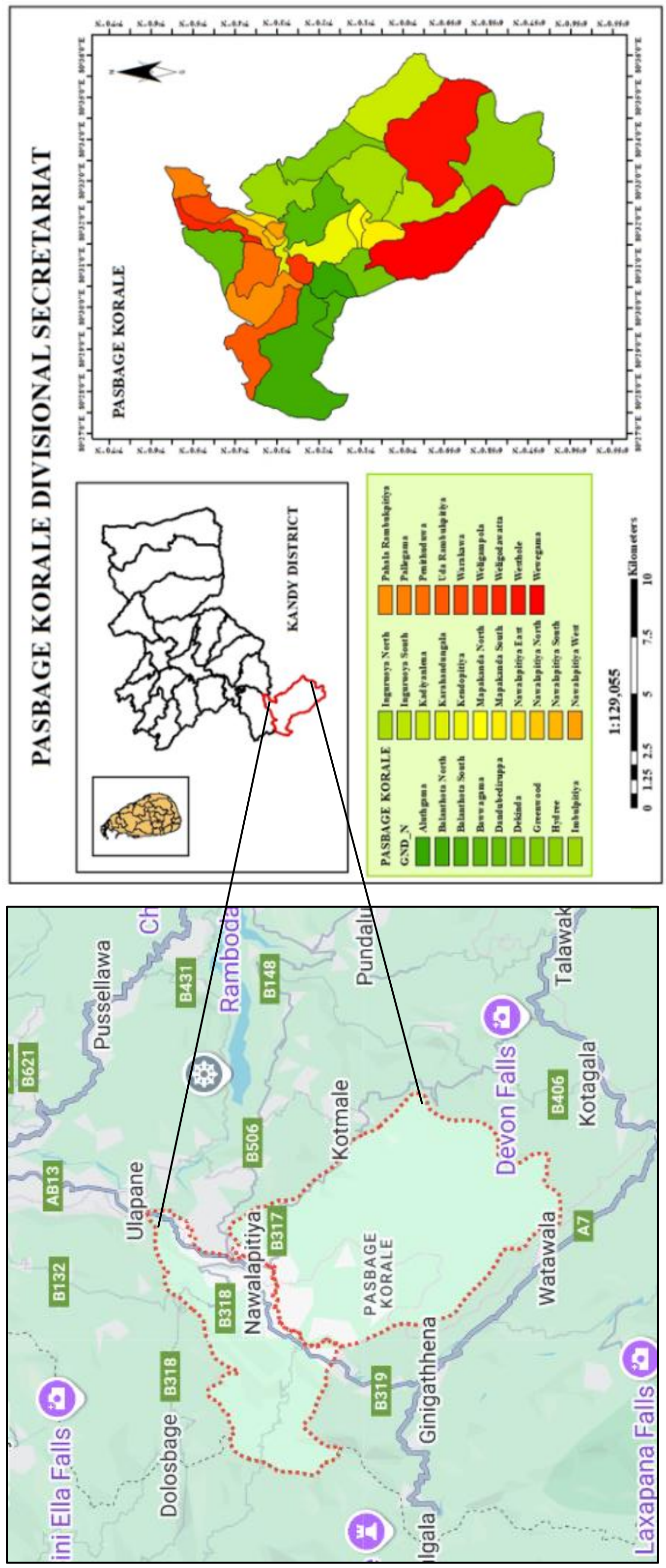

Fig. 1. Study Area - Kandy District, Central Province, Sri Lanka.

The total population of the PKDSD is 77,655. PKDSD is situated at an altitude of 550-1200 feet above mean sea level. The northern boundary is the Ganga Ihala Koralai Divisional Secretariat, while the Kothmalai Divisional Secretariat of Nuwara Eliya District is to the east. The southern boundary is the Ambhakamuwa Divisional Secretariat of Nuwara Eliya District, and the western boundary is the Yattianthotta Divisional Secretariat of Kegalla District. Kothmale Oya, a tributary of the Mahavali Ganga, one of Sri Lanka's most important rivers, flows through this region.

To achieve these objectives, both primary and secondary data were utilized. Primary data were collected through direct observation, focus group discussion, and key informant interviews. Monthly rainfall data from 1991 to 2025 were obtained from the Department of Meteorology, Colombo, for the Nawalapitiya, Kothmala Power Station, Watawala, and Kenilworth Estate stations, which represent the study area. Satellite data were obtained from USGS EarthExplorer and Google Earth Pro satellite images, Shuttle Radar Topography Mission (SRTM) data, and relevant topographic maps were obtained from the Survey Department of Sri Lanka. Information on past flood events, the affected population, and related details was obtained from the Paspaage Korala Divisional Secretariat, the District Disaster Management Division, and other relevant sources. The collected data were analyzed using both quantitative and qualitative (mixed methods) approaches. Flood hazard assessment was conducted using the Analytical Hierarchy Process in ArcGIS 10.8.

The specific objectives of the study wrre to assess flood occurrence and severity based on past flood conditions using Standedized Precipitation Index, and generate flood hazard and risk maps using AHP. The AHP, introduced by [28-30], is an effective tool that can be used for decisions making that are complex in nature. It helps the decision making to set priorities that will help in making the best decisions. Hence, what is required is to reduce the complex decision to a pairwise comparison, synthesize the results and make the best decision out of it.

What AHP does is to consider a set of evaluation criteria, and a set of alternative options among which the best decision is to be made. It generates a weight for each evaluation criterion according to the decision maker. This means that the higher the weight, the more important the corresponding criterion. Pairwise comparison on the other hand is a method that is used to compare indicators to one another based on their importance in a particular phenomenon or context of decision making. This makes it an indispensable part of a complete AHP decision making method. Pairwise comparison has been used in various aspects from individual to collective decision making. According to Saaty (2008), in order to make a decision in an organised way to generate priorities we need to decompose the decision into the following steps:

The AHP is based on constructing a series of pairwise comparison matrices (PCMs) to compare criteria to each other. The AHP is used to estimate the weighting of each criterion, which describes its importance. Saatysuggestsa scale of 1–9 for PCM elements, where in the value of 1 suggests that the criteria are equally important and the value of 9 leads to the inference that the criterion under consideration is essential with regard to the other criterion with which the comparison is made. The relative weights of the parameters were computed using the AHP.

