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Research Article

Geospatial Analysis of Waterlogging Impacts on Land Use/Cover in Jashore District, Bangladesh (1980–2019)

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Abstract

Waterlogging poses a significant threat to a developing country's long-term growth. This research presented the impacts of waterlogging on land use land cover (LULC), located in the five water-logged unions (Kultia, Durbadanga, Haridaskati, Sundoli, Nehalpur) under Manirampur Upazila of Jashore District. Primary data were collected through FGD, KII and questionnaire and secondary (TM Landsat satellite images) data are collected from USGS and Google Map. In addition, district, upazila and union cadastral maps are collected from Bangladesh Bureau of Statistics (BBS). Hybrid classification methods (supervised and unsupervised) are applied to achieve the objectives of this research. The study reveals significant changes in LULC from 1980-2019. Agricultural land area has been drastically reduced from 6720.84 to 3112.11 ha. Correspondingly, water bodies have increased from 2030.04 to 4993.2 ha. Besides, the vegetation cover has slightly increased from 2873.88 to 2900.43 ha, and the settlement area has more than doubled from 453.24 to 945.36 ha during these 40 years (1980-2019). The study claims that waterlogging has significant impacts on all the components of LULC. The novelty of this research is it focused on the waterlogging impact of the Jashore District as it is not discussed like other coastal areas of Bangladesh. The findings of this research should be used as a guideline for the policy makers, the NGOs and the other organizations to take decisions in the study area.

Keywords: LULC, Vegetation cover, Satellite images, USGS, Waterlogging, Settlement area.

1 Introduction

Waterlogging is a significant risk factor in the agricultural sector, mainly affecting regions close to water shores or even at a lower standard (Pan et al., 2021). Research has reported reductions in cultivation land area due to prolonged waterlogging while the size of water bodies grows. In Bangladesh, about 5% of the geographical area is waterlogged, which could extend to 14% by the year 2100, as Valipour (2014) estimates. Analysis of data collected from the Khulna-Jashore region showed that approximately 8000 hectares (ha) of area experience waterlogging. Besides the land issue, this leads to food insecurity and decreased livelihood opportunities in rural areas. In most areas, land use land cover (LULC) changes from arable to pastures and wetlands, which is permanent and alters land use over long periods (Huang et al., 2024). Climate change controversy, inadequate drainage systems, and the wrong type of land management make it worse (Yan et al., 2024). Even though some crops may demonstrate the ability to cope with temporary flooding, long-term water saturation leads to total crop loss and the abandonment of the affected area (Zhang et al., 2024).

Waterlogging is both natural and man-made phenomena that occurs in many cities in the modern urbanized era over the world (Rahman et al., 2009) that becomes a major environmental concern in planning (Hassan & Islam, 2014). The ecology and environment (biotic and abiotic) are directly affected by waterlogging and rural areas, are also in great danger due to various reasons (Pan et al., 2021). Now-a-days waterlogging has become a manmade problem (Rahman et al., 2020). It has significantly impacted on changing LULC, socio-economic condition and the rural livelihoods of the local people (Alam et al., 2017). This type of calamity is occurring in the plains because of poor drainage system and drainage congestion in the low-lying area (Guozhen et al., 2016). In addition, it becomes a disaster when it lasts longer than one month or causes crop failure, as well as harm to societal structures and institutions. Waterlogging for an extended period creates problem for drinking water, sanitation, public health, emergency housing, food and working prospects (Rahman et al., 2009). Waterlogging is observed throughout the world, i.e., Australia, China, Pakistan, Bangladesh, India, and so on (Bastawesy et al., 2012). Therefore, this problem is regarded as a global issue (Bastawesy et al., 2012). Around 5% area of the total Bangladesh is affected by waterlogging and it is becoming a common phenomenon which will be around 14% by 2100 (Bangladesh Forest Department, 2016; Rahman et al., 2009, Valipour, M., 2014). Previous study revealed that about, 8000 ha of land was waterlogged in Khulna-Jashore region of southern part of Bangladesh (Awal, 2014). Though, urban area, such as Dhaka, Chottogram and Khulna City Corporations are now experiencing waterlogging as a regular phenomenon in the rainy session (Awal, 2014). In the study area, beel (shallow depressions) waterlogging is the regular phenomena in the last 35/40 years that have a negative impact on LULC (Paul et al., 2014). In the 1959, East Pakistan government had taken a project for southwest tidal areas under the Coastal Embankment Project (CEP) (Mizanuzzaman, 2017). The government established a polder system in the ’60s to protect from floods in the coastal areas along with the salinity and sudden upsurge from the rivers (Mizanuzzaman, 2017; Karim & Modal, 2017). This project is mostly to blame for study area drainage congestion and channel navigation loss. This project built many polders and embankments in southern Bangladesh that covered small parts of the study area. This experiment was initially very effective in terms of large-scale crop production and became a nuisance for residents when the river began to siltation after 20 years of construction (Paul et al., 2014). Muktersori and Bharob Rivers in the study region have also silted up because of this project and the Bhabadaha sluice gate was built under the CEP project. The Farakha barrage has exacerbated the siltation problem and the study area’s rivers (Muktersori and Bharob) have lost their navigability rapidly (Awal, 2014). The depth of some parts of Muktesori River is almost equal to beel Bokor and beel Kedar and the depth of some places is found higher than the beel Bokor and Keder. This situation presents the incapability of flow of the river water. As a result, lacking the flowing water gets locked in the beel area. Thus, it creates a waterlogging problem in the study area.

