ANALYSING THE IMPACT OF FLOOD CAUSED BY IMPROPER LAND USE ACTIVITIES IN MUTTUR DS DIVISION

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Abstract

Flood occurs due to both natural and man-made causes. Among these two most highlighted causes are conversions of natural landscapes for human usage. Muttur experiences severe flood hazards due to the North East Monson and exhaust of doubles with the Mahaweli River in rainy seasons. Flood damage increases as a result of inappropriate land use practices. The primary objective of the study is to analyze the relationship between the impact of the flood and improper land use activities. To achieve the objective the data is collected based on a questionnaire survey, furthermore, the land sat images are used to identify, how the land cover changes occurred in Muttur, with the help of the matrix method using ARC GIS 10.1 software. The study found that the Built-up land in Muttur is rapidly increasing annually is about 141, 50. The land area of water bodies is (-91, 82) and the non-built lands (-49, 68) continuously decreased. It is because water bodies and non-built-up lands are converted into urbanization and tourism development activities, therefore, rainy season water flowing directions are blocked, and it is caused a high impact of the flood. Furthermore, Chi-square analysis strongly proves improper land use activity is the reason for the high impact of the flood in Muttur. The total sample population is a hundred with a df value is 3 and a p-value is about 0.001. The chi of the impact of the flood and the improper drainage system is 37.079, flood impact and urbanization chi respectively 23.775, Chi of the flood impacts and the deforestation/overgrazing of natural vegetation is 17.045, Flood impacts and the wetland converted into buildup/ development chi is 33.333, Flood and the Mining of sand and other resources chi is 12.676, and flood impacts and over-pumping of groundwater chi is 28.671. To overcome this situation, the study recommends reducing the building construction in wetland areas, providing pipeline drinking water facilities to reduce the over-pumping of groundwater, banning sand mining activity in hazardous areas, and implementing visible land-use management strategies in the research area.

Keywords: *Chi-Square, Flood, Improper Land-use, Land Sat Images, Matrix Analysis*

1. Introduction

In Sri Lanka, floods are a more common occurrence than other natural disasters. The increase in population and subsequent need for land have forced more and more people to live and work in these vulnerable areas, thereby intensifying the risk to life and property in the event of major floods. Urban areas are highly affected by flood hazards during the monsoon period in Sri Lanka. Major floods are associated with the two monsoon seasons. During SWM (May-Sep) the Western, Southern, and Sabaragamuwa provinces are vulnerable to floods. During NEM (Dec-Feb) the Eastern, Northern, and North-Central provinces are at risk of flooding (DMC, 2005). Muttur region is one of the coastal areas inhabited in the Trincomalee District, and it is a notable flood-prone area on the island of Sri Lanka. The reason for this is that humans have been misusing the land. People who are living in flood-prone areas face damages and losses during the flood period. Analysis of the impact of the flood in Muttur is the time needed to consider the well-being of the residents who live under flood-prone zones within the Division, Because of its location, the effects of periodic flood vulnerabilities and risks are high. Therefore, identifying how improper utilization of land does become a factor in the constant impacts of flooding on the Muttur division was the major objective of this study. This study is expected to make awareness among the dwellers here and to change the humans' eco-friendly and much closer to their ecosystem.

2. Literature Review

Land use and other human activities also influence the peak discharge of floods by modifying how rainfall and snowmelt are stored on and run off the land surface into streams. In undeveloped areas such as forests and grasslands, rainfall and snowmelt collect and are stored on vegetation, in the soil column, or in surface depressions. When this storage capacity is filled, runoff flows slowly through the soil as subsurface flow. In contrast, urban areas, where much of the land surface is covered by roads and buildings, have less capacity to store rainfall and snowmelt. Construction of roads and buildings often involves removing vegetation, soil, and depressions from the land surface (Konrad, 2011). According to Bart Schultz (2012), a growing portion of the world's population now resides and works in flood-prone regions. The value of land, structures, and infrastructure has increased dramatically and will continue to expand as a result of urbanization, industrialization, and rising standards of living, particularly in emerging nations.

The natural disaster flood is a notable disaster worldwide, there is many cities year by year facing flood hazard risk. The poor are particularly vulnerable in most of these regions because rapid urbanization has pushed them into the most unsafe neighborhoods, frequently in low-lying areas and along streams prone to flooding (Ghose, 2013). Floods have been on the increase in recent years and humans have been blamed for it. Although floods do occur naturally, however, some that have taken a heavy toll on lives and property are man-made failures such as the bursting of dams, urban flooding, and debris flow in densely populated areas (Gziddens, 1990). More people are being pushed to live and work in risky locations due to the growing population and the ensuing need for land, which increases the risk to people's lives and property in the case of a major flood. The major causes of floods in Sri Lanka can be related to heavy rainfall, a huge amount of water from river catchment areas, deforestation, improper land use, and a lack of scientific soil conservation practices (Mark, 2015). In Sri Lanka, unplanned urban development, the destruction of ecosystems (stormwater retention areas), lax enforcement of regulations, improper construction, and neglectful maintenance of stormwater drainage systems are all factors that contribute to the severity of the effects of natural disasters. While this urban poor is crucial to the operation of cities and is often the first and hardest affected by catastrophes, they also increase the likelihood of disasters occurring in cities (Hemanthi Ranasinghe, 2007).

