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Case Study on Identification of Flood Hazard in the Lower Catchment Area of the Attanagalu Oya River Basin

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Abstract

The present work aims to identify flood hazards and risks, particularly to the Attanagalu Oya river basin in Gampaha district, the western province in Sri Lanka. Attanagalu Oya river catchment area periodically faced flood hazards. The flood is categorized by complex like 2008, 2010, 2016, 2017, and it chose 2016 as the primary flood event. Study areas have been selected depending on data availability. Attanagalu Oya river basin is mainly focused as a study area. However, here selected only four Grama Niladhari Divisions are as a sample area. Those are; Kirindivita, Ambanvita, Thammita West, Gonagaha1. Furthermore, many flood hazards can be identified when considering the flood events history. But here selected only two years were 2010 and 2016. These two years were selected with high flood events. For the study, that flood series used 1 feet elevation contours used to identify flood levels and used LiDAR image to identify risk areas in the study site. Due to the blockage of the main waterways that discharge water into the Negombo Lagoon, limited water transportation, low lying land reclamation for development, mainly affect paddy lands and roads, and flood as a major problem identified temporarily and spatially. Eventually, the study could identify flood-prone areas and map the risk zones within the study area.

Keywords

Flood Hazards, GIS and RS, Attanagalu Oya, Risk Levels

1. Introduction

Floods are one of the most common hazards in the world. However, human activities in many circumstances change flood behavior. Land clearing for agriculture and other activities in the catchment enhances the magnitude of the flood, which increases the damage to the property's life. Sri Lanka is located in the Bay of Bengal and has pressure variation high winds. Unexpected heavy rains due to these factors mainly affect the river Kalu Ganga and Kelani Ganga, subject to frequent floods. Kelani and Maha Oya in the Western province of Sri Lanka with an extent of 727 km^2, it contains four streams Diyaeli Oya, Attanagalu Oya, Urawala Oya, and Kimbalapitiya Oya, which discharge into the Negombo lagoon as Dandagamuwa Oya (Wijesekara & Kudahetty, 2010). Hence a study is based on the Attanaglu Oya river basin. The research object is to assess the flood hazard area based on the flood year of 2016.

Flood is a significant problem faced by many of the river basins and most experienced in the lower flood plains where there is substantial urbanization. Flood is among the most devastating natural hazards globally, widely distributed, leading to significant economic and social damages than any other natural phenomenon (DMSG, 2001). Pressures of population growth, issues such as unemployment, the need to be near a water supply, electricity, and transport services create stress on the land requirement. The increasing demand for land makes most people fill the lowland, wetland, and flood retention areas to build dwelling units and related infrastructure. The drainage water that would typically occupy these areas would then move to locations further down streams, draining any rain or drainage water to the closest waterway, therefore in areas of human occupation. The human reaches the ground runoff diversions, facilitated by drainage networks gush towards the lower terrains. As a result, high runoff leads to floods and less infiltration, resulting in poorly grown water replenishment in the lower flood plains bounded by the sea; this will result in higher floods and floods with exceptionally prolonged durations. The results are why the effects of floods in this studying selected the Attanagalu Oya river basin in Sri Lanka.

There is slightly over 4000 ha paddy cultivation irrigated under the Attanagalu Oya irrigation scheme, the largest irrigation project in the basin. The study area is situated in the wet zone with annual rainfall ranging from 1400 to 2500 mm both monsoons provide almost precipitation. April to December is followed by a distinct period from mid-January to late March. Peak rainfall occurs from October to November and again in May to June while considerable runoff is experienced. Therefore every year has to be faced with flooding hazards in the study area.

The basin provides a home for about 5% of Sri Lanka's total population and has a population density of 1280 per km^2. Ekala, Ja-ela, Minuwangoda and Katunayake are some of the existing industrial estates. Flooding is the primary concern in the river basin. During May 2016, mainly on the 16th, 17th and 18th of May, Sri Lanka was affected by heavy rainfall resulting in floods in various

parts of the country. Attanagalla is one area severely affected by the flooding s in May 2016 that was predominantly due to the overflowing of the Attanagalu Oya. The floods caused heavy damage to lands, crops, houses, economic damages, and loss of lives (IWMI, 2016).

So far, good experiments or research on this subject have not been carried out using modern technology. However, incorporating modern technology to identify flood hazards is of high importance. Therefore, it is considered a high value-adding initiative to perform a study on flood hazard & risk assessment in Attanagalu Oya river basing Sri Lanka.

2. Methodology

This research mainly aims to identify flood hazards and risks, particularly to the Attanagalu Oya river basin in Gampaha district, the western province in Sri Lanka. In connection with the above general objective, the following specific purposes are as focused.

- To identify spatial and temporal patterns of the flood hazard.
- To identify flood inundation area and risk area

Attanagalu Oya river basin is mainly focused as a study area. However, here, designated only four Grama Niladhari Divisions as a sample area. Those are Kirindivita, Ambanvita, Thammita West, Gonagaha 1.

A flood inundation map was developed accordingly to past flood experiences. Using this map, flood variation was recognized. Therefore here identified and selected for GNDs. As a sample area for the validation of the study. That GNDs are Abanvita, Kirindivita, Thammita West, and Gonagaha 1. That area illustrates according to the below data. Those GNDs were selected almost every year in flood situations, and it was, identified here as a more risky area. Accordingly, the following tables and maps show floods inundated areas in the years 2010 and 2016.

2.1. Study Area

Geographically Attanagalu Oya basin drains to the western coast of Sri Lanka between 79˚50'E and 80˚07'E and 60˚59'N and 70˚17'N coordinate (Wijesekara & Rajapaksha, 2013). The study area is the Attanagalu Oya basin, Sri Lanka. This river is situated on the Western hill slope of the island. Attanagalu Oya most of the southwest monsoon rainfall making the river basin. Vulnerable to frequent floods. Attangalu Oya watershed lowers 727 km^2, and significant land use covers are residential, agricultural cropland and wetland land-use types (Wijesekara & Rajapaksha, 2013).