Bangladesh has experienced various types of water-related natural hazards, i.e., cyclones, storm water surges, riverbank erosion, salinity intrusion, drought and waterlogging (Adri & Islam, 2012). These hazards regularly occurred on the geophysical settings of Bangladesh. The coastal region in the south-western portion has anthropogenic involvement by different development projects and activities. In the south-western region of Bangladesh, the control of hydro geophysical setting rises to adverse phenomena named as a waterlogging (Adri & Islam, 2012). Waterlogging is also related to the natural hydro-physical settings and leads to waterlogging. Hydro-physical-settings can be hindered by anthropological development projects like an embankment, dam, sluice gate, water budges model for an urban center, farm, commercial activates, etc. (Barnett et al., 2008).

The south-western coastal zone of Bangladesh faces random waterlogging in every year. Jashore District is a part of this zone and is affected by waterlogging every year. Some upazilas of this district are directly affected by regular waterlogging (Hassan & Islam, 2014). Catchments of the Hari-Mukteswary, Aparbhaddra- Harihar and Shri Rivers are generally considered as the Bhabodha areas (Mizanuzzaman, 2017). After 1980, regular waterlogging started to occur in the southern part of Bangladesh. Best of the knowledge and based on the above discussions, the researcher find few research connected to LULC with geospatial analysis. No prior study has analyzed 40-year LULC trends in Jashore using hybrid classification. For this reason, this research was conducted. After the above review of literature, it is quite proved that this research is novel research as this focuses on the Jashore District and its waterlogging scenario of the past 40 years trend. The objective of this research is to find out the changing trend of LULC over 40 years (1980-2019) due to waterlogging.

2 Methods and materials

2.1 Study area

Jashore district is in the south-western region of Bangladesh. The geo-position of the district is between 22˚47’ to 23˚47’N latitudes and between 88˚40’ to 89˚50’E longitude (Shaibur et al., 2018). It is bordered by India to the west, Khulna District and Satkhira District to the south, Magura and Narail District to the east, and Jhenaidah District to the north (Hossain et al., 2016). Beel Kadira, Beel Bokor, Muktesori River and different canals are situated around the study area. This Muktersori River and canals are the main water passing pathways of this area. Beels, rivers and canals are situated around the study area. Five unions (Kultia, Durbadanga, Haridaskati, Sundoli, Nehalpur) of Manirampur Upazila of Jashore District are purposively selected to perform the study.

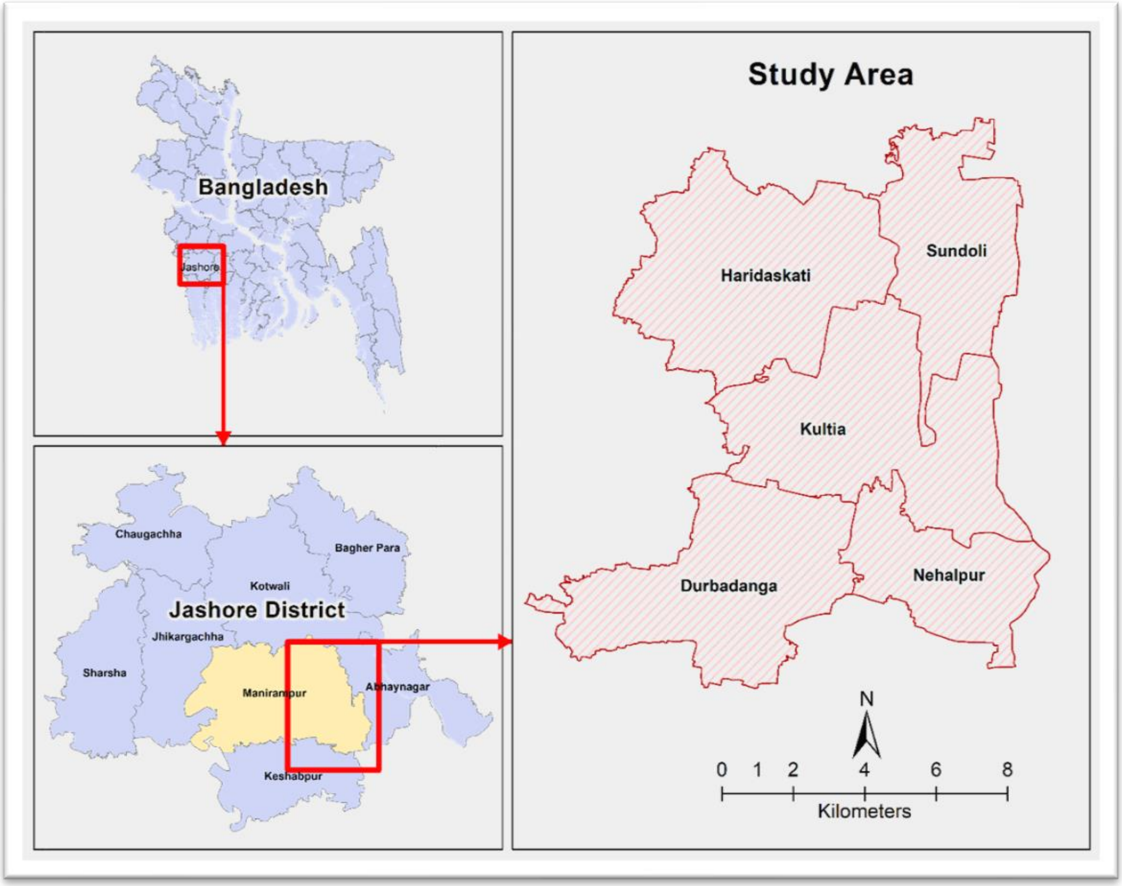

Figure 1: Study area map

2.2 Socio-economic data

Total household data is collected from the respective union parishad. The sample size (178 household survey) was calculated statistically at a 95% confidence level using the Kothari sampling determination formula, that were distributed proportionately (Tawsif et al., 2024a). The household heads were the respondents for the questionnaire surveys. The questionnaires are pretested and constituted with semi-structure with three parts (demographic profile, waterlogging impacts, waterlogging duration) (Tawsif et al., 2024b). About 10 Key Informant Interviews (KII), key persons were local male and female counsellors, teachers and different key persons from the different professions in the local area, and 3 focus group discussions (FGD) are performed with a checklist and observation was also used to collect primary data. KII and FGD participants were aged more than 45 years, because older people had more knowledge and experience about waterlogging. In the survey, male and female participants were included.