To generate the flood hazard and vulnerability maps, the weighting method for the hazard index was implemented in three steps. First, in order to portray the heterogeneity of dissimilar environmental and socioeconomic factors contributing to flood hazard, all the environmental and socioeconomic variables were standardized and named. For examples, parameters such as slope, elevation, rainfall pattern, river network, drainage density, river buffer, and Land use/Land cover (LU/LC) were used (Table 1 & Fig. 2). Second a knowledge-based weighting system was applied to each of these variables, indicators that represent a high level of dispersion were given more weight; a variable depicting a uniform situation across the study area is not likely to distinguish between vulnerable and non vulnerable zones. The weights and ratings assigned to these parameters are provided in Table 1. The variables of rainfall, LU/LC, elevation represented by DEM were given to high importance (Table 1) since the lowlying regions where the highe rainfall with improper landused planing of the study area are frequently inundated by flood water.

Table 1. Identification method of Flood Hazard of the study area.

Factors	Classes	Rating	Weight (%)
Drainage Density	0-195.9	1	15
	195.91-391.8	2	
	391.81-587.7	3	
	587.71-783.59	4	
	783.6-979.48	5	
Rainfall	1801-2500	1	30
	2501-3100	2	
	3101-3700	3	
	3701-4300	4	
	4301-5300	5	
Slope	<10	5	10
	10-18	4	
	18 - 26	3	
	26 - 34	2	
	> 34	1	
DEM	555-749	5	25
	749-952	4	
	952-1146	3	
	1146-1365	2	
	1365-1723	1	

Land use/Land Cover	Built-Up	6	25
	Agriculture	5	
	Water Bodies	4	
	Forest	3	
	Barren Land	2	
	Rocky Area	1	

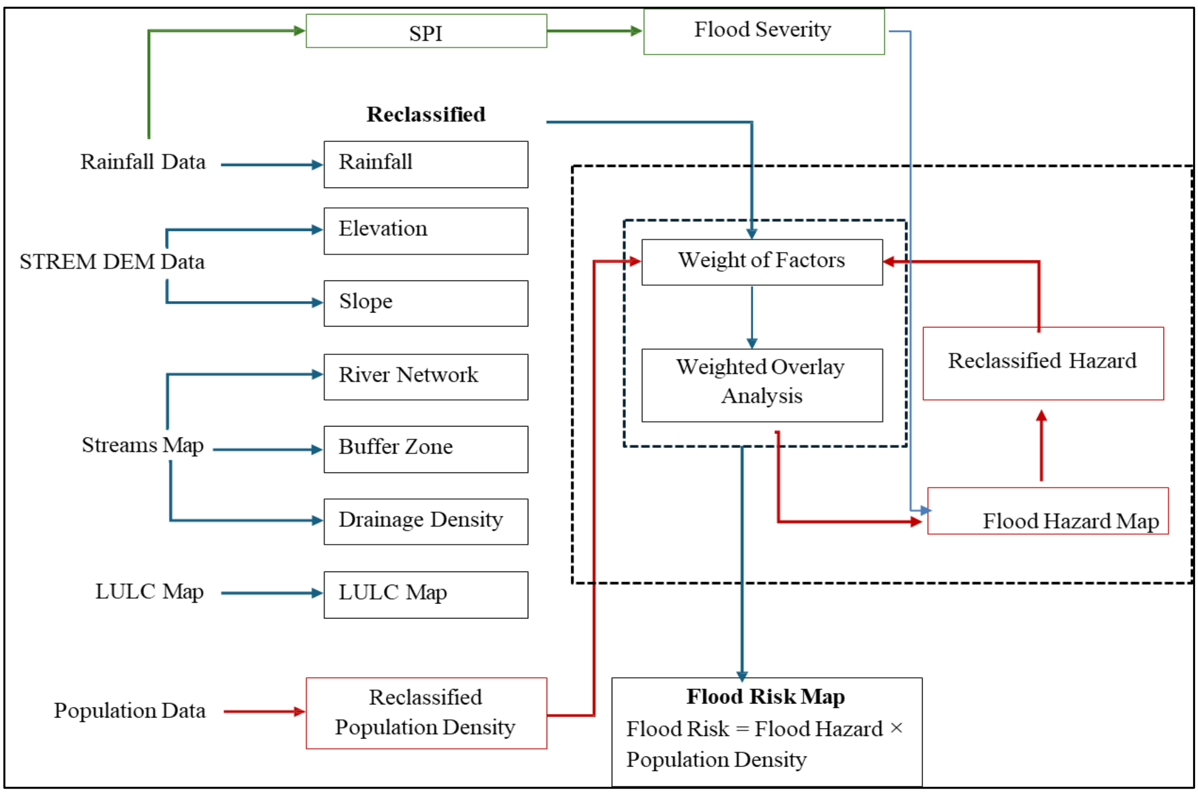

Fig. 2. Flowchart detailing the methods employed to identify and map flood-Risk & Hazard.

To study the elevation and slope, the Digital Elevation Model (DEM) was generated. Drainage density and riverine flood conditions were studied using river proximity analysis. The spatial pattern of rainfall was examined using interpolation techniques, using by Kriging method. All these parameters were integrated through waited overlay operation to generate a flood hazard and reisk maps. Subsequently, the flood hazard map was overlaid with population density to produce a flood risk map, with the assigned weights and ratings applied. The dominance of the parameters and their weights was determined and validated through field observations and stakeholder interviews (Table 2).

