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Causes and impacts of flood inundation: a case study based on Mavadippalli, Sri Lanka

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ABSTRACT

A flood is a climatic hazard and disaster which causes socio-economic, environmental and property losses to a country. Every year, a flood disaster batters any country in the world, in particular the tropical regions where the monsoonal influence is severe. Sri Lanka, being a tropical country, goes through the monsoonal effect through which much of the rainfall is received. Albeit the rainfall reception occurs mostly in the wet zone including the central highlands, it drain through the coastal belts of Sri Lanka through the rivers and low-lands. Thus, it creates inundation in the neighborhoods of the rivers and low-lands. The same happens in the Mavadippalli area in the Ampara district of Sri Lanka. This study is to explore the causes of the floods and consequences and to create future anticipation. For this study, both primary and secondary data were gathered. As primary data, observations, field visits, interviews and questionnaire surveys were made as well as hand held GPS was used then, the DEM was generated from the randomly collected GPS points and, as secondary data, previously published articles, topographic maps and statistical reports were used. The gathered data was analyzed using Arc GIS 10.3 software. It was found that the Pallaru River, a tributary of Gal-Oya overflows when experiencing torrential rainfall. The long-term observation from Google Earth images have also shown the shrinkage of the respective river beds. It is evident that, according to the DEM, the Mavadippalli area is one of the low-land in the district which is overwhelmed during the high downpour in the nearby areas. Further, some kinds of aquatic macrophytes also hinder the smooth release of the water from the bridge across the Sammanthurai-Ampara main road, which leads to the overcapacity of water and consequent flooding. To sum up, many recommendations have been proposed, such as; proper land use planning, risk management, conducting awareness programs, cropping the slanting areas etc. to curb the ramifications of the flooding in the Mavadippalli area.

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***Keywords*:** flood, climatic hazard, disaster, tropical region, monsoonal influence, Mavadippalli

1. INTRODUCTION

Masaru mentioned that the world is encountering vulnerable situations from natural disasters. Climate change is now considered as an important factor that increases flood risk, with an increase in the frequency and intensity of torrential storms, [14]. Adam et al., pointed out that floods, river bank erosion, cyclones, tornadoes, cold waves, arsenic contamination in groundwater, water logging, and salinity intrusion have frequently occurred, [1]. Thus, Tilahun et al., noted that extreme weather events which are expected to get worse due to climate change and variability, [21]. Wagenaar et al., pointed out that floods cause the largest portion of insured losses of all catastrophes around the world, [23]. Nurashikin et al., stated that floods are one of the most destructive natural disasters. Since flooding is becoming more common and frequent, planning and preparedness for the worst scenario must exist as a central consideration in development, [16]. The inherently destructive and disruptive nature of natural disasters may result in serious economic losses, pointed out by Vikrant & Subir, [22]. It number of deaths, and results in the most damage. Economic impact of natural disasters along with their impact on gross domestic product (GDP) growth [22].

Heidi gave a bare description of the flood that rising groundwater and high groundwater levels are accompanying phenomena of river floods, but are often neglected in ex-post event documentations or ex-ante risk analyses, [12]. Nquot & Kulathunga gave a simple illustration that the flash flood is usually sudden and unexpected, arising from heavy and persistent downpour, [17]. Flooding is one of the major contributors to the loss of life and economy from disasters. Zbigniew & Kundzevicz portrayed that floods in small basins may be generated by short duration, high intense rainfall [24]. Qomariyatus et al. mentioned that floods are one of the disasters feared by people in society, because floods come with a high water discharge, inundated at a highly suppose that floods associated with rainfall are produced by thunderstorms and that, a single thunderstorm cell can produce enough rainfall to cause a flash flood in terms of hydrological causes, floods can be caused by increased runoff due to ice and snow melt, impermeable land surfaces with saturated water, poor infiltration rates and land erosion, [15]. Intense and long-lasting rain is the most common cause of river (fluvial) floods in large river basins, but high latitude regions are subjected to snow melt floods (sometimes enhanced by rain or ice jams), [24].

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Dushmanta & Srikanth remarked that the Inter-Governmental Panel on Climate Change (IPCC) has predicted in of extreme rainfall in the next few decades due to climate change in the monsoon Asia region and that is definitely going to worsen the flooding situation in Asia, [7]. Aifang et al., have noted that more values expose assets in developed regions, whereas more people are exposed to floods in Asian countries, [3]. Emdad stated that the development and disaster relationship discourse require in depth conceptual and empirical research with a view

to revealing further specifications in the area of understanding the phenomena as well as formulating human action strategies, [8].

According to Chandrasekara et al., coast communities, their livelihoods, and the coastal ecosystems of Sri Lanka are vulnerable to extreme rainfall events, [5]. Dobrovibova et al., illustrated that, while in the 1980s, 147 M inhabitants had been affected by natural disasters, it was already 211 M inhabitants in the 1990s [6]. Chandrasekara stated that exploring distributional changes in extreme rainfall series recorded across Sri Lanka is crucial to understanding flood risk in the context of climate variability and change [5]. Kaleel remarked that eastern, north and north central provinces are seriously affected by the monsoon rain continuously, [13]. Ampara district is one of the dry zones in Sri Lanka which receives less than 1750 mm rainfall annually due to the northeast monsoon. Brian & Stephane noted that according to the World Bank post disaster needs assessment, the government disbursed US $ 6.6 million in emergency relief, and total recovery needs were later estimated at nearly US $ 800 million, [4].