Table 1: Collected data type and source

Data Type	Data Source	Software use	Analysis/Output
Primary Data A. Questionnaire Survey (178) B. KII (10) C. FGD (3)	Field survey Field interview Field observation	SPSS and MS Excel	Demographic profile, History of this region's waterlogging, waterlogging impacts, Waterlogging duration, Pitfall to change the land use, LULC pattern

2.3 Satellite and Spatial data

This study employed a hybrid classification approach that combines both supervised and unsupervised classification techniques. This method allows for a more accurate and efficient categorization of land cover types by leveraging the strengths of both approaches. The satellite imagery was classified into four major LULC categories, such as water bodies, agricultural land, vegetation, and settlements. These categories were chosen based on their relevance to waterlogging impact analysis in the study region.

A total of five Landsat images were used, corresponding to the years 1980, 1990, 2000, 2010, and 2019. All images have been taken from the post-monsoon season (October–November) to ensure temporal consistency and comparability. The post-monsoon period was selected because waterlogging conditions become more apparent after the monsoon rains, allowing for better assessment of permanently and seasonally waterlogged areas. To verify and enhance the classification results, field visits were conducted in Kultia village, one of the most affected areas by waterlogging. These ground surveys provided ground truth data, which is essential for validaing satellite-based classifications.

The satellite imagery was primarily collected from the United States Geological Survey (USGS) and Google Earth. In addition to satellite data, spatial boundary layers, including district, upazila, union, and cadastral maps, were collected from the Bangladesh Bureau of Statistics (BBS) and the Local Government Engineering Department (LGED) websites. Furthermore, relevant secondary data were gathered from both governmental and non-governmental organizations, such as the Bangladesh Water Development Board (BWDB), scientific journals, statistical yearbooks, published research, and official project reports. These datasets supported the analysis by providing context on historical land use, water management, and environmental changes in the study area.

Table 2: Collected satellite images and sources

Data type	Data source	Software use	Analysis/Output
TM Landsat Image	USGS	ERDAS Imagine 2014 and Arc Map 10.3	Changing trend of LULC
District, upazila, union and cadastral maps	BBS (Bangladesh Bureau of Statistics) and Local Government Engineering Department (LGED) websites, Google Earth Map	ERDAS Imagine 2014 and Arc Map 10.3	Union shapefile and study area map

2.3.1 Image Processing

After collecting the Landsat satellite images, several image preprocessing steps were applied using ERDAS Imagine 2014 and ArcMap 10.3 to enhance the quality and usability of the data for further analysis. Initially, the individual spectral bands from each image were layer-stacked to form a composite image. The images were then subset based on the study area boundary, which includes five unions: Kultia, Durbadanga, Haridaskati, Sundoli, and Nehalpur. Subsetting ensures that only relevant portions of the image are processed. By using ERADAS Imagine 2014 hybrid classification methods is used in which include supervised and unsupervised classification (Singh, 2020; Zhang et al., 2021).

Critical preprocessing procedures including cloud-free images and radiometric correction are applied to the TM Landsat images in order to assure the accuracy and precision of satellite-based LULC categorization. Google Earth Explore was used to download cloud-free TM Landsat images. When the TM Landsat imagine (1980-2109) was obtained, there was 0% cloud cover (Xie et al. ,2019). Objects like water bodies and agricultural fields in post-monsoon seasons are frequently visible and accurate in these TM Landsat images.

Radiometric correction was applied to normalize differences in sensor calibration and atmospheric conditions across different image acquisition dates. This process included:

• Dark Object Subtraction (DOS): Used to reduce atmospheric scattering by identifying the darkest pixels (typically water) and adjusting all bands accordingly.

• Haze Reduction: Enhances image clarity by minimizing atmospheric haze.

These corrections ensured consistent reflectance values across all images, enabling accurate comparison over time. As a result, the temporal LULC analysis remained valid and reliable for precisely monitoring the impact of waterlogging (Xie et al.,2019).

2.3.2 Accuracy assessment

Accuracy assessment is a crucial step in remote sensing-based land cover analysis, as it quantifies the degree to which the classified image matches actual ground conditions (Foody, 2002; Congalton & Green, 2009). To evaluate the quality and reliability of the LULC classification, a thorough accuracy assessment was conducted using four key metrics: overall accuracy, user’s accuracy, producer’s accuracy, and the Kappa coefficient (Congalton, 1991).

The assessment was conducted using confusion matrices, comparing classified land cover types with reference data collected through field visits and high-resolution imagery from Google Earth Pro, ensuring a reliable ground truth. Ground truth data were collected during field visits to Kultia and adjacent unions, providing direct observation of actual land cover conditions. These field-based observations, combined with satellite reference imagery, enhanced the accuracy and credibility of the validation process. According to widely accepted standards, classification results with accuracy above 85% are considered satisfactory, while those above 70% are acceptable for most practical applications (ScienceDirect Topics, n.d.).