Table 2. Identification method of Flood Risk of the study area.

Factors	Classes	Rating	Weight (%)
Hazard Map	Very low/ Null Low Moderate High	1 2 3 4	60
Population Density	<500 500-1500 1500-2500 2500-4500 4500-10000	1 2 3 4 5	40

The temporal rainfall anomaly has been studied using the Standardized Precipitation Index (SPI). The SPI was developed by Edwards and McKee et al. (1993) [31] which was originally introduced to monitor wet and dry conditions in Colorado. In fact, precipitation is the primary input parameter for monitoring wet and dry conditions, and intra-seasonal rainfall anomalies. In addition, the SPI is effective for analyzing the cycle of wet and dry periods. Long-term precipitation records are fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for a given location and time period is zero. Guttman (1998) [32] suggested a type III gamma distribution. Rainfall anomalies are then analysed from the normalized precipitation series using SPI criteria (Table 3).

Table 3. SPI Categorization.

SPI Values	Categorization
2.00 and more	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-0.99 to 0.99	Near Normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2.0 and less	Extremely dry

About 30 years of monthly rainfall data were used to compute SPI, based on this compution extreme, severe, and moderate flood years along with the normal years were identified. The method of computation of SPI is described below. The computation of SPI requires long-term precipitation data to determine the probability distribution function, which is then transformed into a normal distribution with a mean of zero and a standard deviation of one. Thus, SPI values are expressed in standard deviations, with positive SPI values indicating greater-than-median precipitation and negative values indicating less-than-median precipitation. Edwards and McKee et al. (1993) [31] developed the SPI to monitor drought. The SPI value (Z) is a standardized variable calculated from the cumulative probability, F(P). Although the overall computation involves several complex statistical procedures (e.g., the gamma distribution, maximum likelihood estimators), the core concept yields a standardized score comparable to a Z-score. The transformation from the cumulative probability, F(P), to the final SPI value, Z, is performed using the inverse normal cumulative distribution Function ((ϕ^{-1}), also known as the inverse of the standard normal distribution:

$$SPI = Z = \phi^{-1}(F(P))$$

Thom (1966) found that the gamma distribution fits climatological precipitation time series well. The gamma distribution is defined by its frequency or probability density function: The probability density function of the gamma distribution is defined as: The gamma distribution G (α,β) has density function:

$$f(x;\alpha,\beta) = \frac{1}{\Gamma(\alpha)\beta^{\alpha}} x^{\alpha-1e-x/}\beta \quad \text{for} \quad x,\alpha,\beta>0,$$

where: $\Gamma(\alpha) = \int_0^{\infty} e^{-t}t^{\alpha-1}\, dt.$

$$\Gamma(\alpha+1) = \alpha\Gamma(\alpha)$$

Using the fact that $f(x;\alpha,\beta)$ it is a density function for all positive or otherwise, find the mean of the gamma distribution.

3. RESULTS AND DISCUSSION

3. 1. Spatial and Temporal Pattern of Rainfall

The average annual rainfall in Pasbage is 3180 mm, with a range is 1800-5300 mm. The spatial distribution pattern of mean annual rainfall is shown in Figure 3. Lower rainfall is observed in the eastern part of the study area, namely Greenwood, Kadianlena, and a part of the Westhola Grama Niladhari Division, while higher rainfall is observed in the western part of the region. Mostly, the western region receives rainfall ranging from 3100 to 3700 mm annually. The Palantotta North, South, and the Hydree regions experience the highest rainfall, ranging from about 4300 to 5300 mm (Fig. 3a).

The Pasbage region received rainfall about 54.4% (1730 mm) during the South West Monsoon (SWM), which prevails from May to September and extends into the Second Inter Monsoon (SIM) season during October and November. The SIM rainfall contributes approximately 753 mm (23.68%) of the annual rainfall. In contrast, the North East Monsoon Season (NEM) and First Inter Monsoon (FIM) Season contribute relatively smaller proportions, amounting to 284 mm (8.93%) and 413 mm (12.99%) respectively. Temporal analysis of annual rainfall reveals an increasing trend, with an r^2 value of 0.45, which corresponds with the occurrence of consecutive flood events-since 2018 (Figs. 3b & 4).

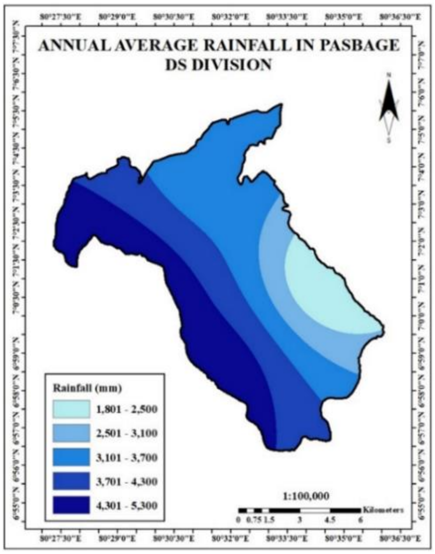

Fig. 3a. Annual Rainfall

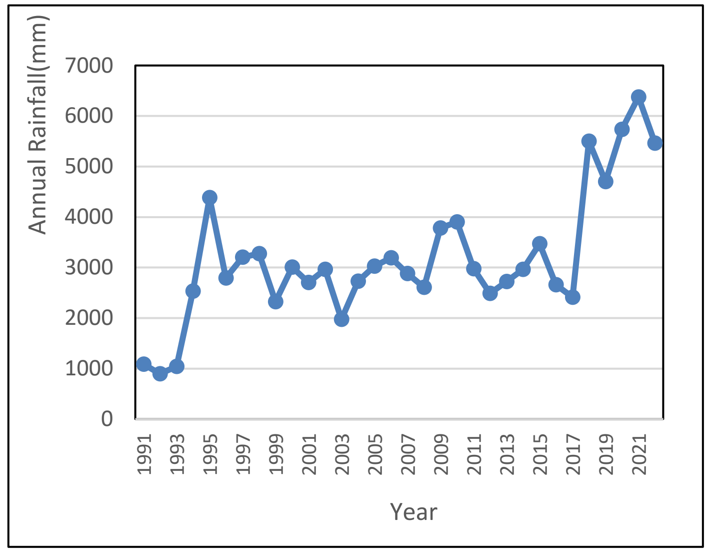

Fig. 3b. Annual Rainfall.