3. Materials and Methods

3.1 Study Area

Muttur is a town in the Trincomalee District of Sri Lanka and it is located about 25km south of Trincomalee, on the southern side of the Trincomalee harbor. The Muttur area is surrounded by the Bay of Bengal from the north, the Bengal Sea from the east, Kinniya from the west, and Seruwila from the south. This area falls within the dry zone segment of Sri Lanka. This study area (Figure 1) is also seen with 8°27’14” N and 81°15’56” E coordinates. Height above mean sea level 9m (29ft), Muttur DS Division included 42 GN Division, 76 villages, and 17219 Families with 63368 total populations (City Profile, 2011).

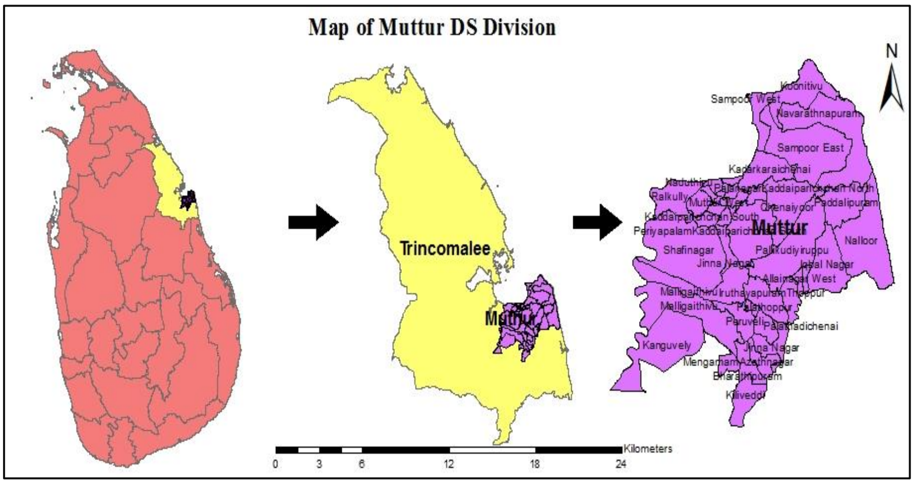


Figure 1: Study area
Source: Survey Department of Sri Lanka, 2018

3.1.1 Water Resources

Census and Statistics in 2017, 1127.6 Sq.km of the water bodies of the Muttur are covered by large inland water areas, and covered by the wetland is about 551.8 Sq.km. While observing the water bodies, one of the physical features is seen here (Figure 2). The NEM brings a major part of the rainfall for the water body. Mahaweli River is flowing across the region. Therefore several streams and tanks have connected this area.

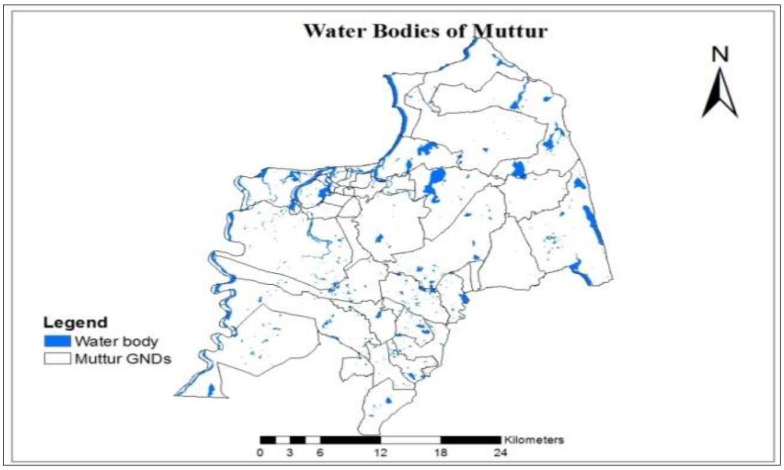


Figure 2: Water Bodies of Muttur DS
Source: Survey Department of Sri Lanka, 2018

3.1.2 Land Use Pattern

The land area of the Muttur is about 195km^2. Agriculture and sand mining is the most common land usage practice in the Muttur Division because the Mahaweli River is flowing across this region (Figure 3). The land which is bordering the lagoon is alluvial soil (Batticaloa Development plan 2030). This is a reason why agriculture is the main livelihood of these people living area. The settlement of this region of people is also seen to the same extent as paddy cultivated lands. Forest density is very high and home gardens also play people's livelihood activity.