Table 3: Accuracy assessment summary of LULC classification (1980-2019)

Year	Producer's accuracy (%)	User's accuracy (%)	Overall accuracy (%)	Kappa coefficient
1980	82.65	84.23	83.50	0.81
1990	86.14	87.89	86.90	0.84
2000	88.34	89.79	89.00	0.87
2010	91.25	92.13	91.60	0.90
2019	93.45	94.02	93.80	0.92

The classification accuracy was assessed utilizing the kappa coefficient, alongside user accuracy and producer accuracy for each land use and land cover class. The kappa coefficient value ranges from 0.81 to 0.92 for Landsat images taken between 1980 to 2019, which shows that there is strong agreement. User's accuracy reflects the likelihood that a pixel assigned to a specific category accurately corresponds to that category in reality. In this analysis, the user's accuracy ranges from 84.23% to 94.02% between 1980 and 2019 images, showing that the class represented on the map is accurate. Producer's accuracy denotes the likelihood that a ground pixel is accurately categorized . It was essential to evaluate whether areas are permanently waterlogged, which are seasonally waterlogged, specifically about gher or fish farming zones. The study found that the producer's accuracy of the 1980s Landsat image is 82.65%, the lowest of the five images, and the producer's accuracy of the 2019 Landsat image is 93.45%, the lowest of the five images. This range of values shows that the mapped ground feature is high quality. Overall accuracy lowest levels ranged from 83.50% in 1980s Landsat image to 93.80% in the 2019s Landsat image.

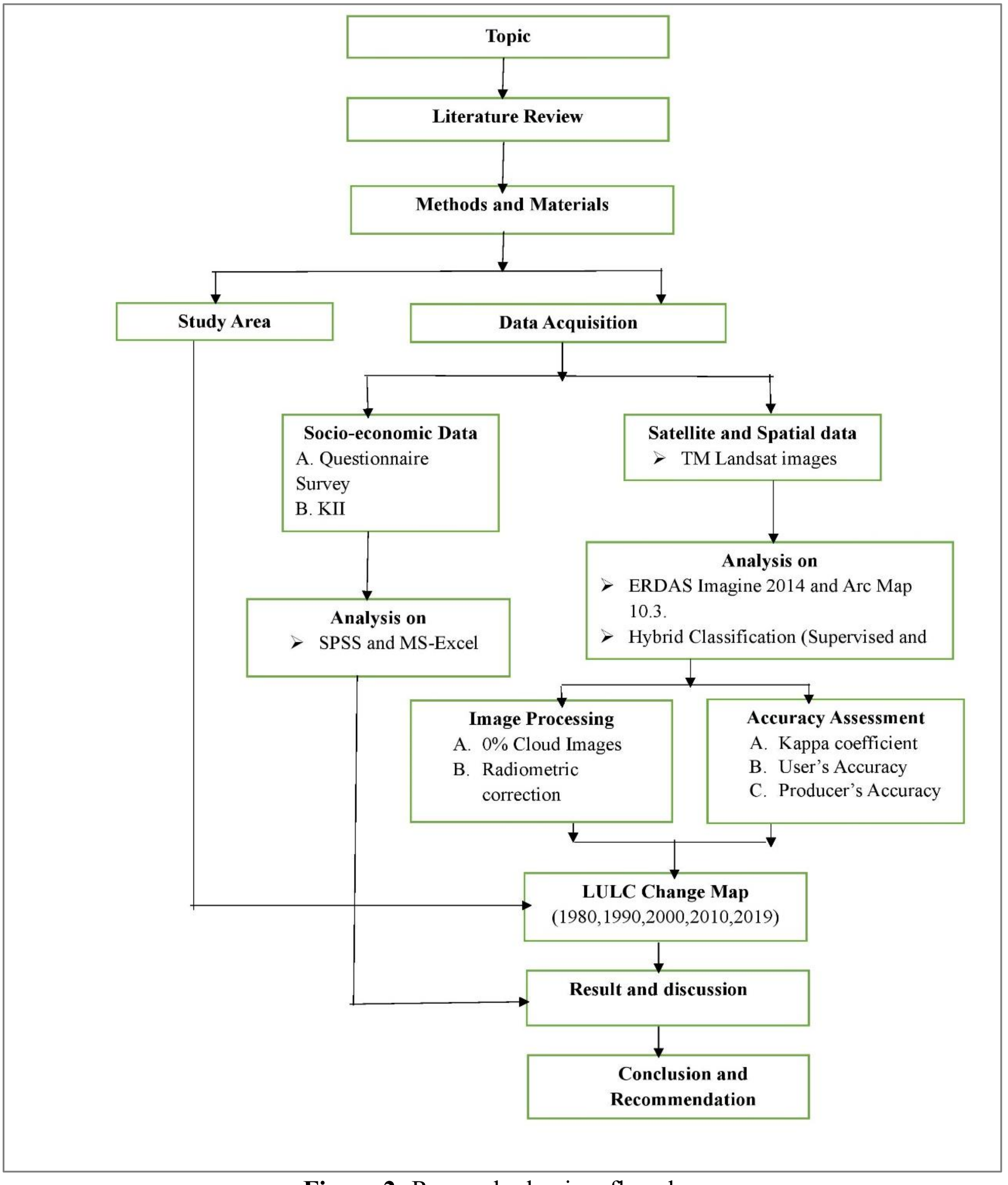

Figure 2: Research plan in a flowchar

3 Results and Discussion

3.1 Duration of waterlogging

According to results from the field survey conducted in the five union of the study area, 43.70% respondents mentioned 3 to 5 months as the highest duration period of waterlogging. The second highest duration period of waterlogging is 2 to 3 months which is mentioned by 29.50% of the respondents. About 20.80% of waterlogging problems last more than 5 months according to field survey because of heavy rainfall which was regarded as the third highest response.