The Attanagallu Oya basin, located between Kelani River and Maha Oya river basins, has a catchment area of 736 km^2 and is approximately 45 km long and 35 km wide. The river originates from the lover pen plains of Kegalle District. It flows westwards throughout its course unit. It meets the ancient depositional plain around Kotugoda, where the river is deflected northwards before turning south to become the Dadugam Oya. Two other smaller streams, the Mapalan

Oya and the Kibulapitiya Oya Drain the northwestern portion of the basing and join the main Attanagalu Oya around Madawala. The Attanagalu Dandugam Oya was finally discharged into a wetland at the junction of the Negombo lagoon and Muthurajawela Mash. The upper catchment of the river is approximately 250 km^2, consisting of rubber and coconut estate and the highest elevation is 300 MSL at Gilapitamada. Figure 1 shows the location map of Attanagalu Oya river basin. The lower catchment is predominantly cultivated with paddy. There is slightly over 4000 ha paddy cultivation irrigated under the Attanagalu Oya irrigation scheme, the largest irrigation project in the basin. The Attanagalu Oya irrigation scheme consists of ten major diversion schemes for irrigation with 34 minor diversion weirs in the lower reaches. The Muthurajawela costal Mash, 6232 ha in extent, is located at the western end of the basing. Freshwater from the 727 km^2 drains into the system via Dadugam Oya and Ja-Ela at the point where the Negombo estuary and marsh meet. The marsh estuary complex from which it is present is estimated to have originated about 5000 mn years ago. (District Profile, 2010) The wetland ecosystem is a typical barrier-built estuary, whey the mash and lagoon are partially separated from the sea by the sand barrier. The sand barrier is developed due to the interaction between wave action

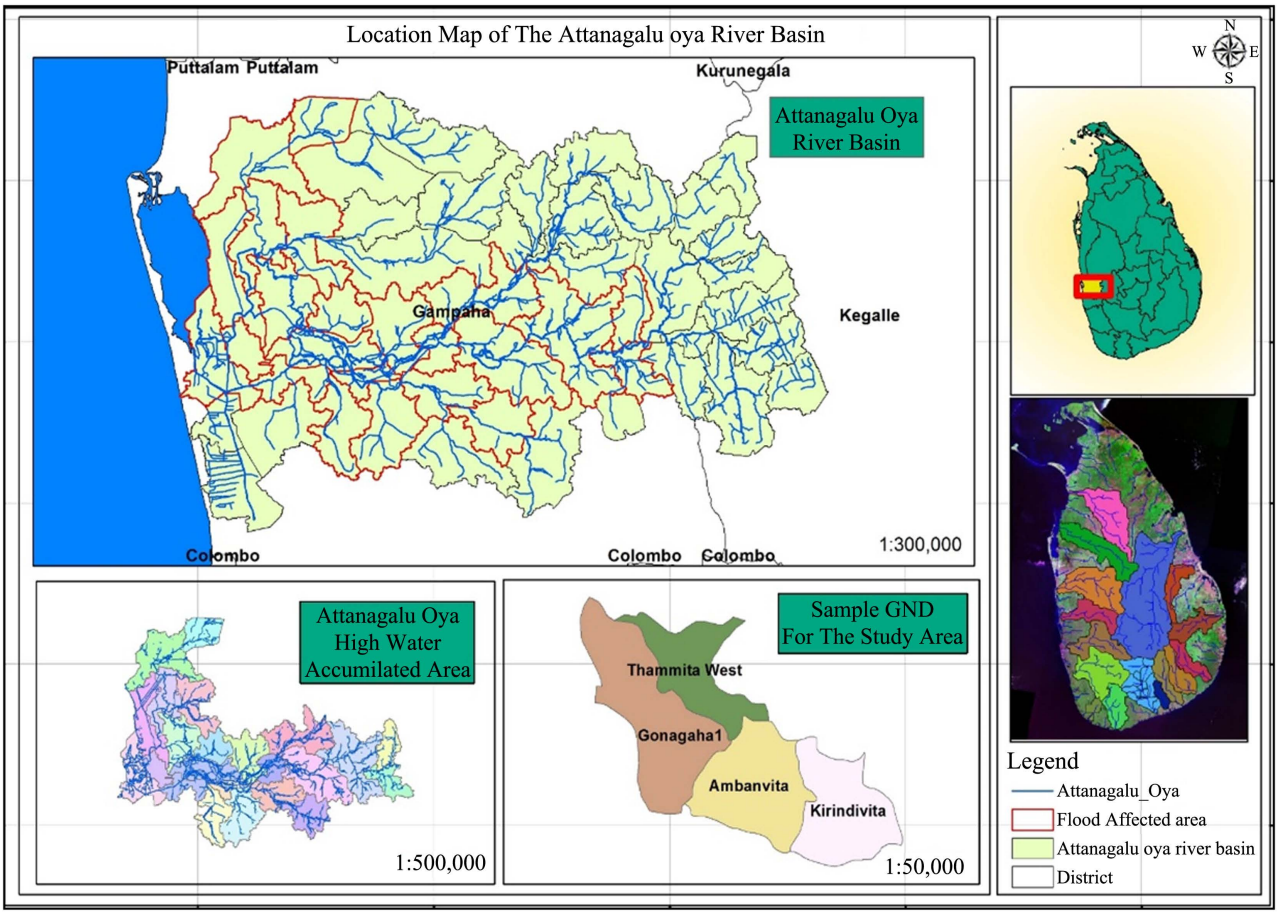

Figure 1. Location map of Attanagalu Oya river basin. Source: Research data, 2021.

and the coastal current of the sea with the sand and sediments that the Attanagalu Oya and Kelani rivers discharge. The lagoon and the marsh is one of the 41 wetland sites identified in the Asian wetland directory and has been studied under the wetland conservation project implemented by the Central Environmental Authority.

2.2. Data Source

Here will be used reliable data is necessary to realize the designed objectives. The study will be based on secondary data, and here used there are several data sources. Topographic maps have been used to extract information layers, such as administrative boundaries. Administrative boundaries are essential in this study because of identify study area location and political boundary. As an example, population density. As well as according to administrative boundaries can join population data identify where the high population density area and high flood risk area is. Therefore administrative boundaries are mainly an essential layer. As a topographic data water body, river, lakes, roads, railway, vegetation area and land use category significant study for the flood hazard. This study is mainly particular about the waterbody layer. Here mainly attention to the Attanagalu Oya river basin. And then the Attanagalu Oya river basin is enormous. Therefore, the star lar theory was used for the select Attanagalu Oya water body. According to that data will be carrying out the study. This study's topographic and GIS data consist of digital contour, land use data, and LiDAR data contour maps used wherein 1:10,000 scale and contour interval 5 m, 1 m and 30 cm data used for the study elevation land-use changes spatially as shown in Figure 2.