An extreme flood event was recorded in 2021, resulting in the most severe damage across the study area. The Grama Niladhari Divisions of Palwagama, Nawalapitiya West, Kentopidiya, and Karakandukala were severely affected. Additionally, severe flood events were reported in 2018, 2020, and 2022 (Table 4). During this flood event, the Grama Niladhari (GN) divisions of Palwagama, Kendopitiya, and Veligampola were severely affected, whereas the GN divisions of Warakava and Pallegama experienced comparatively minor impacts. The study area recorded moderate flood events in 1995 and 2019; however, no significant flooding was reported for about 22 years prior to 2018. An assessment of historical flood patterns reveals a noticeable increase in flood occurrence in recent years compared to earlier periods (Fig. 4).

Table 4. Flood and Normal Years.

Flood severity	SPI Amplitude	Year
Extreme flood	2.00 & above	2021
Severe flood	1.50 - 1.99	2022, 2020, 2018
Moderate flood	1.00 - 1.49	2019,1995
Normal Year	-0.99 - 0.99	1994, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017

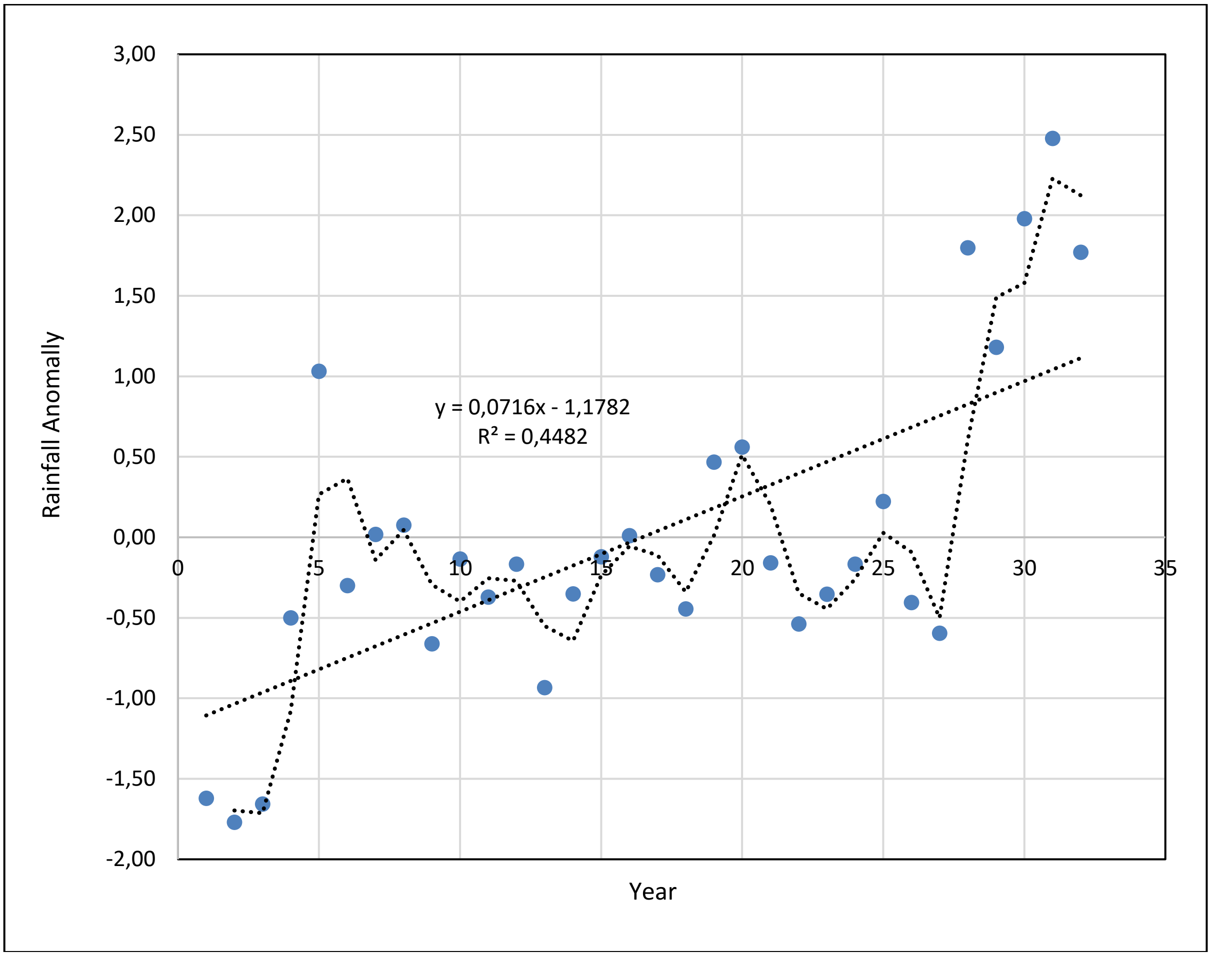

Fig. 4. Annual Rainfall Anomaly.

An effective flood management plan and mitigation strategies are essential. Flood occurrence in the study area is influenced by both physical and anthiropogenic factors. The key physical determinants include rainfall, elevation, slope, river network, and drainage density. Anthropogenic factors, such as inadequate drainage maintenance, illegal construction in low-lying areas, poor solid waste management, and land-use changes, significantly exacerbate flood risk in the study area.