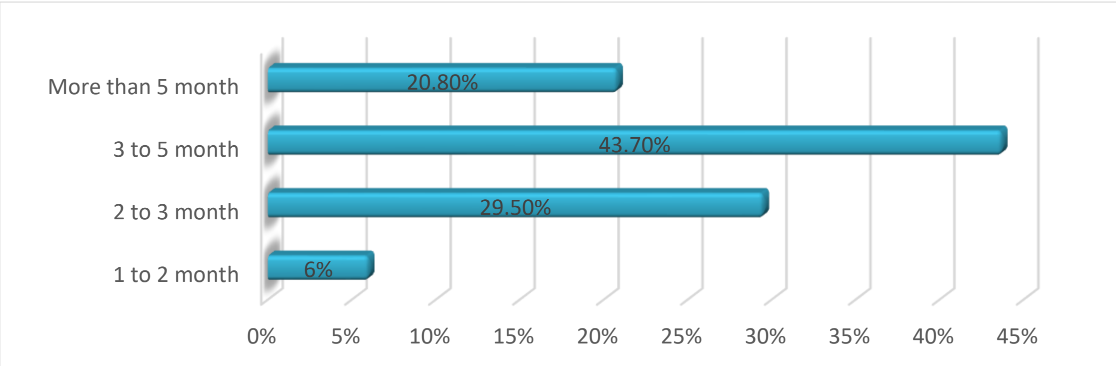

Figure 3: Duration of waterlogging (field survey, 2020)

In which year a little amount of rain occurs, the waterlogging problem is found to be less than that of other heavy rainfall years. In the lowest rainfall year, waterlogging occurs in beels and has no impact on households (Islam et al., 2020; Rahman et al., 2021). In this type of beel area, waterlogging stays for a short period of time, for example, 1 to 2 months, which is found in only 6% (the lowest percentage of waterlogging) study area. But when waterlogging stays for more than 3 months, cultivation in the agricultural field is greatly hampered. When waterlogging stays for more than 5 months, there is no cultivation possibility for two years. More than 4 months of waterlogging with heavy rain also destroy fish cultivation (Rahman & Alam, 2022; Kabir et al., 2019). In most cases, for more than 3 months, waterlogging destroys households, cultivation and fishing gher (fish enclosure).

3.2 Land use pattern of the study area

There are mainly two types of land use patterns, which are planned and traditional land-use patterns. About 74% of the land in the study area is used in the traditional way. The reason behind the traditional land use is waterlogging. Most of the land is in the lowland beel area. Regularly, the beel area is affected by waterlogging. So, there is no way for planned land-use patterns. There are two ways of using the lowland beel area. One type of use is for agricultural crops production and another use is for fish cultivation in a gher. The cropping system follows the traditional system. It should be mentioned that almost 20 years ago, people started using the gher system for fish cultivation (Awal, 2014). Still there is no new planning for fisheries cultivation in a modern way. However, the fishing gher owner does not want to invest more in the gher land because of the waterlogging risk that creates huge losses for the farmer every year (KII and FGD, 2020).

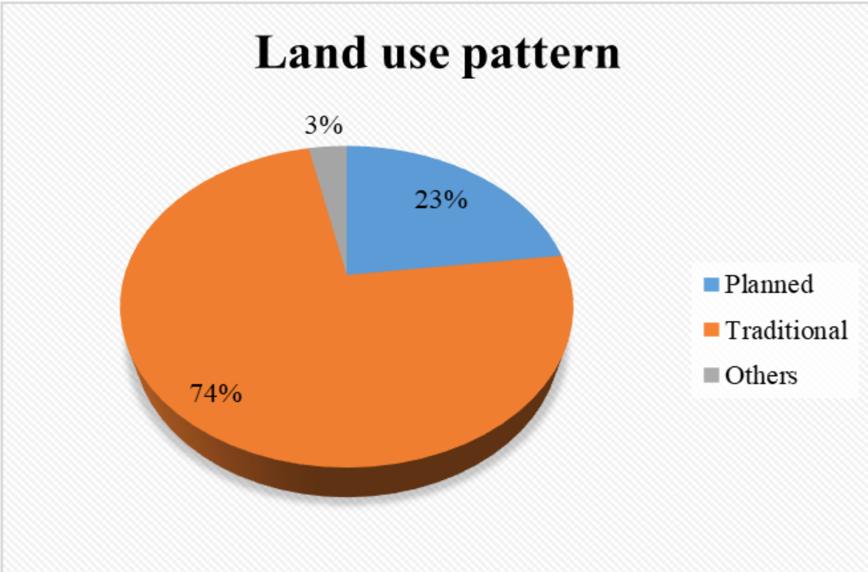

Figure 4: Land use pattern (Source: field survey, 2020)

There is a planned land-use area in the study area, which is 23% of the land and used as a marketplace and homestead (Fig. 4). Homestead land is limited and for this reason, they are trying to utilize it in a planned way (Field survey, 2020). Market land is also limited to every owner and for that they use it in a much-planned way. Apart from that, the value of those lands is very high and there is a necessity of using them in a much-planned way because they earn more from this land use. Waterlogging is found less on this land-use than agricultural land (Das & Rouf, 2023). So, the probability of investment loss in this land is less than that of the agricultural land. Another type of agricultural land use is less than 3% because there is no land-use dimension (Fig. 4). There is no specific classification of another land use pattern. This is mainly new planning for land use.