3. Result and Discussions

3.1. To Identify Spatial and Temporal Patterns of the Flood Hazard

Attanagalu Oya river basin faces flood hazards every year. That reasons for here

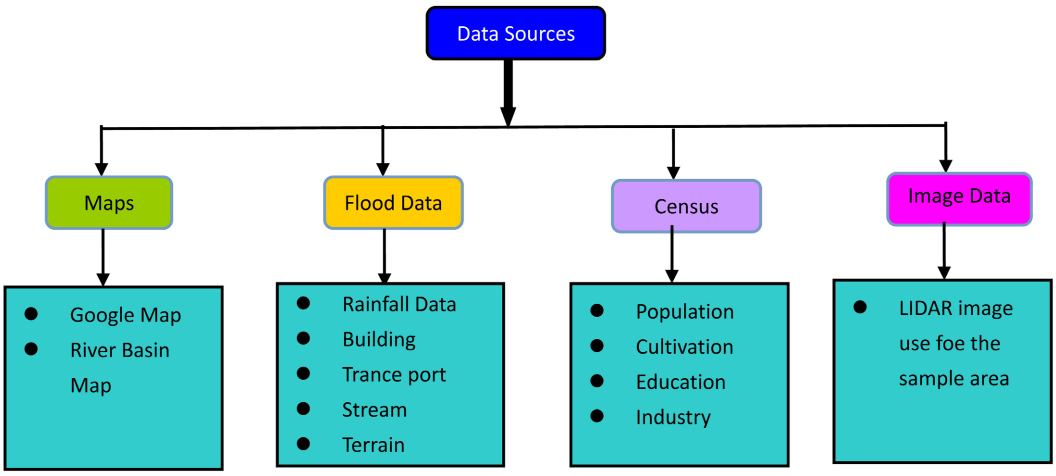

Figure 2. Data sources. Source: Research Data, 2021.

identified. Because of Attanagalu Oya river basin is most of the watershed area. Therefore here determination what is the function of flood hazard. Particularly in the Attanagalu Oya river basin with heavy rains in the upper catchments areas. Of the area; damaging houses, urban centres, schools, the roads network, home gardens, crops, industries. As such, inhabitants of this area have been badly affected by frequent floods. Their livelihood and social life have been severely affected and disturbed as shown in **Figure 3**.

A major proportion of the basin, 64% area, is situated at an elevation of less than 35 m in the sea level. 30% area cover by 30 m - 165 m. Moreover, only 6% present lies above 165 m. Upstream water is connected Attanagalu Oya watershed area. Around 85% are used for the residual area. A high drainage density area coves this area. As well as high intensity rainfall area. Therefore lower portion

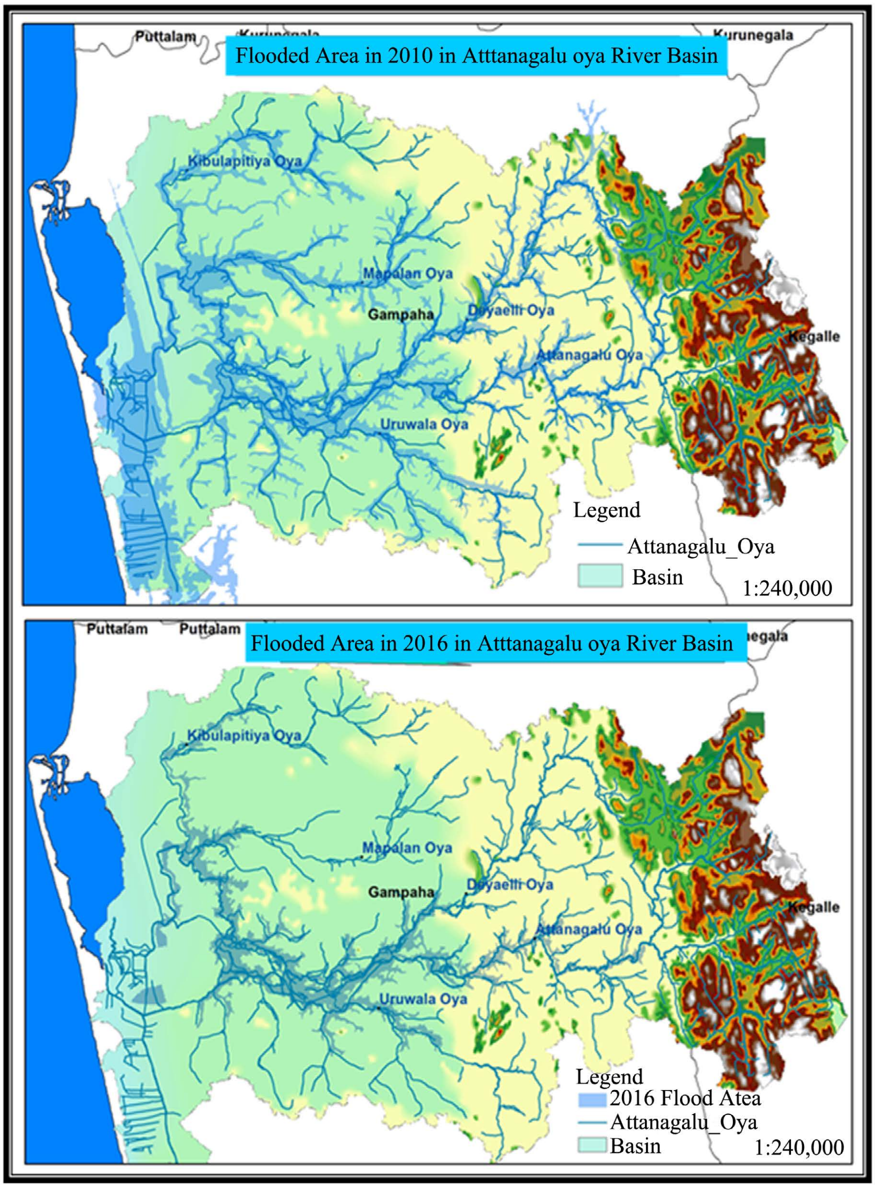

Figure 3. Flooded area in 201 and 2016. Source: Research Data, 2021.

of the face for the flood hazard every year. Gampaha town where it enters a moderately bord inland flood plain. That flood plain area study for the most critical method was used for the analysis. A GIS is a specialized database system for storing and manipulating geographic information. It is particularly well suited for environmental data since almost all environmental data has a spatial component that can be used to locate the dataset in both space and time. Therefore, the 1 m contour data set was used to identify flood risk areas shown in Figure 4. Therefore here, categorize flood areas as five steps.