3. 2. Digital Elevation Model (DEM) and Slope of the Study Area

The study exhibits clearly distinguishable high-, med-, and low-altitude zones situated at an average altitude of approximately 1,200m above from mean sea level. The terrain of the area is characterized by a mix of steep and gently sloping hills. A comparatively low-lying belt extends horizontally across the lower part of the northern half of the study areas, forming a distinct topographic unit relative to the surrounding upland. This lowland zone encompasses several GN divisions, including Palantotta-South, Aluthgama, Weligampola, Tekinda, Kentopidiya, Navalapidiya-South, Navalapitiya-East, Navalapitiya-West, and Imbulpitiya, whereas the rest of the study area is upland terrain (Figs. 5).

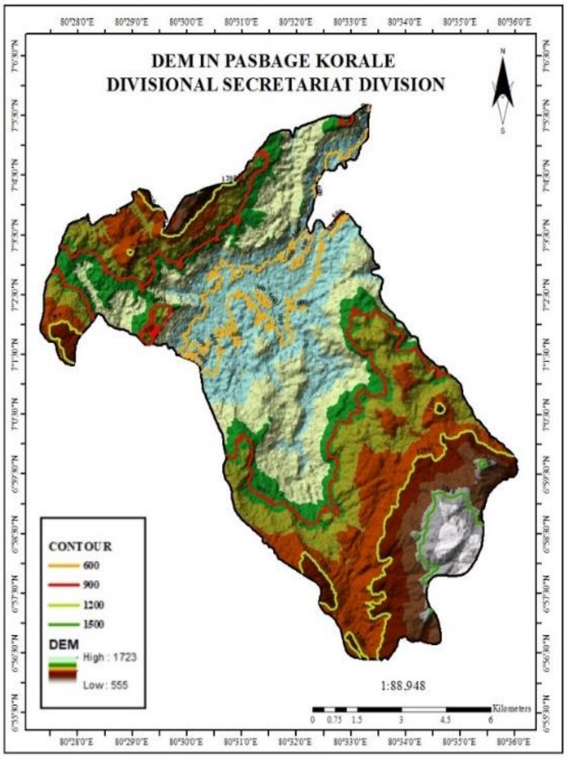

Fig. 5. Digital Elevation Model.

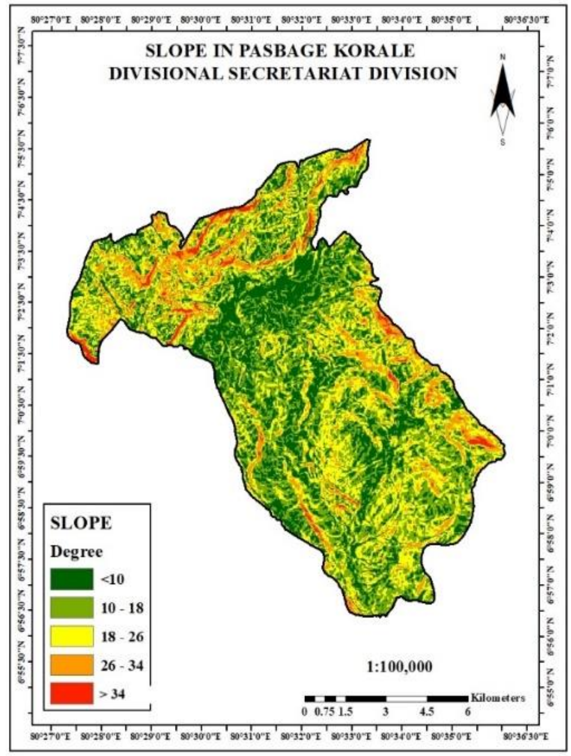

Fig. 6. Slope

Slope analysis indicates that the predominant slope angles in the study area range from 10° to 26°. The northern sector is dominated by gentle slopes, generally less than 10°, particularly in areas extending from the northeast to the western margins of the study region. These gently sloping terrains contrast with localized hilly areas exhibiting relatively steep slopes. The Paspage Korala DS division displays a highly complex slope configuration, while the Pahala Rabukpitiya, Ben Thoduwa, and Dandupediruppa GN divisions are characterized by steeper slopes rangeing from 18° to 34° (Fig. 6). As a result, rainwater flows down the slopes more rapidly, reducing flood risk in these high-slope areas. Even though some areas in the southern and northern parts of the study area have slopes of less than 10 degrees, these slopes significantly influence flood risk in Navalapitti North, East, and West, as well as in Weligampola, Palwagama, and Palanthota.

3. 3. Drainage Density and River Buffer Zone

Drainage density is a significant factor in determining flood occurrence. When the river's drainage density is high, the range of flood levels also increases. The Mahaweli River and its tributaries extend across the study area, and higher flood risk has been observed historically along the Mahaweli Riverbank. Flood events were recorded in the areas where second, third, and fourth-order rivers converge (Fig. 7).

For example, Nawalapitiya-North, Nawalapitiya-South, Aluthgama, Tekinda, Imbulupitiya, Westhola, Inguru Oya-South, Palanthotta-North, and Palwagama are located at the confluence, different river orders, and have experienced frequent flooding. Flood risk is predominantly higher in areas with high drainage density. A river or tributary is crossed within the study area; each GN division is intersected by a river or tributary. A river buffer zone map supports the identification of potential flood-prone areas. Using spatial analysis tools, river proximity was identified, and to assess the flood scenario, river buffer zones were generated for all rivers (Fig. 8).