3.3 Major LULC change

In 1880, major areas were mainly agriculture-based and then the agricultural land in the study area was about 6720.84 ha, which is revealed from the current study . The agriculture field was capable of getting inclined with three season's cultivations. The rainy season was suitable for rice and jute cultivation, the winter season was for vegetables and the summer season was for watermelon. At that time villagers were not introduced to IRRI cultivation, theAman, Arash was a major part of rice cultivation in the study area. The village economy was dependent on agriculture (KII and FGD, 2020). Everyone was related to the agriculture sector. It revealed that, in 1980 vegetation area was 2873.88 ha in the study area. In the last 40 years, there was a decrease in vegetation area day by day. In 1980, the water body in the study area was 2030.04 ha, which were mainly rivers, canals, ponds, wetlands and low areas of beel. Since we took a post-monsoon image, there was no rain as a result, there was no temporary water body which was seen in rainy season, only the permanent water bodies were present (Geospatial analysis).

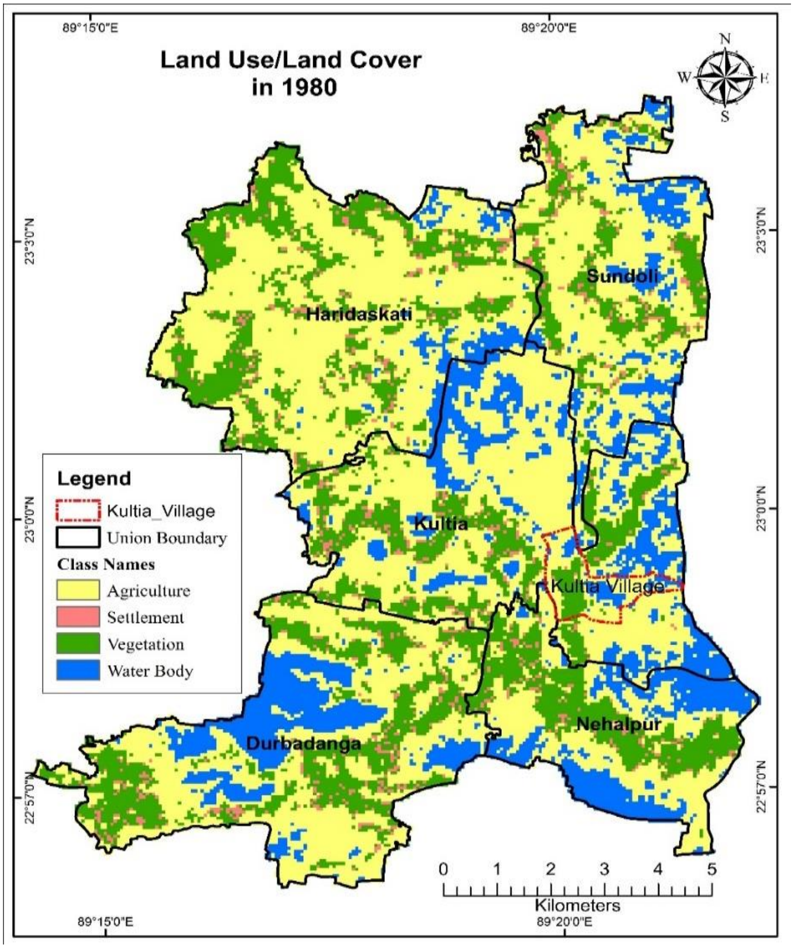

Figure 5: LULC in 1980 in the study area

After 10 years of waterlogging, there were some changes that occurred from 1980 to 1990. In 1980, agricultural land was 6720.84 ha, and in 1990, agricultural land was 5893.47 ha. 800 ha and it had been decreased during this time. On the other hand, in 1980 the water body was 2030.04 ha but in 1990 the water body area was 2491.47 ha. So, it found that 800 ha of agricultural land had decreased, but on the other hand, water bodies increased by 400 ha. In the study area, frequent floods were responsible for creating wetlands beneath the beel. During that decade, crop production was hampered by frequent floods. Local people claimed that 1988's massive floods were the starting point of waterlogging (KII and FGD, 2020). The impact of 1988's flood was massive and the flood lasted for more than five months. As a consequence, in

1989, floods came into action in the early summer that destroyed summer crops. This was the study area's starting point for waterlogging. After this year, waterlogging became a regular phenomenon in the study area. Senior citizens in the study area claimed that they got their last summer crops before the 1988's floods. After 1988, waterlogging has been seen frequently and people could not get any summer crops (Field survey, 2020). In 1990, the settlement area was 560.7 ha in the study area, which was more than the 1980's settlement area because of drastic demographic change. Many agricultural lands became settlement areas and as a result settlement land was increased. But vegetation cover has increased in the last decade. The geospatial analysis revealed that, in the year 1980 the vegetation area was 2030.04 ha and in 1990 vegetation area was 2491.47 ha which had increased by 400 ha in the last decades.