Here consider flood-affected buildings in the Attanagalu Oya river basin. The here identify separately 2010 and 2016 flood-affected building categories in the Attanagalu Oya river basin. This table illustrates flood-affected human settlement buildings. As well as here can identify high affected settlement is buildings. Here include building category considering the house, flats, and residential buildings. 2010 flood affected that building was 16,490 and 2016 lower flood was effected building was 9477 as shown in Figure 5.

Here recognized 2010 and 2016 flooding of the roads as shown in Figure 6. There mainly risk-averse. Also, the total road is shown separately in the meters, such as Expressway, Main road, Secondary Road, Railway Road, Cart and jeep

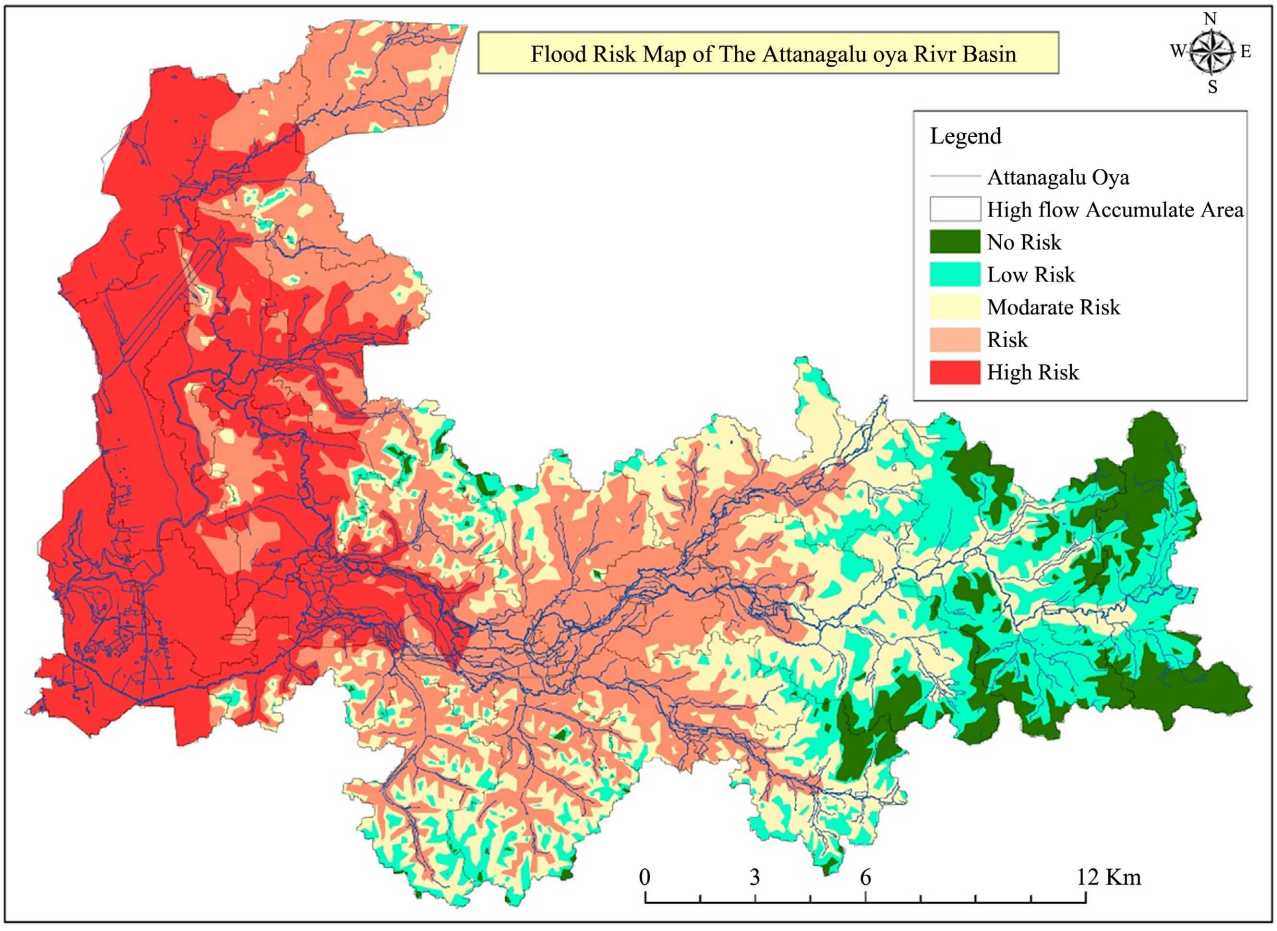

Figure 4. Flood risk map of the Attanagalu Oya river basin. Source: Research Data, 2021.