Beyond the rainy seasons, especially in the northeast monsoon period, the Ampara district is seriously affected by flood. As well, there are also some issues that cause floods, and their impact also heavily affects the land, people, and plantations and so on. Therefore village Mavadippalli is also heavily experiencing the serious impact of floods socially, economically, and also physically too. If it there floods with extreme severity, it will definitely affect paddy land which is dependent on the Pallaru River rather than the people and their properties. This village, Mavadippalli, has acres of paddy land rather than residential places. Haruhisa and Jun mentioned that climatic factors (such as climatic trends and random variability in the system) and no climatic factors (such as yield technology and changes in data accuracy) contribute to non-stationarity of the weather--yield relationship [11]. Therefore, the effects from the flood and the climatic conditions affect the paddies more than settlements and residence here.

Background of the study

Figure 1 exposes the study area- Mawadippalli and this image was retrieved from Google Earth Pro and ArcGIS10.3. The study area is in the Karaitheivu DSD, Ampara district, Eastern province. A 31 road (Ampara- Karaitheivu prime way) crosses through the village. Sammanthurai surrounds it in the west and Karaitheivu in the east. The village Mavadippalli is between latitude 7° 22’19.09’’ degrees N and the longitude 81° 49’18.43” degrees E. The annual temperature of the place ranges from 27 °C - 30 °C. Annual rainfall also ranges from 1500 mm to 225 mm the total population is 3155. One of the major river’s (the Gal Oya) tributary called Pallaru, is crossing through the village Mavadippalli. Gal Oya is the 16th longest river in Sri Lanka, and it begins from the East hills of Badulla and ends in the South of Kalmunai, Indian Ocean. It is 108 km (67 miles) length in South East of Sri Lanka. Senanayake Samudra is known as Galoya reservoir and it is very special when compared with other reservoirs in Sri Lanka in multiple ways.

Objectives of the study

Research was carried out and structured on the basis of its goal or major aim exhibits the major purpose of the study. Sub-objectives contribute the general aim and determine the finalization of the study. This study learns about the causes and the impact of flood inundation and how dangerously these factors affect the specific area.