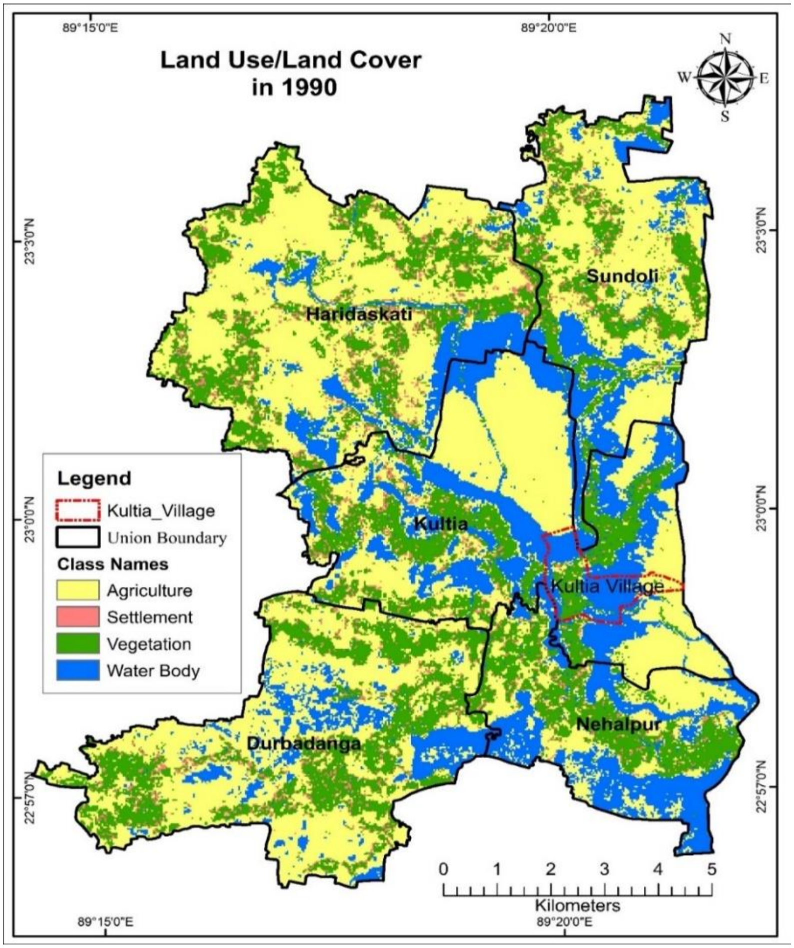

Figure 6: LULC in 1990 in the study area

After 10 years, there were some changes in LULC from the year 1990 to 2000 in the study area for waterlogging. Most of the changes occurred between the years from 1990 to 2000, because waterlogging was a frequent phenomenon during that decade. In this decade's local people were not prepared for the adaptation to the waterlogging. People's resilience capacity was lower because they could not assume the effects and nature of waterlogging (Field survey, 2020). Agriculture land was 6085.8 ha in 2000, which was 800 ha fewer than in 1980 but 200 ha more than in 1990. From 1995 to 1998 the waterlogging impact was less than before the year 1995. But the increasing trend of water bodies was continuing (Table 4). Waterbodies increased from 2030.04 to 2680.83 ha during 1980-2000 because of the waterlogging problem. Vegetation areas decreased in 1980 because regular waterlogging impacted vegetation (Geospatial analysis). This area’s vegetation characteristics are not like mangrove vegetation. So, when they have gone underwater, their roots become affected. This system is mainly responsible for decreasing the vegetation area. The settlement area was 683.46 ha in the study area, which was more than in the last decades. Continuous increase in settlements is also another cause of the decrease in vegetation area.

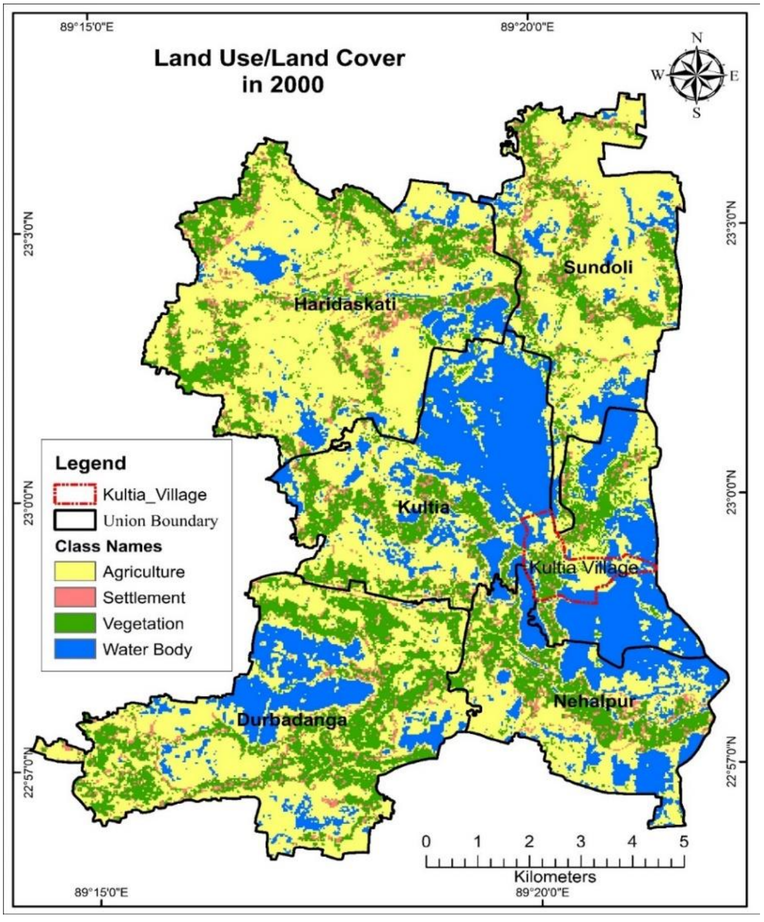

Figure 7: LULC in 2000 in the study area

In 2010, we can see a massive change in LULC from the present study. In 1980, the water body was revealed as 2030.04 ha which became 4479.93 in 2010, which indicated a massive increase and it is more than double that of 2010. It is not a sudden phenomenon. It is an effect of continuous waterlogging in the study area. When a post-monsoon image gives this result, it also proves that the rainy season's situation will be worse. In the post-monsoon or winter season, the cultivation land was 3932.19 ha, less than in the year of 1980. In 1980, agricultural land was 6720.84 ha, but in 2010, agricultural land decreased to 3932.19 ha. Almost 3000 ha of agricultural land had decreased in the last 30 years, but 2500 ha of the waterbodies increased at the same time (Geospatial analysis). The cause of LULC change was waterlogging, and a proper solution needs to be found. These land covers were rapidly changing from agricultural land to waterbodies. When agricultural land converts into waterbodies, this water becomes useless (Rahman & Islam, 2022).