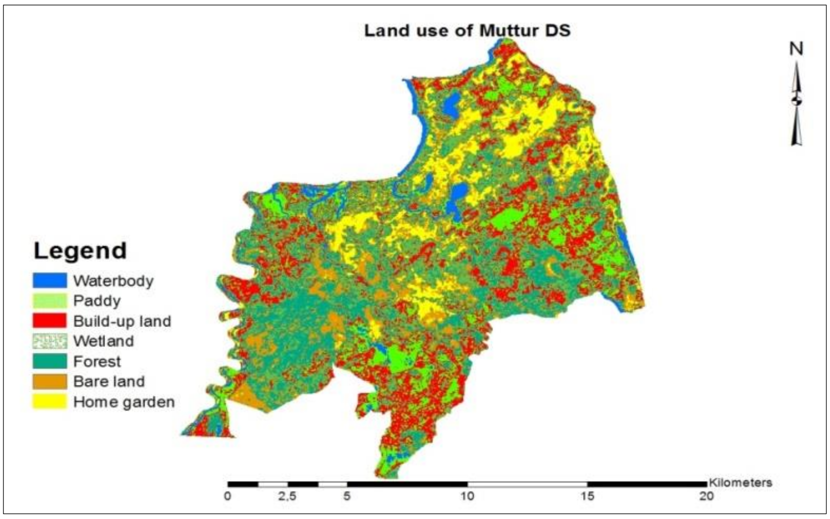


Figure 3: Land use map of Muttur DS
Source: Survey Department of Sri Lanka, 2018

3.2 Data Collection

The primary data was collected from the questionnaire, observation, discussion so on. Secondary data was collected from satellite images (USGS Earth Explorer), Annual reports from the Department of census and statistics, and preview articles. The sample size for the questionnaire survey was selected, from the population of five GN divisions out of 42 GN divisions in Muttur. Hundreds of local people are used as a sample of the survey. Direct Observation is simply conducted to observe and collect more information about improper land use and flood. Photographs of these activities taken by the researcher while doing the observation prove how people misuse the land near river banks. The land use/cover changes that improperly occurred in Muttur over the past thirty years are being analyzed using satellite images. Table1 gives information about the satellite images.

Table 1: Information on the data used for LULC change in Muttur DS

Data	Acquisition	Sensor Name	Spatial Resolution	Source
Satellite Data	1991	LT05_L2SP_141054_19910903_20200915_02_T1	30meters	
	2000	LT05_L2SP_141054_20000420_20200907_02_T1	30meters	USGS
	2021	LC08_L2SP_141054_20210921_20210925_02_T1	30meters	

3.3 Classification of Images

To identify the individual geo-referenced land sat images, this study mainly used supervised classification, a statistical technique for categorizing photographs based on the covariance and variance of the spectral response patterns of a pixel. The research area was divided into three LULC groups (Table 2). By performing field checks and comparing them to already-existing, field-checked land use and cover maps, the classification's accuracy was confirmed.

Table 2: LULC classification system

Land-use classes	Description
Water bodies	• Water locations, both natural and man-made (lakes, rivers, ponds)
Non-built-up	• Agriculture Home Gardens(all croplands and home gardens) • Open, Vacant Lands (Barren lands, playgrounds, open spaces uncultivated agricultural land) • Forested Areas(Dense forest, light forest, scrub lands)
Built-up	• Every human-made structure, including homes, businesses, industrial zones, areas for transit and communication, public and semi-public spaces, public utilities, and plotted lands.

3.4 Matrix Analysis

This study makes strong use of the matrix approach to demonstrate how land usage has changed in the Muttur DSD. According to that, satellite images were downloaded from the USGS Earth Explorer with the help of the Arc GIS software, they would be classified into supervised classification under the 3 categories: (1- Water, 2- Non-Built, 3-Built-up).

3.5 Chi-square Analysis

The Chi-square (Equation 1) was used to show the relationship between the Levels of flood impacts and improper land use activity. The independent variable is improper land use activities (improper drainage system, urbanization, buildup settlement in wetlands, deforestation, sand, and other natural resources mining) and the dependent variable is the impact of the flood.