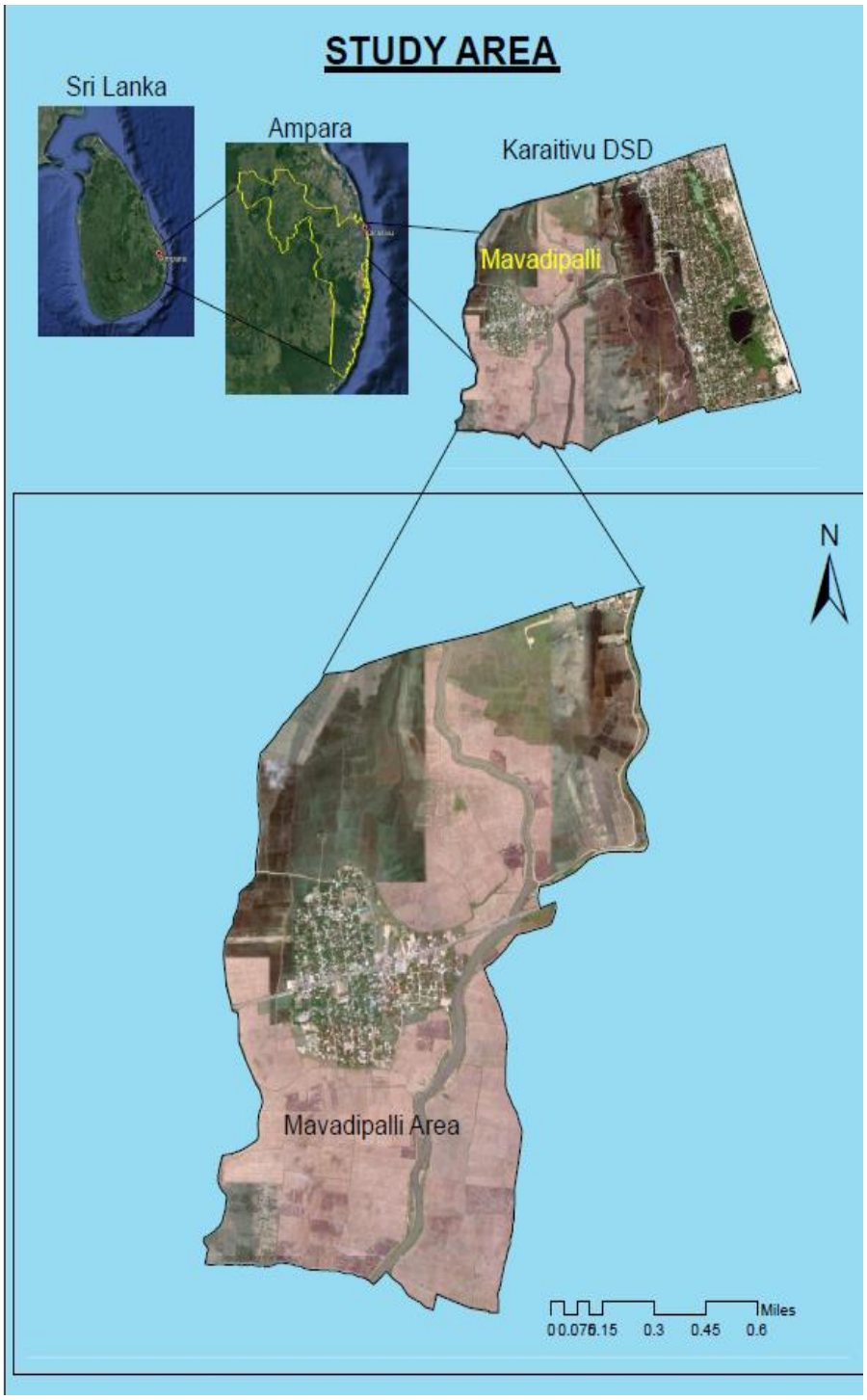


Figure 1. The study area of Mavadippalli

Main objectives

- To identify the major causes and impacts of flood in the study area.

Sub objectives

- To prepare the flood vulnerability map of the study area.
- To propose the mitigation measures to the flood hazard in the study area.

2. MATERIAL AND METHOD

This research explores the causes and effects of the flood inundation in the research area, Mavadippalli. This study was conducted using elementary and secondary data. As well, qualitative and quantitative approaches are also considered during the data collection process. Field visit-observation, interviews and questionnaires were used to collect primary data for the study. Research is carried out and structured based on its goal or major aim, and exhibits the major purpose of the study. Sub-objectives contribute to achieving the overall goal and determine the study's completion.

Kabir stated that censuses, organizational information and data compiled from qualitative methodologies or quantitative research are common sources of secondary data, [20]. As a result, the researcher assembled secondary data from research articles, data accumulated from the annual reports of the DS office, published articles, magazines, and government department reports. The departments and government institutions have published and unpublished quarterly and annual reports giving secondary information efficiently. This information has aided in the discovery of the study's findings. For further data analysis, the collected data was analyzed using ArcGIS 10.3 software, and Google Earth Pro was the prominent software to get the satellite images to prove the facts of the study. As well, MS Excel was very helpful for the statistical description.

3. RESULTS AND DISCUSSION

Flash floods can occur with no heads up, as its islets. In a low of moment, flickering allusions can come off. Because of tropical cyclones, an immense quantity of downpour can befall and it may effectuate flooding and flicker flooding once the squall reaches land and low-lying areas. As the inquest field experienced flash flooding due to the secrecy of the Pallaru river stream, there is a list of flooding events that occurred in the study area, inundation events due to overflow of water from the rivulet during the monsoon period.

Rainfall rate and rainfall duration

The inquisition field — Mavadippalli frequently undergoes a flurry of inundation. These flurry inundations occur due to the durability of the outermost cloudburst of 6 hours or a minimum of 3 hours or in a low-lying time. Thus, within a short span, the rain rate is lofty. The region around a flood way can be soaked fluent if it rains for an elongated moment. Thus, during the greater rainfall, the land cannot be saturated, so it falls along the outside — this is feted as the tide — off. Thus, if there is a ponderous rainstorm, there is a minor pitfall of it living sopped up through the soil (infiltration), so it drives off into the swash? When the water reaches the swash, the superfluous potential to overflow. Therefore, this is the scenario that occurs during the northeast monsoon annually in the probation area of Mavadippalli.