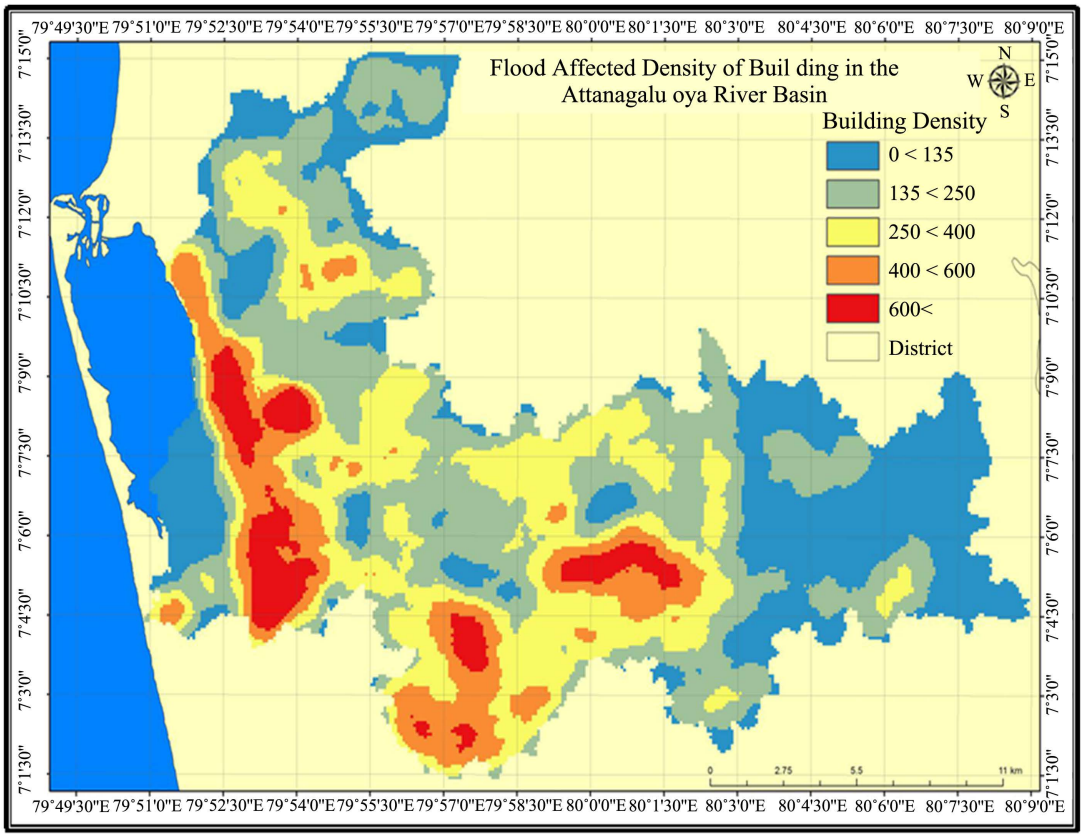

Figure 5. Flood affected building density in the Attanaglau Oya river basin. Source: Research Data, 2021.

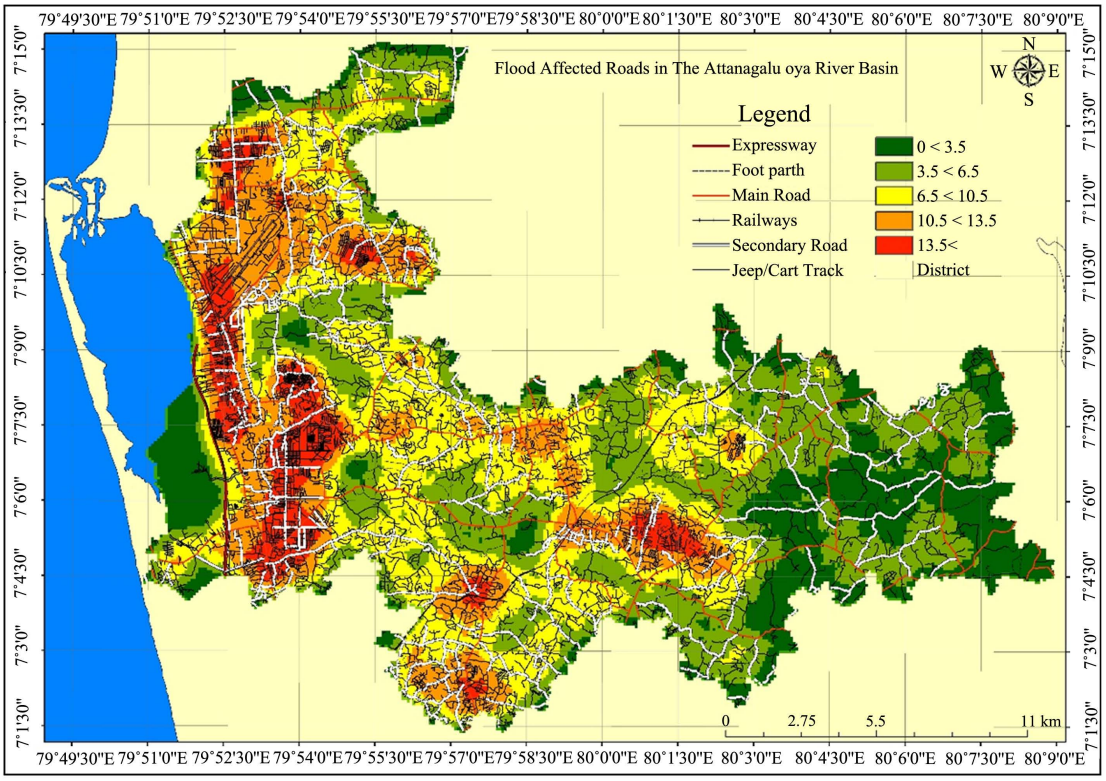

Figure 6. Flood affected rods in the Attanagali Oya river basin. Source: Research Data, 2021.

road. For the study, the risk of roads occurring in the years according to the road users has different risks. Therefore here, mainly flood-affected roads were cart and jeep road and footpath. As shown in Table 1.

Figure 7 and Figure 8 Illustrates the 2010 flood inundated GND Distributions. According to the 2010 flood effected number of the GN Division was 310. According to the 2016 flood effected number of the GN Division was 199 as shown in Table 2 and Table 3. As well as here, therefore, clearly show that detail had to depend on sample area. Summarize the higher flood-affected DS Division This study selected four GN divisions for the validation of the survey. Therefore that data can be shown in the selected GN division.

Table 1. Flood affected roads in the Attanagalu oya river basin.

Road category	2010 (Meters)	2016 (Meters)
Express Way	17951.79	887
Main Road	58743.28	18982.61
Secondary Road	124509.81	28274.05
Railway Road	38832.28	19989.02
Cart and Jeep Road	448948.6	129581.71
Foot path	68812.1	35431.64
Total	**757797.86**	**233146.03**

Source: Research Data, 2021.

Table 2. Flooded land areas in 2010.

GND Name	Flooded Area km²
Ambanvita	1.108
Kirindivita	1.721
Thammita West	0.647
Gonagaha 1	1.629

Source: The researcher calculated based on the flood data in 2016.