$$x^2 = \Sigma \frac{(0-E)^2}{E} \tag{1}$$

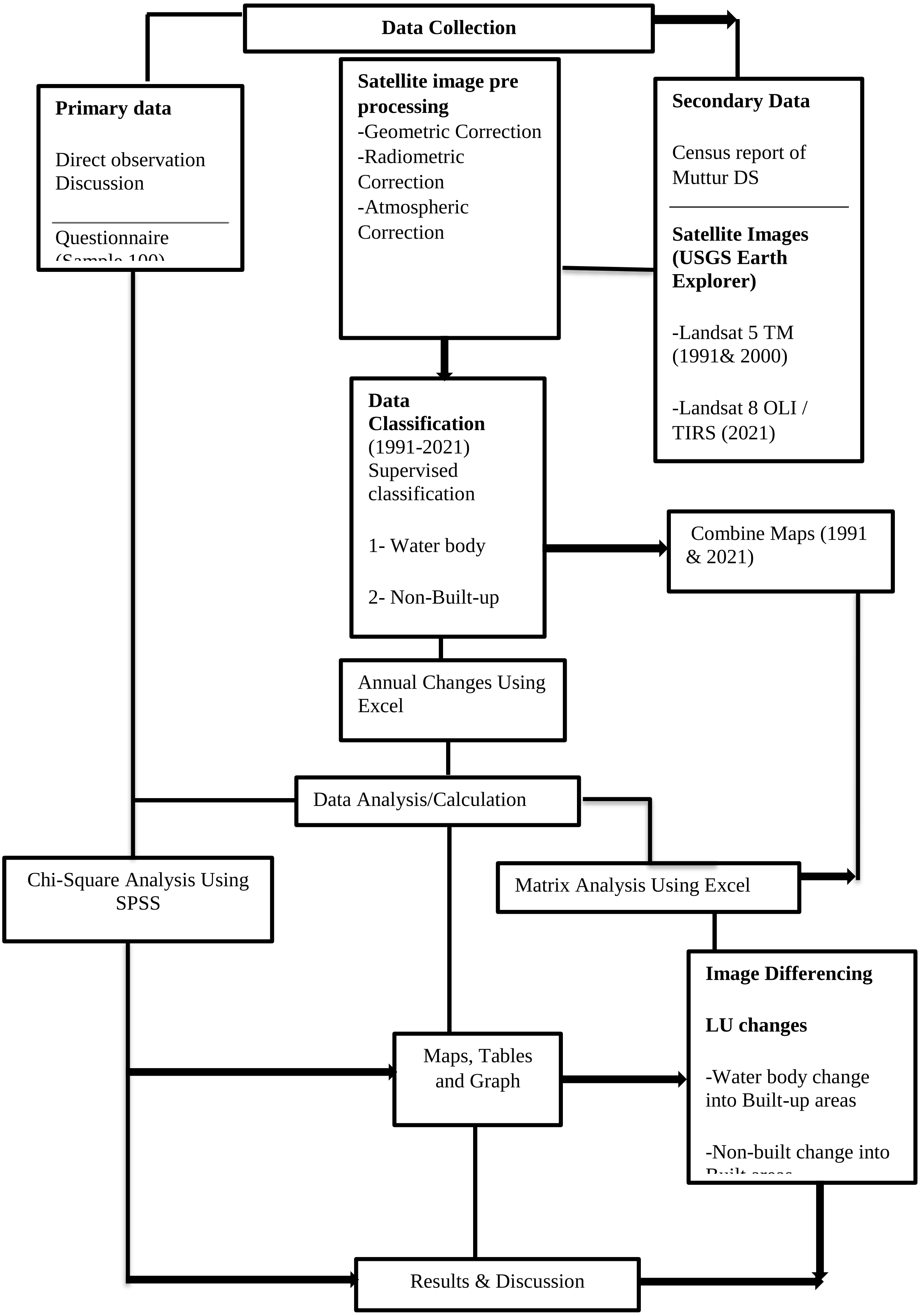


Figure 4: Methodology

4. Results and Discussion

Considering improper land use in this division from past to present, it has increased very fast. Awareness of people about land management techniques is very low (Figure 5). It is because the majority of the sample population is living on government lands Therefore, they did not take any effort to protect and manage those lands. Only 15 respondents agreed that they have knowledge about these management technics but they were not encouraged to apply those technics.

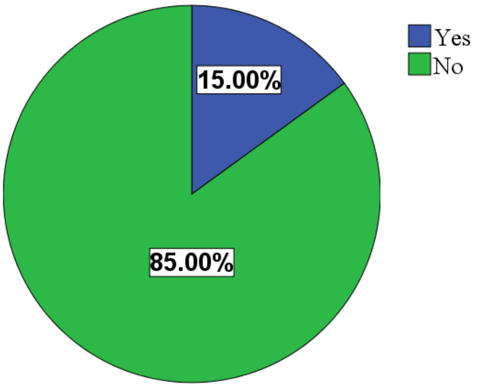


Figure 5: Number of people aware of land management technics
Source: Sample Survey, 2020

Rapid urbanization plays a key role in this area and also wetlands are converted for urban, tourism, and development purpose about 24. Urban growth can alter stream courses, reducing their ability to carry floodwaters. Road and buildings Construction in low-lying areas exposes it caused to higher flood risks in this area. Another thing is when the flood occurred in Muttur, negative drainage can cause water to pool in areas around the home. Flash floods during periods of heavy rain are caused by the lack of ground green cover caused by deforestation, which is about 19 (Figure 6).

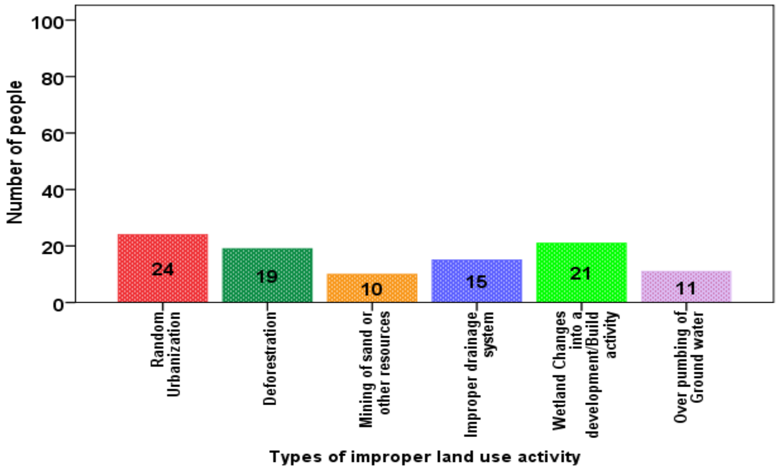


Figure 6: Types of improper land use activities in Muttur
Source: Sample Survey, 2020

Children are highly vulnerable when a flood occurs in Muttur and pose a major threat to personal health and safety due to flood waters surrounding areas or at home, according to respondent number 39. The elderly population needed some extra assistance during the flood hazard. In rural communities, pregnant women and disabled people have more experience with floods. Pregnant women were affected during the flood as respondents 16. During the flood period, disabled people have more difficulty standing than non-disabled populations (Figure 7).