Over flow of river

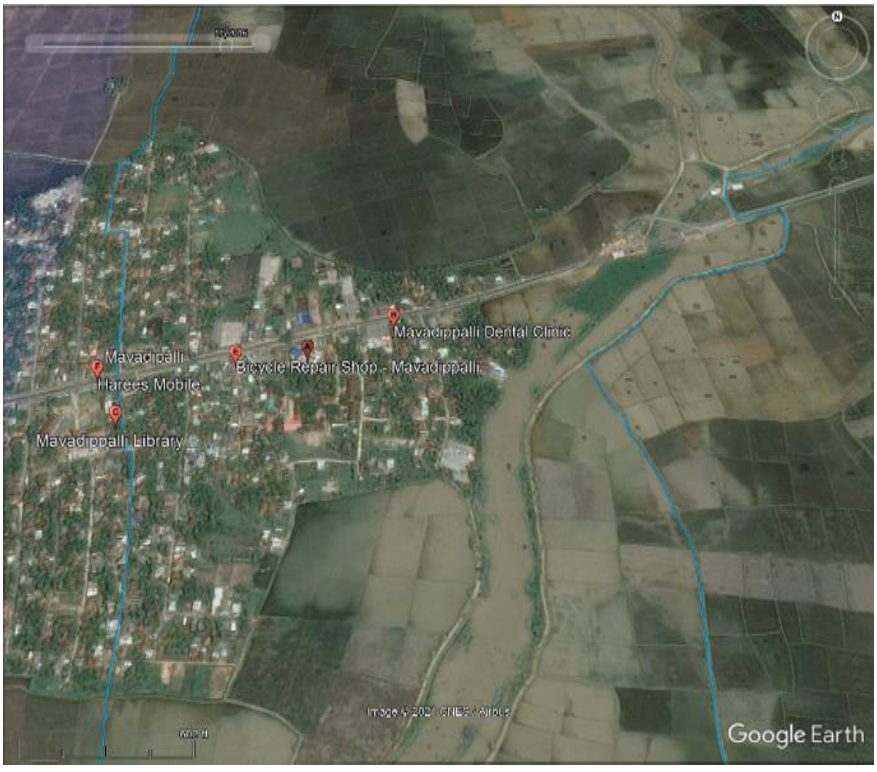


Figure 2. Over flow of water from Pallaru River

The researcher retrieved the above image from Google Earth Pro. It shows the overflow of the Pallaru tributary during the moist season in 2016, November. Here, the nearest areas of the stream were inundated by the overflow. Therefore, the overextended rainy periods cause flow. The immense volume of water in the enormous range can be covered by rain water. The lowlands and downstream can be able to face the effects of flooding. But in the vaster rivers, this process is very slow. Hence, the modest rivers, streams, or tributaries like Pallaru River cannot bear the enormous water within it. As these small tributaries do not have such an amount of water, the river rises fast. There, it forcefully spreads water along the tributary banks and near places of the stream or when there is any blockage or debris in the tributary or dams. When the soil is saturated with rain water it turns off. It is from tributary rivers as well as from low land.

Improper maintenance of river Bank

The Pallaru River does not have the proper and ample maintenance. There are several paces of banks filled full of sediment. The retrieved image 3 from Google Earth Pro shows the silts along the stream and in some places the accumulation of these sediments is rich. Orange colored arrows mark the sediment accumulation on the bank of the river Pallaru.

Figure 3. Sediment accumulation in Pallaru River

In past years, people used these shores for bathing, for fishing, for washing their wheels, carts, and even for spending their leisure time. Hence, in the heavy storage of sedimentation on the banks of the Pallaru River, people resist it for multiple purposes. Overrule sedimentation storage reduces the extending of the banks of Pallaru river. Thus, there is ample possibility for the overflow of water and it can cause flooding and inundation along the banks. Inadequate maintenance of drainage facilities such as blockage by debris may bring floods.

Lack of vegetation

Vegetation can cover all the soil, and it can ward off drought and flooding. In the study area- Mavadippalli, there is a lack of greenery shelter along the Pallaru river bank. Even in some areas, plantations such as Japan Iconia, small scrubs, bushes, green and leafy vegetables, do not inhibit overflow, but they can control the speed of the flood. The building grows coconut seedlings and mango trees which are countable in fact. The vegetation cover is removed by the amount of water when the dam opens for an exceeding volume of water then, it causes a flash flood in the study area. Thus, this deportation of flora shelter is one of the reasons for the overflow in the study territory. The vegetation shelter in the stream is mentioned in figure 2 on the face of the filling. As well, image 04 also depicts a clear picture of the expulsion of the greenery dress after the surge in 2019 May.

Figure 4. Over flow of water from Pallaru River

Therefore, the renunciation of Japan Iconia weed from the river due to the speed of the water, increasing the effects of the flooding and torrent on the nearest paddy lands and residential places.

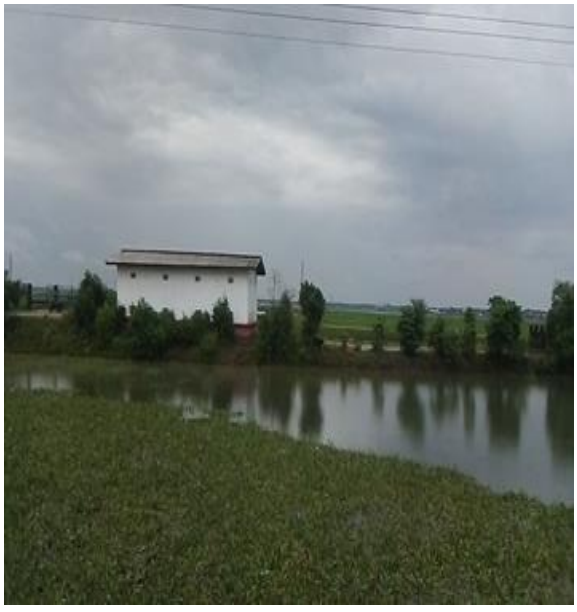
Inadequate capacity of the canals

These in which are connected with the Pallaru River and it distributes water for irrigation to paddy cultivation in the study area. There is a major canal which separates the boundary of the village and it provides water for sub canals within the study area. The width of this canal is 10.55 m and the length of the canal is 2.85 and the poor efficiency of the major and the sub canals causes over outflow of water during the rainy seasons and it urges flood inundation in the agricultural lands of the area. Sub-canals vary in their width. Thus, during flooding, these canals do not keep the water in them. Over rush of water occurs certainly for instance; a sub canal has 4.86 m width in the east as well this same sub canal is 4.31 m in the west part of the field. Another canal in the east is 3.26 m in width as the same canal is 4.91 m in the west. Therefore, the difference in its width influences the saturated efficiency of the canal. Thus, it leads to the inadequacy of canals, which paves a path to flooding in the agricultural plots as well.

Impacts of flooding in Mavadippalli:

Water in the watershed is used in various ways, such as for domestic, quenching thirst, (growing plants and trees) for irrigation, and for power generation. When it violates its ample level, it will be terrific such a heavy downpour. Thus, floods can deplete someone's property, economy, life, and environment as well, the people like residences, paddy owners, farmers, and paddy plots, too affected. Due to this torrent caused by the Pallaru River, there are so many effects either on people or on paddy fields. They are as follows

Environmental- Contamination, Ecological System Damage



Figures 5-7. Environmental contamination.