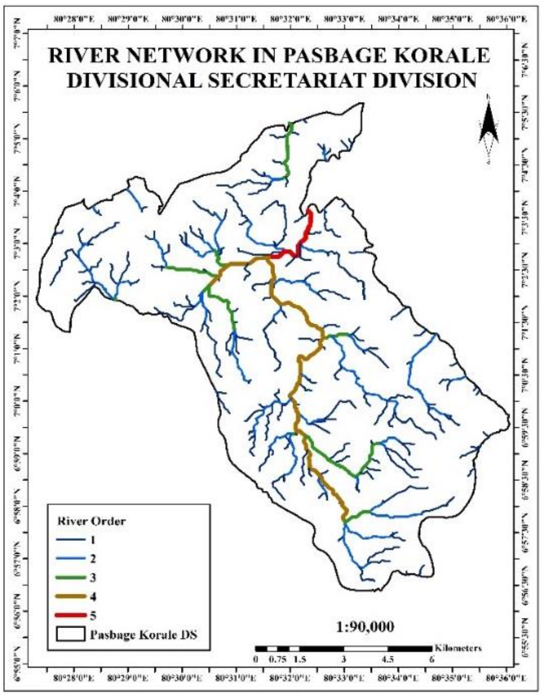

Fig. 7. River Network

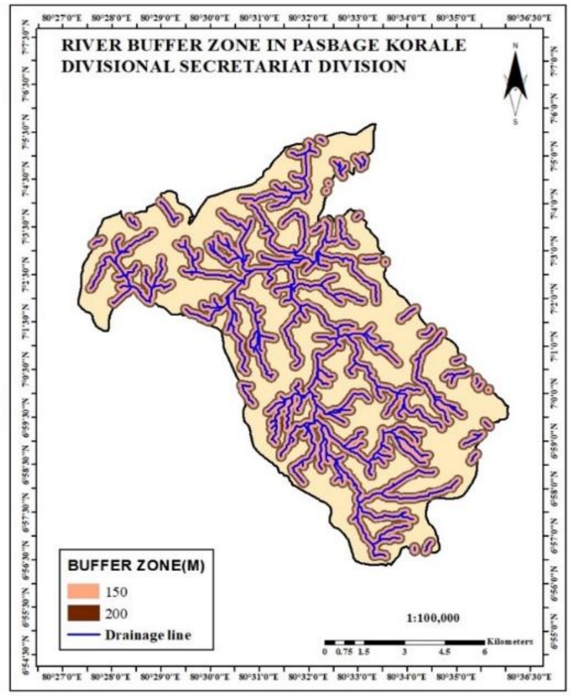

Fig. 8. River Buffer Zone

The main course of the Mahaweli River flows from south to north, and almost all parts of the study area are drained by the river and its tributaries. Areas with high drainage density and flood risk include Nawalapitti North, East, and West; Karakandugala; Palwagama; Weligampola; Kanthopitiya; Inguruoya North and South parts; Aluthgama; Palantotta; parts of Palwagama; Imbulpitiya; and the Hydree Gram Niladhari divisions (Fig. 8). Areas with medium drainage density are predominant throughout the study area.

In contrast, drainage density is very low in the areas of Greenwood, Kadianlana, and Pallegama. It is also noteworthy that the northern part of the Udarambuk Pitiya GN division is less densely drained.

3. 4. Land Use/Land Cover

Figure 10 shows the pattern of Land Use/Land Cover (LU/LC). The LU/LC pattern has changed singificanly fairly over time. Rapid population growth and urbanization are the main causes of these changes. An assessment of the LU/LC pattern in the study area reveals that the agricultural lands are more extensive in the southern half than in the northern half. In terms of settlement patterns, close-knit settlements have developed in an elongated, condensed form extending from northeast to west. Agricultural land covers 4,646.16 ha, while forest cover accounts for 4,402.93 ha.

The built-up area extends over 2361.87 ha. Based on these observations, croplands dominate the study area. Barren lands occupy only a very small area. Approximately 363.04 ha of rock formations are present in the study area.

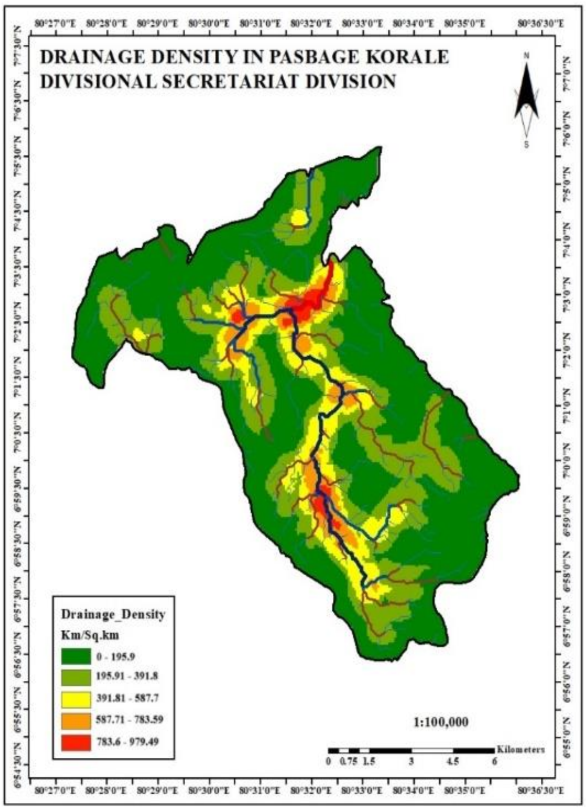

Fig. 9. Drainage Density.