Table 3. Flooded land areas in 2016.

GND Name	Flooded Area km²
Ambanvita	1.261
Kirindivita	1.738
Thammita West	0.782
Gonagaha 1	1.262
Total Affected Area in 2016	5.43

Source: The researcher calculated based on the flood data in 2016.

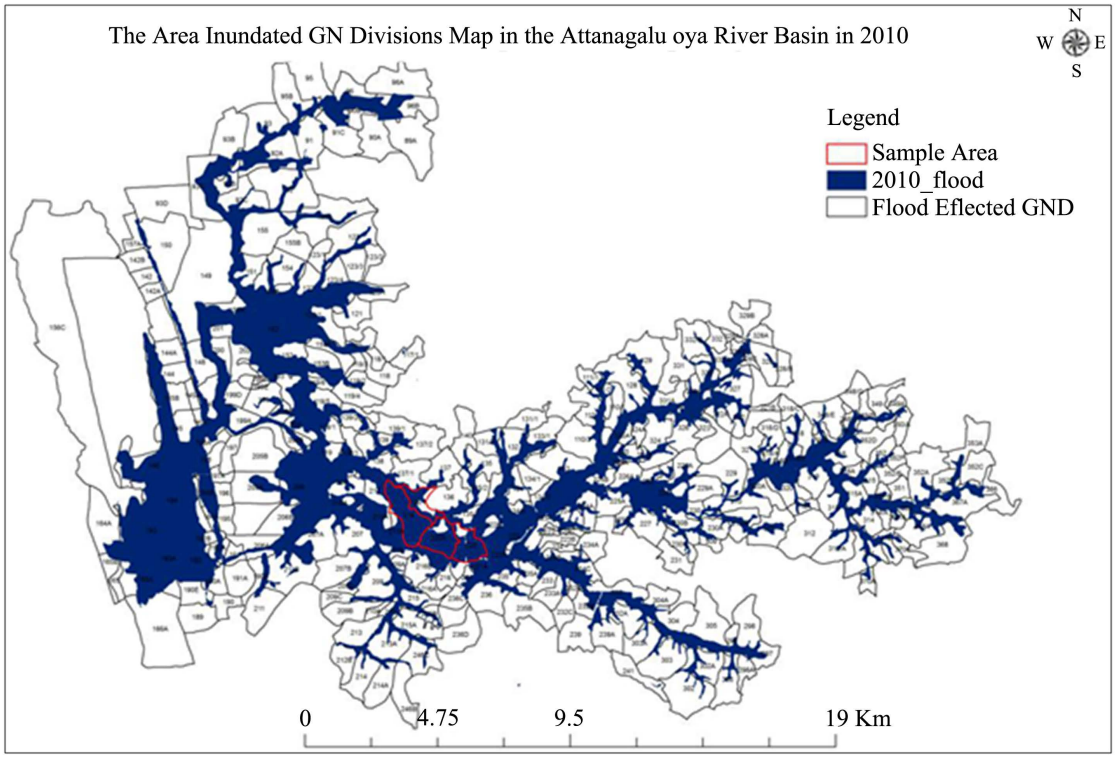

Figure 7. The area inundated GN division map in 2010. Source: The researcher calculated based on the flood data in 2010.

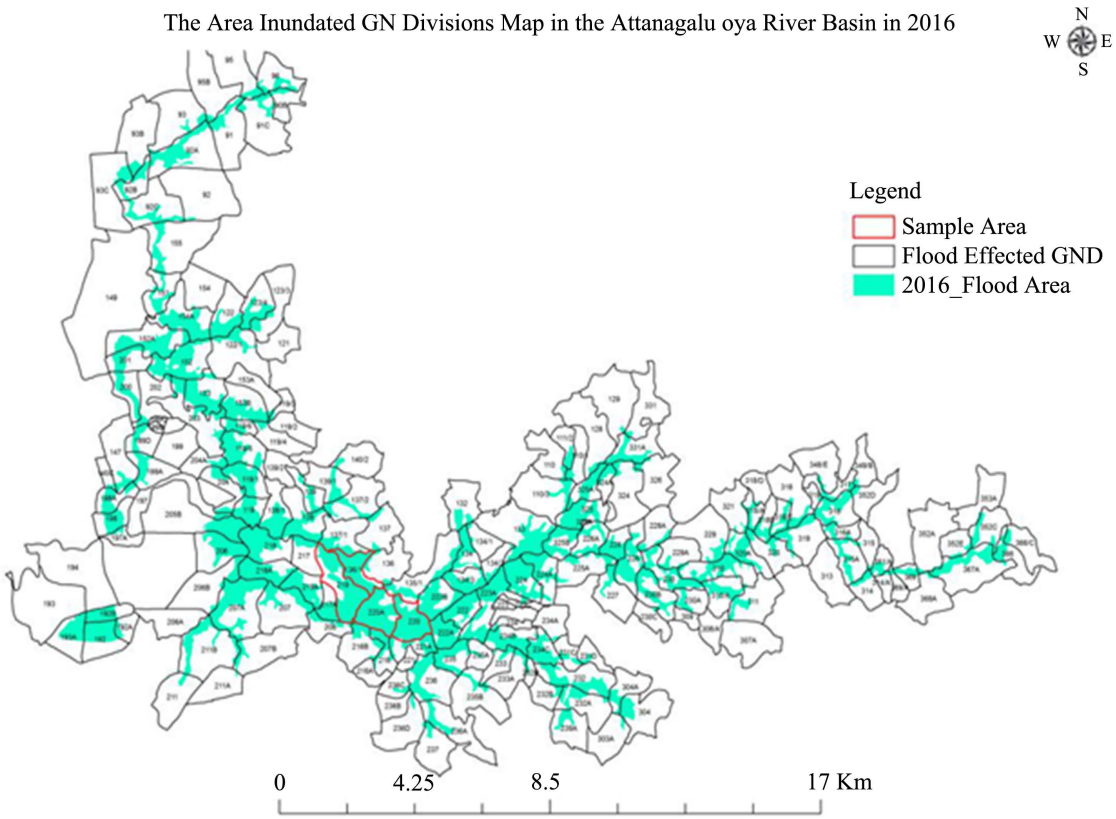

Figure 8. The area inundated GN Division map in 2016. Source: Created by author, 2021.