The Figures of 5, 6, and 7 were captured from the affected study areas. The Figure 5 is brought back from a residence place. This lawn is dotted with the maximum amount of garbage which the overflow water transfers and leads to soil deterioration and water pollution in the environment. The blend of sediments and wreckage presents the water pollution in the Figures 6 and 7 in stream. Silts, garbage and chemicals mixed with water lead to water deterioration in the study area.

Flood has the capacity to transmit the sediments and diverse kinds of sliding objects such as, chemical, sewages and light floating plants such as Salvenia Tropica, ferns, duck weeds, Water Lettuce, Water Hyacinth, Giant Duckweed, Horn wort (Ceratophyllum Cemersu). These silts and chemical/ erode particles floated in the water as water passes over and through the water parties and it contributes to pollution. Moreover, some debris, plants, tree logs, floating materials such as plastic pieces, polythene, rubber and the alternative substances also have separate in causing pollution on the surface water and cultivated field. Thus, there are 22 families living near the Pallaru river bank.

They endure the adverse pollution every year and condition is depending on the effect of the flooding in Mavadippalli. This is how floods cause deterioration and contamination every year. Due to these conflicting states, there is a probability to transmit dengue, malaria, water-borne infections and vector-borne epidemics.

Physical Damage: Impact on Housing / Property Damage

The houses such as hut/ cottages or thatched homes conversed into cement wall houses in later years. However, people suffered during the rainy season as they were unable to live in past years. Even though houses change into cemented materials, the state of living will not advance further. Whereas during the uninterrupted rainfall, sealed walls, brick walls, and pillars are split or partially suffered by the flood.

Figures 8-10. Physical Damage by Flood

The Figures of 8, 9, and 10 were taken from the affected houses and represent the physical damage to houses caused by the extreme rainfall in the study area. Namely, when high and severe runoff takes place, the soil flows with the water, there will be a gap allowed to take place between the surface and the basement. Thus, the land substructure is automatically alight, then the crack in the walls occurs. As this scenario has often got place, the split provokes extreme danger and effects.

Impact of livestock

During the floods, the recession of livestock is common, such as goats, sheep, chicken, buffalo, and cow/oxen. After agriculture, animal husbandry picks up the second greatest place of income for subsistence. In some places, deaths are caused by floods, and the mysterious epidemics after the flood likewise cause jolts in the herd. Poultry animals suffer the health-related releases such as respiratory diseases, chicken pox, sore head, bird pox, infectious bronchitis, and so on, at the same time buffalos suffers for the food in the last later years by the floods and heavy rainfall. In the study area, the major problem for livestock is the food crisis during flood and heavy rain.

Impact on road and transportation

One of the tributaries of Galoya passes through the village. It overflows during the north-east monsoon and produces flooding around the river. The most important part of this flood is the result of agricultural land along the river in very 2 m height of Paddy lands and it ascends above 8.6 m from the tributary bed level. It prevails and effects transportation during the excessive rain and north-east monsoon period annually. The A31 Ampara to Karaitheivu way crosses through the study area. A flood dangerously affected this road during the heavy rainfall.

Due to the overflow of Pallaru river water during the rainy season, especially in the north-east monsoon period, people suffered. The passengers and travelers went through so many problems because the inundation took place in Mavadippalli. They are as follows;

- The water discharge crept vehicles.
- Inconvenience while passing over the road.
- Traffic / block had taken place.
- It was unfit to attend the offices or schools on time owing to the flood.
- It could not approach in the emergency to arrive at the base hospitals like Sammanthurai Base Hospital, or Ampara Base Hospital.
- Sometimes, boats were used to preserve the communal communication and comfort to transport to other side when the flood trucked.
- Some fishers and local people also used this flood for the fishing activity because this heavy rain and flood weakened the subsistence of resident populations in the study area as well. Due to this activity, people went missing, had injuries, and occasionally deaths also occurred.

Figures 11-13. Effect of flooding in transportation in the study area Mavadippalli.

The above shots show the effects of flooding on the highway which passes across the village of Mawadippalli. Figure 11 demonstrates how water comprises transportation, as well the image 12 and 13, are the same. The bus slants as the water covers the road, and the passengers face obstacles to this adverse situation as well.

Impact on Agricultural Land

The Paddy fields near the stream generally suffer from the torrent catastrophe particularly during the north-east monsoon between Decembers–February. According to the interview which was held by the farmers, most of the farmers reported the same condition.

Oxygen Depletion & Imbalance of nutrient uptake:

The submerged land becomes low oxygen for crops. As the oxygen level is low in the soil, the plants can stifle. Owing to extreme inundation levels in the land leads to the insufficiency of oxygen in the soil. In the study area, "the reason for oxygen deficiency is the grown crops and fewer mature plants submerged underwater owing to overflowing. Especially, when the water traps and yearns for more than 7 days–10 days clearly, these plants will decay without having proper oxygen for root respiration", farmer Salam stated.

Figure 14. Affected agricultural lands in Mavadippalli

The above photograph portrays the affected agricultural fields in the study area of Mavadippalli. The Flood inundated the entire land with plants. Thus, it induces respiration obstacle to the plants. As plants attain energy through root respiration, this energy is much needed for nutrition consumption. Under excess soil and water, the lack of root respiration imparts improper aeration to soil, and it considerably disturbs the nutrition consumption.