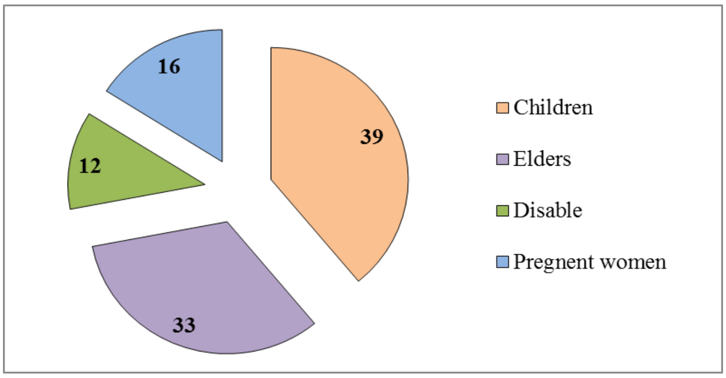


Figure 7: Types of groups affected during the flood hazard
Source: Sample Survey, 2020

Dengue disease is a high occurrence in Muttur after the flood, of which respondents are about 36. Dengue is spread from the standing water during the monsoon season. Fever is another disease spread after the flood it includes; malaria, and yellow fever as respondents of 25. The elderly and children are more vulnerable to fever and dengue than other age groups in flood events (Figure 8).

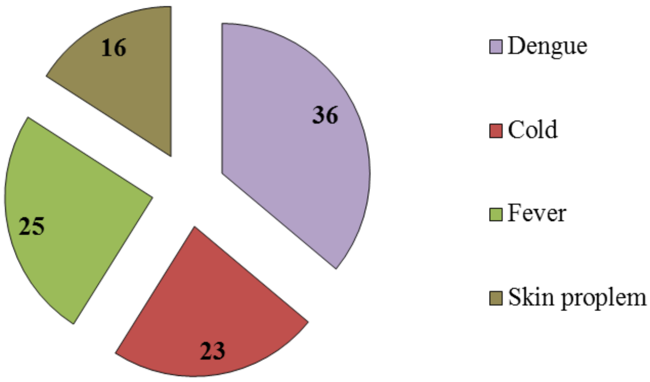


Figure 8: Types of the diseases after the flood
Source: Sample Survey, 2020

4.1 LULC Changes

The supervised classification mainly focuses on two years (1991 and 2021) (Table 3& 4), to identify the changes in land uses. It clearly shows (Figure 9) that, the water bodies of Muttur in 1991 is about 4916, 79 hectares, but they decreased in 2021 which is about 2162, 07hec. Non-built-up lands continuously decreased from 1991 to 2021, which is about 8959, 05hec in 1991, but in 2021 it is respectively 7468, 74hec. When considering the built-up land of Muttur, it increased double from the year 1991, which is about 5522, 31hec in 1991 and 9767, and 34hec in 2021.

Table 3: The land extent of Muttur in 1991

LU_Types	Value	Count	Pixel Area	Area (Sq_Km)	Sq.Km-Hec	Area (Hec)
Water	1	54631	900	49167900	0,0001	4916,79
Non-Built-up	2	99545	900	89590500	0,0001	8959,05
Built-up	3	61359	900	55223100	0,0001	5522,31

Table 4: The land extent of Muttur in 2021

LU_Types	Value	Count	Pixel Area	Area (sq. Km)	Sq.Km-Hec	Area (Hec)
Waterbody	1	24023	900	21620700	0,0001	2162,07
Non-Built-up	2	82986	900	74687400	0,0001	7468,74
Built-up	3	108526	900	97673400	0,0001	9767,34

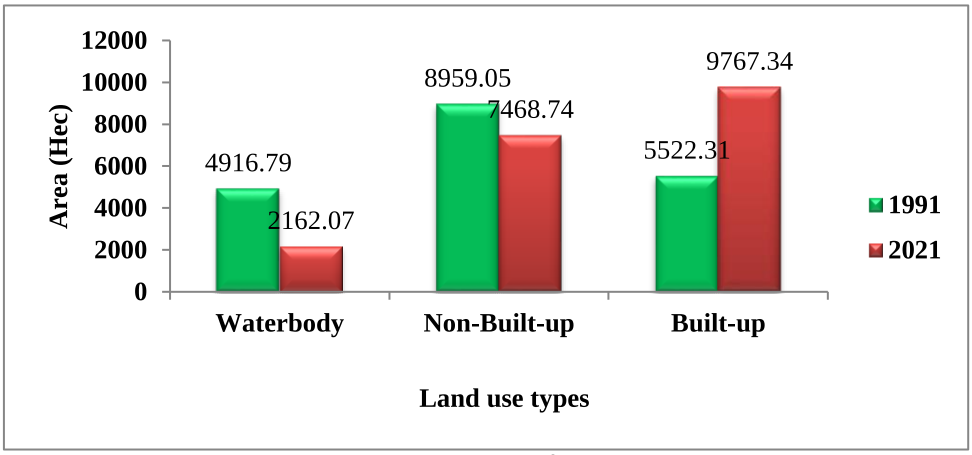


Figure 9: LULC area of Muttur DS

Built-up lands are rapidly increasing annually it is about 141, 50. The water bodies' land (-91, 82) and the non-built lands (-49, 68) are continuously reduced than the built-up lands. It is because water bodies and non-built-up lands are converted into urbanization activities in this area, the rainy season happens, then the impacts of a flood are very high in this area (Table 5).