When considering the regional aspect carrying out a study on flood hazard and risk assessment in Attanagalu Oya lower catchment area. It can be regarded as of high importance and high value-adding initiate. The rapid development of the world and the drastic change that follows post numerous threats on the entire humanity one such major threat is natural hazards. As for as sustainable development is not achieved, society will have to face the consequences in the form of natural disasters. To minimize and prevent such natural disasters that arise through human behaviour, it is essential to identify the most appropriate measures and activities that could be implemented to this issue possible through a proper study carried out on this subject. The area selected for the study, "Attanagalu Oya," constantly faces the threat of flood due to several reasons. Attanagalla is located in a low land with a sea level of 100 - 300 m and near the Nigambo lagoon, surrounded by wetlands. Not only that but also the area is highly subjected to landfilling.

Selected study area very high water accumulated area and high water density area. And have been encroached by housing and other construction activities restricting the water flow. Even though government institutions and many non-government organizations together try to get discussion to control flood hazard. However, there is no proper mechanism for providing constipation for flood hazards. Therefore, it is tough for a recovery program to re-establish livelihood and economic activities.

The government year preparing hazardous public infrastructure, and on the other hand-selected study area has high valley and high watershed and wetland are. Presently that wetland is used for the construction. One of the significant development projects of the Colombo Katunayeka expressway is crossing the Muthurajawela marsh area. Therefore here block water drainage pathway. The most flooded area and its most common hazard in the selected area are identified here. Here identified, The Attanagalu Oya flood-affected area never is controlled with development mechanism. But researcher is going to address this flood problem in the Attanagalu Oya river basin, and there carried out risk area identifies before using GIS technologies.

A flood inundation map was developed accordingly to past flood experiences. Using this map, flood variation was recognized. Therefore here identified and selected four DN divisions. As a sample area for the validation of the study. Those GN Divisions are Abanvita, Kirindivita, Thammita West, and Gonagaha. Which was selected for this study consists of four Grama Niladhari Divisions. This GN Division is selected almost every year in flood situations and it was identified here as a more risky area. Accordingly, the following **Figure 9** and **Figure 10** shows floods inundated areas in the years 2010 and 2016.

3.2. Identify Flood Inundation Area and Risk Area in Sample GND

Here selected Attanagalu Oya river basin faces flood hazards most of the years. Attanagalu Oya river basin is most of the watershed area. Therefore, determine what a function of flood hazard is particularly in the Attanagalu Oya river basin

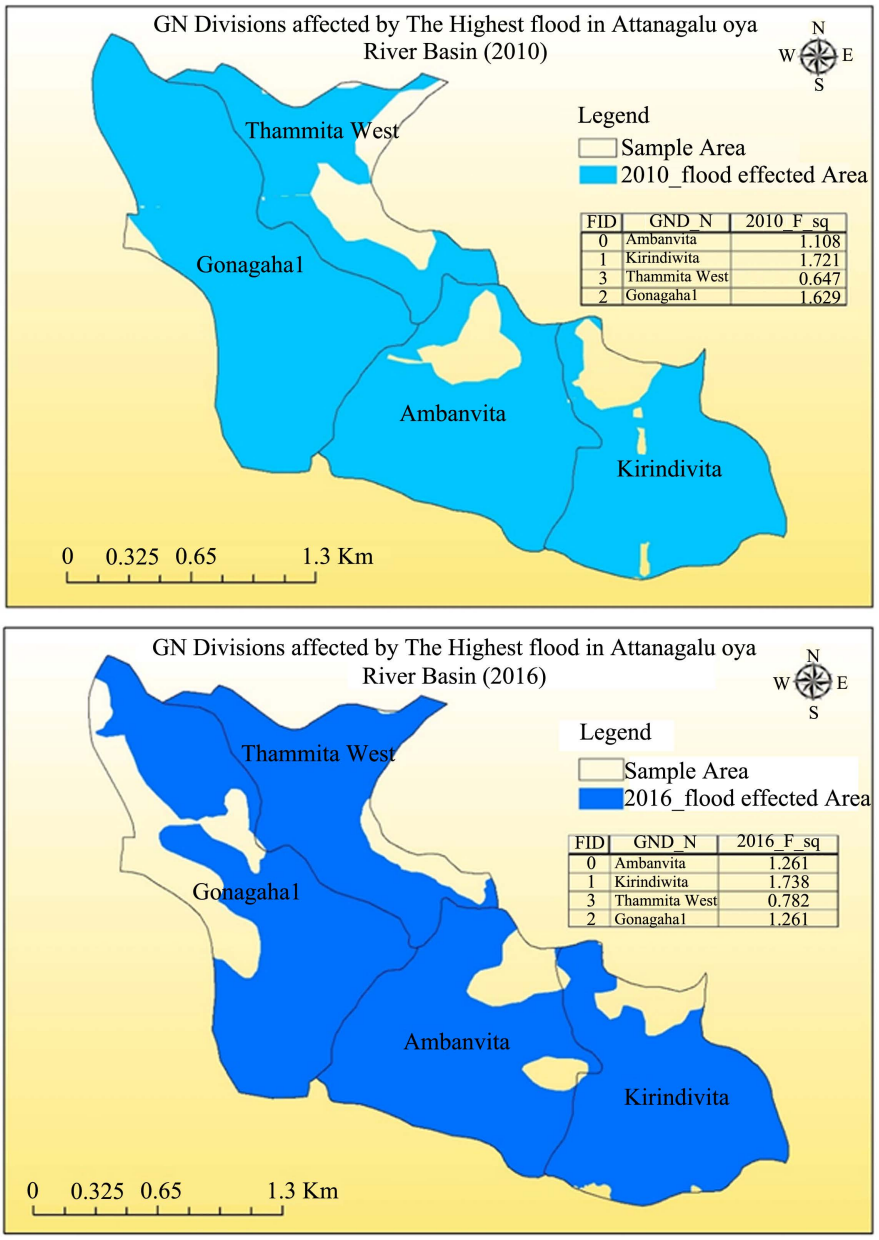

Figure 9. Comparison of the flooded area in 2010 and 2016 in the sample area. Source: Created by author, 2021.