There is a descent consume nutrients such as P, mg, Ca, N, and K. There some nutrients are more soluble, such as manganese and iron. When the soluble nutrients increase, they reach the toxic level in plants.

Disease:
Flooding weakens plants. Nitrogen is the significant source that grows out of plants. Nitrogen level in topsoil declines during the drainage and floating away the manures which was applied directly before flooding to the growing or immature plants. The result is less due to failure of nitrogen in poorer crops and their smaller yield. Pathogens in plants lead to diseases. Brown Plant Hopper (BPH), stem borer, Paddy bundle pest, and leaf and sheath mites are the pathogens or pests which cause foot rot disease, rice blast, sheath rot, sheath blight and brown spots paddy unless the farmers are unable to name the pathogen and did not do any proper management activity to control them.

Weed

Figure 15. Dominance of weeds in agricultural lands in Mavadippalli

Image 15 suggests the influence of weeds in Paddy cultivation. This weed causes so many complications for the farmers and during the farming activities. In the end, it results in the rate of production from the village Mawadippalli. Mostly farmers lead their families in the study area by determining paddy cultivation as their subsistence as due to the deterioration of the paddy crops by flood, farmers are reluctant to invest in the Maha season. Water after the flooding inundation brings seeds, /weeds and these are spread over the Paddy field after the water recedes. After sloughing or sowing the land, they occupy the land. Thus, this dulls the growth of crops and enhances the growth of weed seeds. Typha angustifoloa, Yellow Core, Horse grass, triangular ax, are the weeds which mostly occupy the paddy land in the

Mawadippalli area. Landowners and farmers cannot cope with this situation, and they lack the cash to hire laborers for weeding. Thus, this vulnerable condition sustains during and after the yield. As well, farmers spend more money on clearing these weeds manually by paying salaries to the daily workers here.

Water recharge for dry places of paddy lands

The agricultural lands and occupation in Mavadippalli are dependent on the stream river Pallaru. The medium flood risk space and low risk space gain water by the monsoon rain while the high-risk areas are experiencing floods. Thus, the lands far from the river are receiving water for agriculture by the canals across these lands. Hence, this canal water supply delays reaching the lands which is the farthest. An interviewer mentioned that 10 -14 days are needed to get the water to reach at least 1-mile distance on normal days of each year. Thus, these, the flow of water by the river mostly inundates the land, which helps to make the land for sloughing after the rainy season.

Low Yield

Figures 16-18. Agricultural lands Affected by flood in Mavadippalli.