Table 5: Land use annual changes of Muttur from 1991-2021

LU_Types	1991	2021	Changes %	Annual Changes
Waterbody	4916,79	2162,07	-56,027	-91,82
Non-Builtup	8959,05	7468,74	-16,635	-49,68
Built-up	5522,31	9767,34	76,871	141,50

4.2 Land use Matrix

Using ARC GIS, combining of two years data of Muttur for the matrix analysis purpose (Table 6). Based on the categories, this analysis highly focuses on two things. One is how non-built-up areas are converted into built-up areas which are about 55780. Secondly consider how water bodies in 1991 converted into built-up land in 2021 it is respectively 24145 (Table 7).

Table 6: Combine set of Raster Data in 1991 & 2021

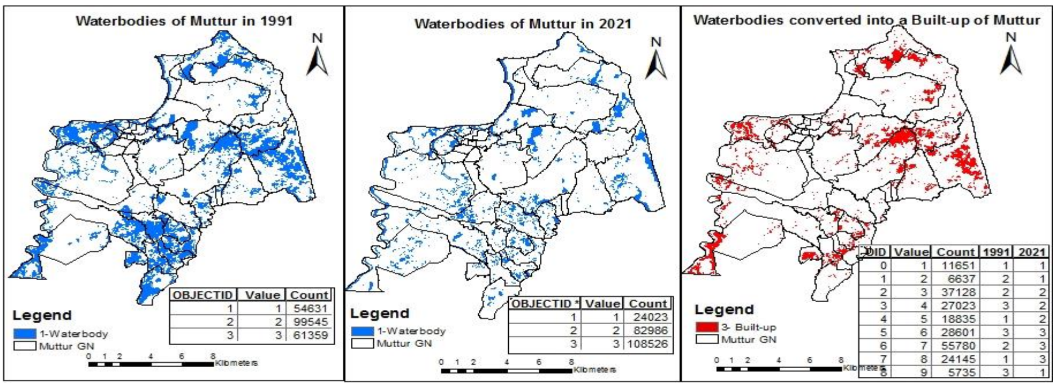
Value	Count	Muttur 1991	Muttur 2021
1	11651,00	1	1
2	6637,00	2	1
3	37128,00	2	2
4	27023,00	3	2
5	18835,00	1	2
6	28601,00	3	3
7	55780,00	2(Non-Built)	3(Built-up)
8	24145,00	1(Waterbody)	3(Built-up)
9	5735,00	3	1

Table 7: Land Matrix Analysis of Muttur DS

		2021		
	LU_Types	**Water (1)**	**Non-Builtup (2)**	**Built-up (3)**
	Waterbody (1)	11651	18835	24145
1991	Non-Built-up (2)	6637	37128	55780
	Built-up (3)	5735	27023	28601

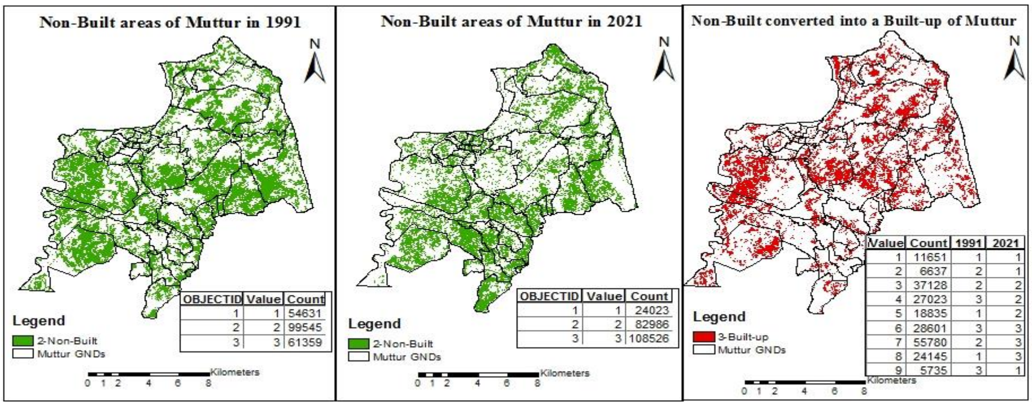
In 1991 water bodies are high density in the Muttur which is about 4916.79hec. A lot of people are engaged with agriculture and home garden activities, but within the 30 years, it continuously decreased from the year 2021 (Figure 10) which is respectively 2162.07hec. Changes in these water bodies are about (-56.027%) (Table 3&4). This is because several water bodies' areas are converted into tourism, development, and urbanization process, therefore impacts of floods are very high in the Muttur DS division.