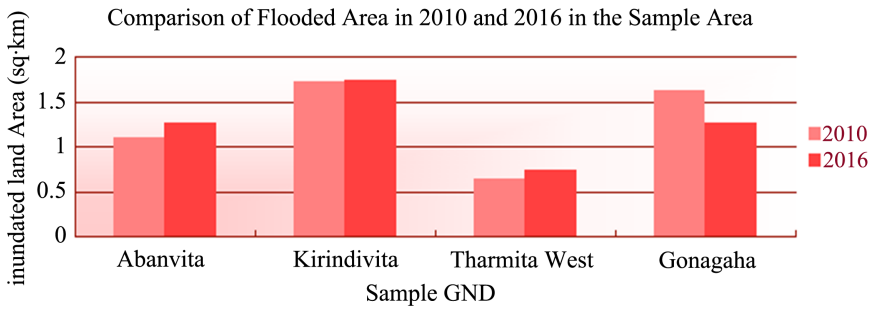

Figure 10. Comparison of the flooded area in 2010 and 2016 in the sample area. Source: Created by author, 2021.

with heavy rains in the upper catchments areas. Of the site; damaging houses, urban centers, schools, the roads network, home gardens, crops, industries. As such, inhabitants of this area have been badly affected by frequent floods. Their livelihood and social life have been severely affected and disturbed as shown in Figure 11 and Figure 12. The methodology was developed to identify the above

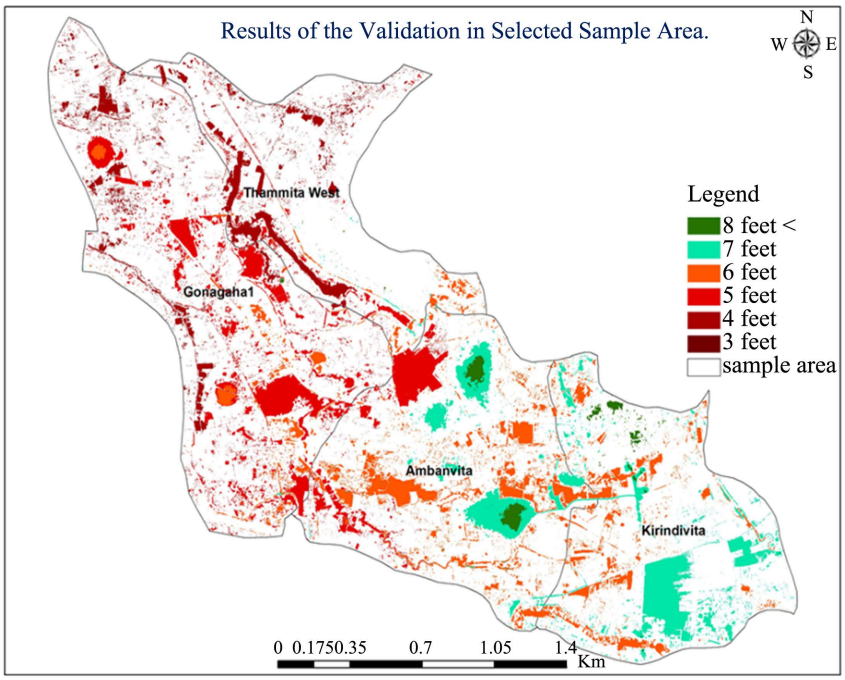

Figure 11. Results of the validation in the selected sample area. Source: LiDAR Data, 2016.

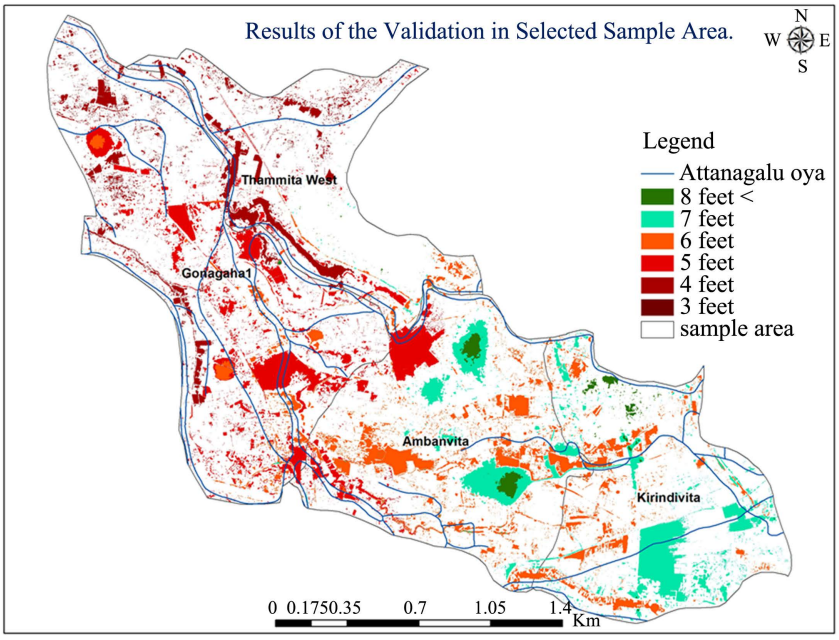

Figure 12. Results of the validation in the selected sample area. Source: LiDAR Data, 2016.

objectives based on secondary data: LiDAR images, topographic maps, meteorological data, and institutional data. In addition, as a study area Attanagalu Oya river basin has been selected, and to analyze the micro-level scale, the researcher decided on four GNDs.

4. Conclusion

Analysis has conduced with spatial and temporal technical as geospatial methods used to achieve primary objectives. To identify the relationship between flood hazard and natural environment, elevation, land use, rainfall, flood events have been used to create a significant relationship between these all. To identify temporal patterns of the flood, initially, based years are 2010 and 2016. Depending on numerous flood events, these two years were selected. Compared to these two events, the 2010 flood events were more significant than in 2016. However, it is affected things are shallow. This situation was primarily land-use changes that decreased wetlands, constructed industries, landfilling, and residents were directly affected. Thirdly, flood inundation and risk areas identify using LiDAR images, especially in the sample area. Finally, identify flood risk for buildings, roads, and land use in the study area. Here could identify most risk to the building, because most of buildings constructed are near the river basin with landfilling. When compared with land use, we can see these changes very carefully.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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