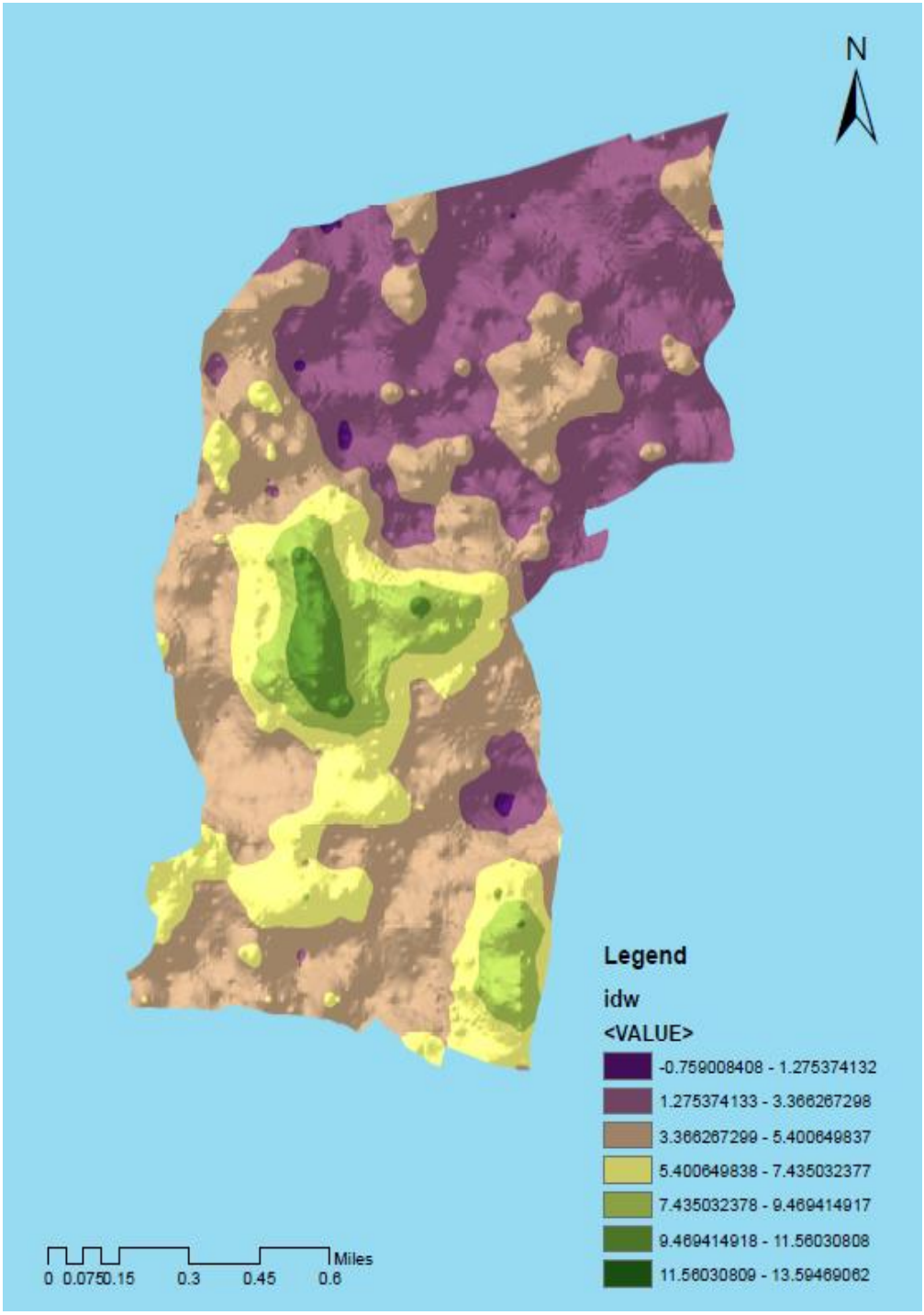


Figure 19. DEM Map of Mavadippalli

Figures 16, 17, and 18 expose the distressed agricultural fields caused by the dominance of floods in the village of Mawadippalli, and these figures are evidence for the causes of the output reduction in the study area due to flood. Due to the flooding, the agricultural lands were

negatively affected, thus, this resulted in the low yield. The yield depends on the severity of the flood and the maturing of the paddy. Perhaps, as floods take place during the Maha season (December – February), paddies are affected in their early immature stage. Typically, an acre produces 35–40 packs of paddies. When it has been affected by floods, the harvest lessens to 10-15 packs per acre. Compared with Yale season, the yield is low in the Maha season in the study area. Therefore, the flood influences the outcome of the production of Paddy.

The Digital Elevation Map of the study area - Mavadippalli

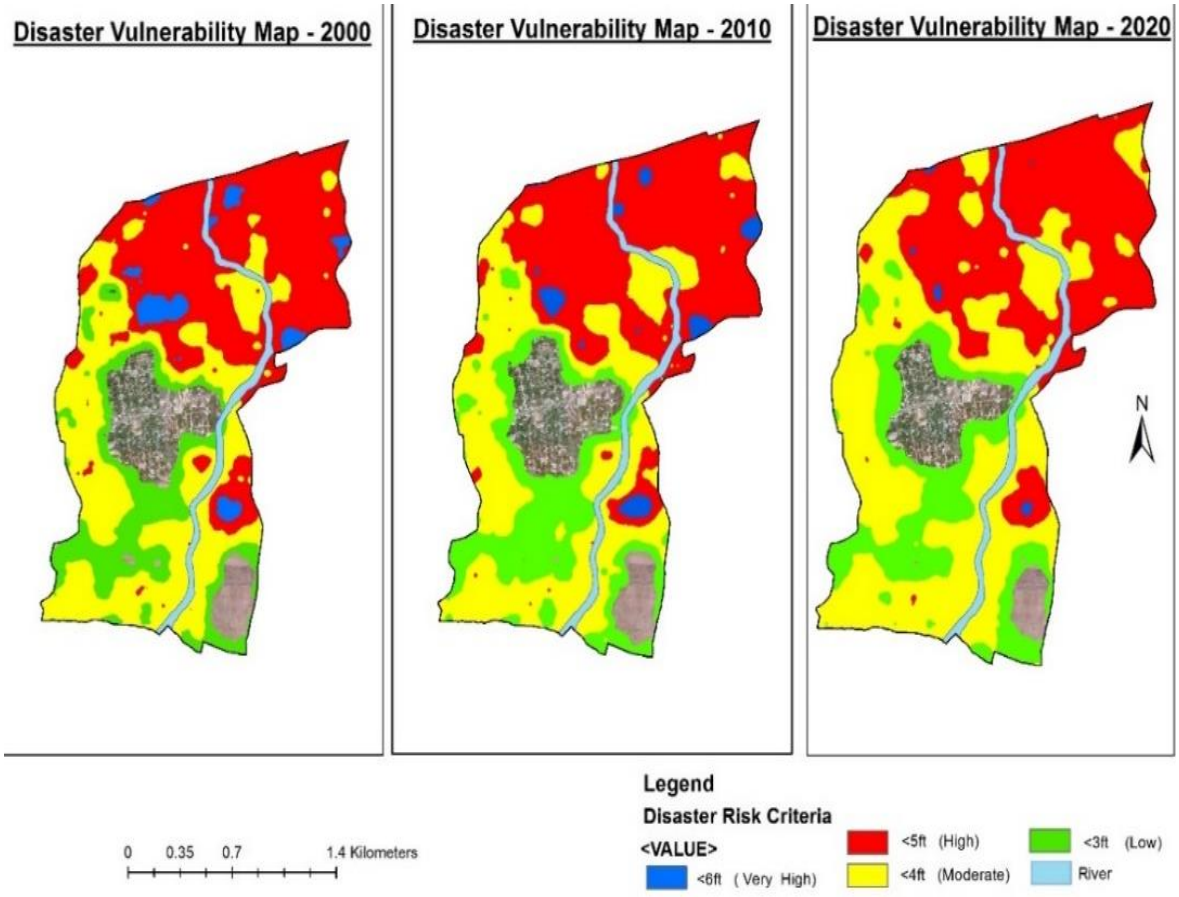


Figure 20. Disaster Vulnerability Map of Mavadippalli – 2020

In order to achieve the sub-aim three of the study, the researchers generated the flood risk map and DEM map using ArcGIS 10.3. Land use planning and zoning is not only in Mavadippalli but also all the risk hazard areas worldwide are able to ward off the hazard when it is taking place. Here, the zoning of vulnerability shows the deeply depressed areas of Mavadippalli by the flood. Exact risk mapping provides people living or employed in flood-prone areas, in front of or along the tributary, with the wisdom they demand to produce choices while designing personal or organizational flood risk management strategies.