Figure 10: Water bodies converted into built up land



The current situation Buildings are rapidly increasing due to population growth near the coastal and riverine areas. Therefore, in this area, people faced coastal and riverine floods during the monsoon period. In 1991 the vegetation cover and other non-built lands are very high which is about 8959.05hec and in 2021, which is respectively 7468.74hec. It continuously decreased for urbanization purposes which a change is about (-16,635%) (Table 3&4). Built-up lands rapidly increased over the 30 years period which is about 76.871% (Figure 11).

Figure 11: Non built land converted into built up land



4.3 Chi-square analysis

Chi-Square analysis has been used to determine the relationship between the dependent variable and the independent variable.

Hypothesis: Independent variables (Improper land uses: Improper drainage system, Random urbanization, Deforestation, Mining activities, Wetlands changes into development activities, over-pumping of groundwater) and Dependent variables (Levels of flood impacts).

H0: There is no connection between independent and dependent variables.

H1: Independent and dependent variables are related.

Significant level: $\alpha = 0.05$

Decision rule: There is sufficient evidence to disprove the null hypothesis if P-value is less than the significant level (0.05).

4.3.1 Statement A- The impact of flood caused by improper drainage system in Muttur

$H_{0:}$ The impact of the flood and an inadequate drainage system are unrelated.

H_1: The effects of the flood and an inadequate drainage system are related.

Table 8: Drainage facility of Muttur * Level of flood impacts

		Very high	High	Medium	Low	Total
Drainage facility of Muttur	Yes	11	0	0	0	11
	No	14	34	22	19	89
Total		25	34	22	19	100

Table 9: Chi-Square Tests

				Monte Carlo Sig. (2-sided)		
					95% Confidence Interval	
	Value	df	Asymp. Sig. (2-sided)	Sig.	Lower Bound	Upper Bound
Pearson Chi-Square	37.079[a]	3	.000	.000[b]	.000	.030
Likelihood Ratio	35.007	3	.000	.000[b]	.000	.030
Fisher's Exact Test	27.831			.000[b]	.000	.030
N of Valid Cases	100					

4.3.2 Statement B- The impact of flood caused by Urbanization in Muttur

H_0: The effects of flooding and urbanization have no causal connection.

H_1: There is a connection between urbanization and the effects of flooding.

Table 10: Random Urbanization Caused by the impact of flood * Level of flood impacts

		Level of flood impacts				
		Very high	High	Medium	Low	Total
Random Urbanization Caused by the impact of flood	Yes	8	28	20	13	69
	No	17	6	2	6	31
Total		25	34	22	19	100

Table 11: Chi-Square Tests

				Monte Carlo Sig. (2-sided)		
					95% Confidence Interval	
	Value	df	Asymp. Sig. (2-sided)	Sig.	Lower Bound	Upper Bound
Pearson Chi-Square	23.775[a]	3	.000	.000[b]	.000	.030
Likelihood Ratio	23.686	3	.000	.000[b]	.000	.030

Table 10: Random Urbanization Caused by the impact of flood * Level of flood impacts

		Level of flood impacts				
		Very high	High	Medium	Low	Total
Random Urbanization Caused by the impact of flood	Yes	8	28	20	13	69
	No	17	6	2	6	31
Fisher's Exact Test	22.537			.000[b]	.000	.030
N of Valid Cases	100					

4.3.3 Statement C- The impact of flood caused by Deforestation/overgrazing of natural vegetation in Muttur

H_0: There is no connection between the effects of flooding and deforestation or overgrazing of vegetation.

H_1: There is a link between deforestation and overgrazing of vegetation and the effects of floods.

Table 12: Deforestation/overgrazing of natural vegetation * Level of flood impacts

		Level of flood impacts				
		Very high	High	Medium	Low	Total
Deforestation/overgrazing of natural vegetation	Yes	16	19	20	19	74
	No	9	15	2	0	26
Total		25	34	22	19	100

Table 13: Chi-Square Tests

				Monte Carlo Sig. (2-sided)		
					95% Confidence Interval	
	Value	df	Asymp. Sig. (2-sided)	Sig.	Lower Bound	Upper Bound
Pearson Chi-Square	17.045[a]	3	.001	.000[b]	.000	.030
Likelihood Ratio	21.874	3	.000	.000[b]	.000	.030
Fisher's Exact Test	18.437			.000[b]	.000	.030
N of Valid Cases	100					

4.3.4 Statement D- The impact of flood caused by wetland converted into a buildup/ development activities in Muttur

H_0: There is no relationship between the impact of flood and wetland converted into built-up land

H_1: There is a relationship between the impact of flood and Wetland converted into built-up land

Table 14: Wetland converted into a Builtup/ Development activities * Level of flood impacts

		Level of flood impacts				
		Very high	High	Medium	Low	Total
Wetland converted into a Builtup/ Development activities	Yes	15	34	22	19	90
	No	10	0	0	0	10
Total		25	34	22	19	100

Table 15: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided) Sig.	95% Confidence Interval Lower Bound	Upper Bound
Pearson Chi-Square	33.333[a]	3	.000	.000[b]	.000	.030
Likelihood Ratio	31.366	3	.000	.000[b]	.000	.030
Fisher's Exact Test	24.499			.000[b]	.000	.030
N of Valid Cases	100					

4.3.5 Statement E- The impact of flood caused by Mining of sand and other resources in Muttur

H_0: There is no relationship between the impact of the flood and the Mining of sand or other resources.