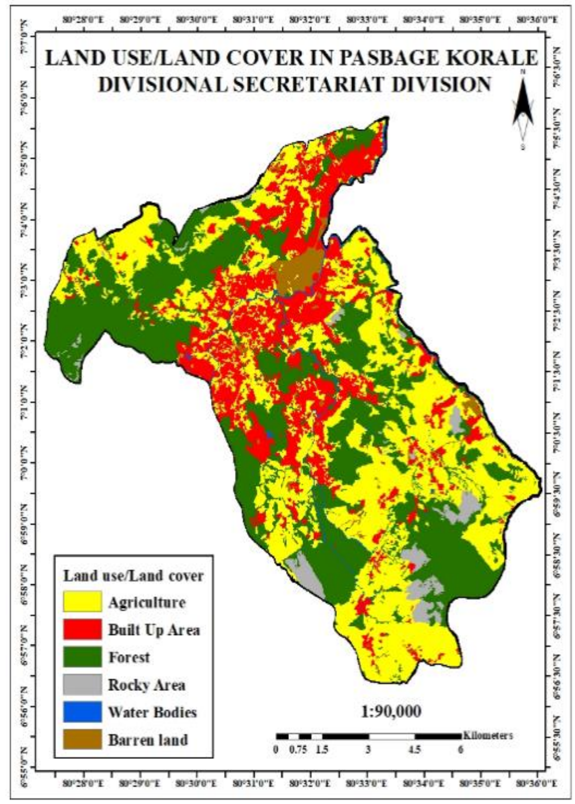

Fig. 10. Land Use/Land Cover.

3. 5. Flood Hazard Map

The generated thematic layers were overlaid to prepare the flood hazard map for the study area. Elevation, slope, drainage density, river buffer, rainfall, and LU/LC are the primary factors most strongly influencing flood hazard in the study area. The flood hazard map classifies flood risk into four levels: high, moderate low, and very low/null (Fig. 11).

Eleven (11) GN divisions experiencing high flood hazard were identified in the study area, namely Navalapitiya-West, Karahandukala, Weligampola, Pawwagama, Maphaganda-North, Maphaganda-South, Weuvagama, Balanthota-South, Aluthgama, Tekinta, and Kentopidiya.

These areas are characterized by low-lying terrain,-high river density, and predominant rainfall during the south-west monsoon and second inter-monsoon seasons. Rapid LU/LC changes are also occurring in these regions. Moderate flood hazard was identified in sixteen (16) GN divisions, which are characterized by moderate elevation and moderate drainage density. Low-hazard areas are generally located in highland regions and are characterized by steep slopes.

Also, GN divisions such as Greenwood and Kadiyanlena exhibit the lowest flood hazard. Some areas are not subject to flood hazard, particularly those with elevation exceeding 1000 meters (Fig 11).

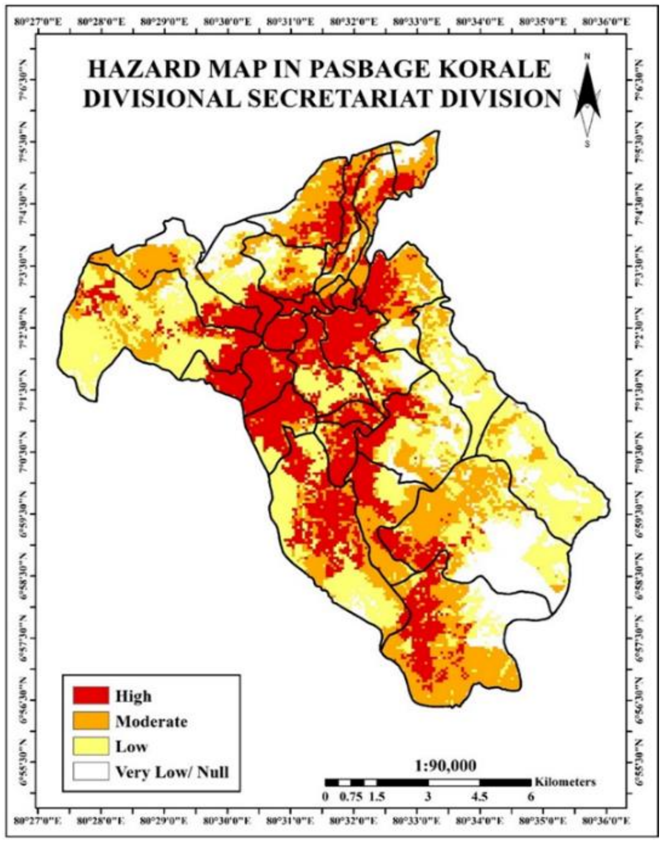

Fig. 11. Flood Hazard Map .

3. 6. Population Density and Flood Risk Map

Paspagha Korale Divisional Secretariat is an area with varying population sizes. This divisional secretariat covers GN divisions with population densities ranging from 500 to 10,000 persons per square kilometer. Nawalapitiya North and West have the highest population densities, ranging from 4,500 to 10,000 persons per square kilometer. About 11 GN divisions were identified as less densely populated areas within the study area.

Moderate population densities, ranging from 1500 to 4500 persons per square kilometer, are observed in the GN divisions of Mapakantha- North, Pauwagama, Palantotta-South, Veligampola, Pallegama, Varagawa, Veligodawatha, Karakandugala, Nawalapittiya East and South. Areas with higher population density tend to have more service centers and more urbanized characteristics.

Within the study area, Mapakanda South, Imbulpitiya, Kentopitiya, Aluthgama, Penithoduwa, and Thanthupedirupa have population densities ranging from 500 to 1500 persons per square kilometer. Overall, the northern half of the study area shows higher population density in GN divisions than the southern half (Fig. 12).