The researchers adopted DEM to recognize the altitude difference in an area. Here, the settlement area is a safer place and the flood vulnerability is less due to the solid infrastructure

and adjacent settlements. Even at a nominal level, this area is suffering from flood hazard every year. It defers the inundation level (water level), and depth of the tributary (elevation changes) in both settlements and agricultural fields, accordingly. The hand held GPS was applied then; the DEM was generated from the randomly collected GPS points, and it withdrew the GPS points of the years 2000 and 2010 from Google Earth Pro. Using these extracted GPS points, the DEM map was developed using the ArcGIS 10.3 software.

The Flood vulnerability map of Mavadippalli is implied here across the 3 decades of 2000, 2010, and 2020. The blue color in the map indicates the extremely high-risk of flooding in the area, red points out the high-level of flooding. The moderate level is in yellow color as well as green indicates the low level of flood risk in the study area of Mavadippalli. Very high level is < 6 ft. Which means over 2 m from the river bed level. Moreover, the high level indicates < 5 ft. which indicates ~1.6 m, moderate level indicates < 4 ft. which indicates 1.22m and low level indicates < 3 ft., 0.95 in meter, ~ 1m is low level of flooding which may indicate the inundation in paddy lands. Refer the Figure 20 below, for the clear picture of the affected areas of the study area- Mavadippalli.

According to the comparative flood map of Mavadippalli, everybody can recognize the variations in flooding and its harshness. Mostly, very high flood events fall off in the late year 2020. Hence, the severity of flood has dropped, a high level of flooding advocated around the study area Mavadippalli. Mostly, the agricultural lands near the Karaitheivu are dealing with very high floods and floods.

4. CONCLUSION

A flood is a calamitous natural catastrophe. It seriously affects the subsistence of people. In the study area — Mavadippalli, flood events are acute annually due to the monsoon rain. There are some circumstances which lead to floods, and their impact is fatal during the excessive rainfall on residential places and agricultural lands. After establishing the Delta Bridge in the study area, the harshness of flood is reduced. Hence, the overflow of water on agricultural lands provokes so many frightful effects on yield and production. In the future, there is a possibility of flooding on the both edges of the Delta Bridge towards Karaitheivu and towards Sammanthurai as the water the both edges of the roads in fact. Therefore, the acknowledged recommendations will be applicable to controlling the severity of floods, if they will be empowered in the process.

Recommendations

The people and the land which are situated around the flood-prone areas frequently suffer from flood events. Therefore, flood risk management investigates to curtail the risk fromthe floods. Floods frequently affect people and land in flood-prone areas. As a result, flood risk management explores ways to undermine flood risk. Factors influence the magnitude of the flood such as the elevation of the study region, proximity to rivers, and vulnerability to fast moving flows, among others. Rafael affirmed that the magnitude of the flood depends on some characteristics like elevation of the specific study area, proximity to the rivers, and susceptibility to fast moving flows, measures that have been taken to allay the potential impact of flooding, the susceptibility of people and property, and the consequences that result from a

flood event, [19]. Therefore, the flood disaster management strategies recognize and implement some measures that can reduce the comprehensive risk in the particular affected area.

- Adaku showed that flood risk management (FRM) comprises measures aimed at reducing the likelihood and impact of floods and it encompasses the prediction of flood hazards, socio-economic factors and consequences, and measures/ tools for risk reduction [2]. Thus, maintaining flood risk management in the affected areas can weaken the fierce impact of flood.
- Using sand bags to deal with the water penetrating into the fields.
- Farmers / government can create Natural Systems such as wetlands, ponds, more canals into the study area.
- Expanding functional capacity of farmers.
- Insurance for physical damage and agricultural insurance.
- Awareness for public (survivors) and farmers who are living and having lands in the flood-prone areas.
- Allowance for physical damage and agricultural insurance.
- Flood Early Warning System (EWS)
- Crop Management:
    - Farmers can create flood tolerant rice varieties such as, Swarna-sub1, MTU-1010, and MTU-1140
    - Applying pre-plant fertilizer.
- For controlling weeds:
    - Farmer should keep clean environment. Through this, they can restrain weeds via wind, water, and animals.
    - Using acceptable quality of biological implies in the fields. For example, applying non -- weed organic or compost manures in the field.
    - Using Integrated Weed Control/ Integrated Weed Control Management. (IWC/IWM)
- For limiting disease:
    - Use noninfectious seeds in the fields.
    - Alike distribution of fertilizers.
    - Remove ill plants.
    - Plant deceases resistance seeds such as BG 305, BG 351, BG352, and BG 97-2.
    - Propagate the seeds at the same time.
- Maintaining the Floodways, Spillways, and Channels:
- Improving water drainage in fields

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