H_1: There is a relationship between the impact of floods and the Mining of sand or other resources.

Table 16: Mining of sand and other resources * Level of flood impacts

		Level of flood impacts				
		Very high	High	Medium	Low	Total
Mining of sand and other resources	Yes	20	31	21	11	83
	No	5	3	1	8	17
Total		25	34	22	19	100

Table 17: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Monte Carlo Sig. (2-sided) Sig.	95% Confidence Interval Lower Bound	Upper Bound
Pearson Chi-Square	12.676[a]	3	.001	.000[b]	.000	.030
Likelihood Ratio	11.864	3	.008	.010[b]	.000	.030
Fisher's Exact Test	11.065			.000[b]	.000	.030
N of Valid Cases	100					

4.3.6 Statement F- The impact of flood caused by over-pumping of groundwater in Muttur

H_0: There is no connection between the effects of the flood and excessive groundwater extraction.

H1: There is a connection between the effects of the flood and excessive groundwater pumping.

Table 18: Overpumping of groundwater * Level of flood impacts

		Level of flood impacts				
		Very high	**High**	**Medium**	**Low**	**Total**
Over pumping of groundwater	Yes	7	26	16	19	68
	No	18	8	6	0	32
Total		25	34	22	19	100

Table 19: Chi-Square Tests

				Monte Carlo Sig. (2-sided)		
					95% Confidence Interval	
	Value	**df**	**Asymp. Sig. (2-sided)**	**Sig.**	**Lower Bound**	**Upper Bound**
Pearson Chi-Square	28.671[a]	3	.000	.000[b]	.000	.030
Likelihood Ratio	32.844	3	.000	.000[b]	.000	.030
Fisher's Exact Test	29.301			.000[b]	.000	.030
N of Valid Cases	100					

The Chi-Square analysis strongly proved improper land use activity is the reason for the high impact of the flood in Muttur. The total sample population (n) is 100 with a df value is 3 and a p-value is about 0.001. The chi of the impact of the flood and the improper drainage system is 37.079, flood impact and urbanization chi are 23.775, Chi of the flood impacts and the Deforestation/overgrazing of natural vegetation is 17.045, Flood impacts and the Wetland converted into buildup/ development chi is 33.333, Flood and the Mining of sand and other resources chi is 12.676, and flood impacts and over-pumping of groundwater chi is 28.671(Table 20).

Table 20: Summary of Chi-square analysis

Pearson	Chi-Square	df	P-Value	Decision
Statement A	37.079	3	0.000	H_0 Rejected
Statement B	23.775	3	0.001	H_0 Rejected
Statement C	17.045	3	0.001	H_0 Rejected
Statement D	33.333	3	0.000	H_0 Rejected
Statement E	12.676	3	0.001	H_0 Rejected
Statement F	28.671	3	0.001	H_0 Rejected

Source: Sample Survey, 2020

5. Conclusion

Due to human activity and population growth, land use changes happen. Various countries and locations exhibit diverse manifestations of land use change. Increased urbanization altered the environment's natural characteristics, such as land use changes (deforestation, wetlands loss), which may be to blame for altered rainfall-runoff patterns and rising peak flows. Additionally, this leads to more extreme and frequent flood disasters. This study successfully attempted to analyze the impacts of floods caused by improper land use activity in Muttur DS. The analysis's results have highlighted Between 1991 and 2021, the Muttur had a significant change in land use and land cover. Improper land uses are the major factor to create a high risk of flood in the region. For this purpose land sat images data from 1991 to 2021 were matrix to analyze how water bodies and non-built lands are converted into build-up areas in the study area. Water body (-91.82) and Non-built-up lands (-49.68) hectares continuously decreased in 2021 when compared with 1991. Built-up land area positively changes annually which is about 141, 50. Analysis of the land use matrices reveals that built-up areas have experienced the largest positive growth rates relative to water bodies and undeveloped regions, which is about 76.871% in 2021. The quantitative analysis of the chi-square test is found to have a relationship between improper land use and higher impacts of floods. The investigations show that changes in proper land use in an improper way have produced a significant change in the peak flow that impact is a serious problem for the community.

5.1 Recommendation

The proper planning and management of land use in flood-prone areas are very important to reduce the impacts of floods for the sustainable development of the area. In the restricted zone, settlements should be pointedly avoided. Urban areas and housing settlements that are prone to flooding should be developed with appropriate drainage systems and escape routes. River and other water body reservoir areas shouldn't be used for new development activities. Natural drainage paths should not be blocked in the process of land subdivision**.** Water detention areas should not be used for new development**.** When submitting the land subdivision plans to the local authority, any detention areas should be indicated in the contour plan. Taking action against those who do illegal activities in the water bodies. DMC should establish an introduction of new technologies which can adapt to the disaster situation. Mainly GPS to identify the exact location of the flood risk, GIS and RS tools for constructing the flood and flood plain mapping, therefore can understand where the high risk and so on. The plan should include a combination of environmental protection, infrastructure, and development plan and it should follow from the bottom to up level approach to achieve the optimum goals of those plans.

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