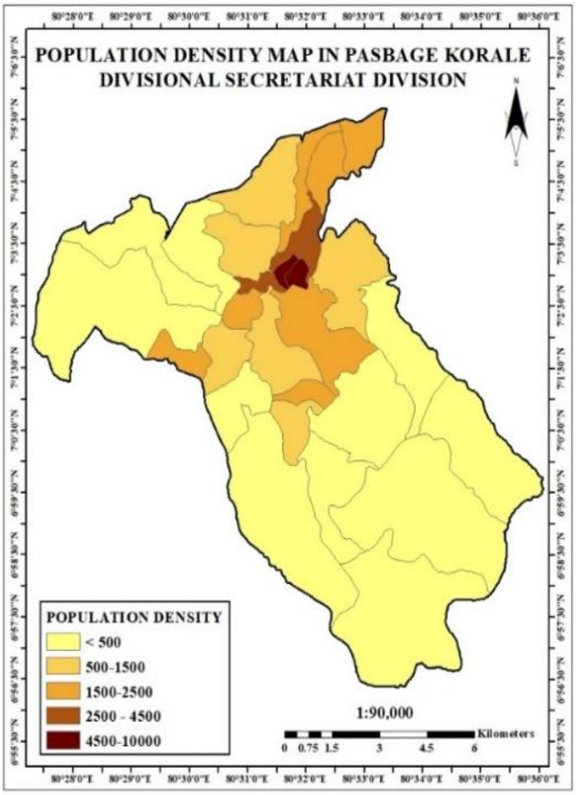

Fig. 12. Population Density.

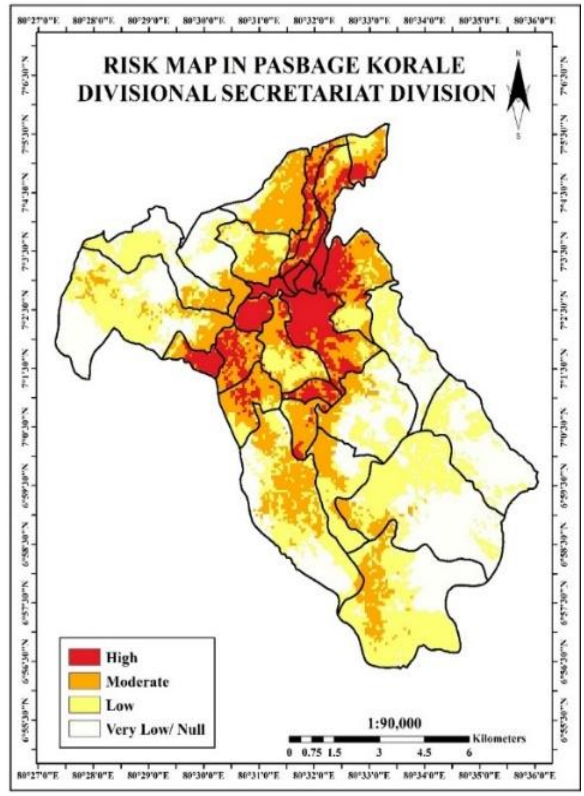

Fig. 13. Flood Risk Map.

Table 5. Extent of flood risk areas and Population- Pasbage DSD.

Nature of flood	Area (ha) likely to affected	Percentage of Area likely to affected	Total Population likely to be affected	Pecent of Total Population (%)
High	1357.68	11.14	24217	31.19
Moderate	2915.03	23.91	27484	35.39
Low	4109.7	33.71	18450	23.76
Very Low/None	3808.02	31.24	7504	9.66
Total	12190.42	100.00	77655	100.00

The seven (07) GN divisions were identified as low-hazard areas. These low-hazard areas have lower population densities and are predominantly covered by home gardens and forests.

The remaining 7,504 people live in areas classified as having very low or no flood risk. The flood risk map was generated by overlaying the hazard and population density maps (Fig. 12). The risk map identifies high-, moderate-, low-, and no-risk areas. It can be observed that every GN division in the Paspaghe Koralai Divisional Secretariat contains at least a small area at risk. Based on the flood risk map, nine (09) GN divisions fall into the high-risk category, covering approximately 1,357 ha and a population of about 24,217. Thirteen (13) GN divisions are classified in the moderate-risk category, encompassing an area of 2,915 ha and a population of 27,484 (Table 5). Altogether, these high- and moderate-risk areas encompass approximately 66.4 percent of the population (Fig. 13).

The results have implications for flood-risk mitigation and land-use planning in the study area. The identification of highly and moderately flood-risk areas provides a basis for the allocation of priority in flood risk mitigation, flood control in flood-risk areas, and improving evacuation planning for floods. The flood risk maps generated in this study could be useful for flood vulnerability reduction and disaster preparedness at the administrative level.

4. CONCLUSIONS

This study applied an integrated GIS–AHP approach in combination with hydro-meteorological analysis to evaluate flood risk and hazard in the Paspaage Korala Divisional Secretariat Division. The reseaarch findings indicate an increasing frequency and intensity of flood in recent decades, particularly during the South-West Monsoon season. This trend reflects the growing influence of climatic variability and land-use changes on flood occurrence in the study area where as Paspaage Korala Divisional Secretariat Division. The spatial analysis found that flood risk is not uniformly distributed across study area, with certain places regularly impacted by high and moderate flood risk. The spatial pattern of flood-prone areas emphasizes the significance of specific area flood management strategies rather than broad mitigating measures. The use of the AHP approach in a GIS setting proved successful in combining several flood-conditioning parameters and defining flood hazards and risk zones in an organized and repeatable manner. In summary, the research shows that geospatial and multi-criteria approach to decision making can greatly improve the assessment of flood risks and proactive flood control tactics. The findings help to improve resilience to floods and reduce future flood-related losses in the Paspaage Korala Divisional Secretariat Division as climatic shift.

Based on the fins of this study, the following flood control; activities have to be implemented. 1) Raising the foundations of houses above 06 feet above ground level along the Mahaweli river bank at Mahakumbara, Labual Koduwa, Selam Bridge, 2) Increase the depth of the river by carrying out periodic dredging operations. 3) Removal of new islands formed by sedimentation without any harm to the environment. 4) Appropriate to dump the removed sediments in areas like Mallantha, Kithulkoda, etc. 5) Increase the depth and width of the canal from Navalapitiya to Tholaspaghe road, Nawalapitiya to Tekinta road. 6) Implementation of solid waste management measures in a systematic manner and 7) Construction of garbage tanks near the roads at Pauwagama, Nawalapitiya East, Palanthota North and South.

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