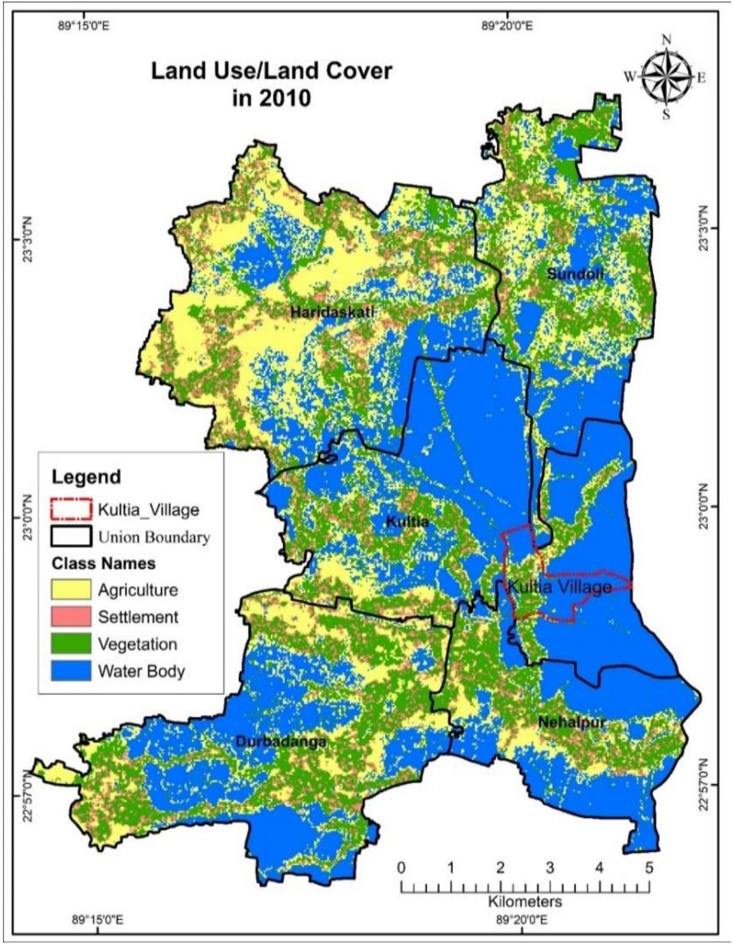

Figure 8: LULC cover in 2010 in the study area

In the present times, the image analysis proves that agricultural land decreased from 6720.84 to 3112.11 ha in the last 40 years. It represents the agricultural land scenario before and after waterlogging. Before waterlogging, there were only 2030.04 waterbodies, but after waterlogging, there are 4993.2 ha waterbodies. It reveals that the decrease in agricultural land is double; on the other hand, the water body is increasing at the same rate. A similar kind of study by Barmon and Rahman (2012) indicated that the 'gher' (prawn-fish-rice) farming system in Bangladesh has resulted in a change from agricultural land to water body, which is affecting food security and agricultural sustainability. Field observations and interviews with local farmers validate that the gher areas in the study region operate as permanent waterbodies. In the last three decades from 1980 to 2010, these areas remained fallow water bodies. In the last decade, some portions have been modified by creating artificial boundaries in beel areas for fish cultivation. Notwithstanding these alterations, agricultural cultivation in the rainy season continues to be troubling due to ongoing waterlogging conditions (Barmon & Rahman, 2012). In the study area, the gher or fish cultivation zones, particularly during the post-monsoon period, are permanent water bodies that are unsuitable for agricultural cultivation. Even when not utilized for fish farming, they remain as permanent water bodies, as evidenced over the past three decades. This research used post-monsoon data from the winter season to address the challenges associated with seasonal flooding, as this period is unaffected by rainy weather (Rahman & Barmon, 2012).

The vegetation cover area is almost the same as it was 40 years ago, which was 2873.88 ha, and now 2900.43 ha. The vegetation cover area has remained almost the same over the past 40 years, increasing slightly from 2873.88 ha to 2900.43 ha. In the study area, vegetation is primarily found in highland areas and around homesteads, which are not permanent water bodies. Therefore, the rate of vegetation decline has remained very low. On the other hand, the past two decades have seen a mild increase in vegetation due to tree plantation initiatives on high fallow land and along the boundaries of ghers. According to residents, these efforts were driven by the desire to generate new sources of income from fruit cultivation and wood products in available highland areas. The increase in settlement areas has also contributed to the stability of vegetation, as tree plantations have been promoted around homesteads. As a result, the vegetation area in the study area has increased by approximately 1%. Research in southwestern Bangladesh revealed that land-use patterns substantially affect tree plantation, with farmers on larger gher lands more inclined to plant trees on gher dikes, particularly when the dike width exceeds 6 feet (Sengupta et al., 2021). A study in the Gazipur district indicated a modest rise in homestead areas from 55% to 57% between 2001 and 2009, ascribed to urban expansion and enhanced homestead cultivation (Hasan & Rahman, 2015).

The present study revealed that increased settlement portion has been doubled. So, there are massive changes in LULC. As a result, many new things come into play in social, economic, and daily life. They tried to find out the new dimension of land use. They have changed their daily lifestyle because of waterlogging has impacted on LULC changes. Many people have changed their profession because of land use and land cover changes in the last 40 years. Many people lost their profession as well because of this change.

Table 4: LULC (hectares) from 1980 to 2019

Land use land cover (LULC)	1980	1990	2000	2010	2019	LULC Change (+/-)
Agriculture	6720.84	5893.47	6085.8	3932.19	3112.11	53.69% (-)
Settlement	453.24	560.7	683.46	778.77	945.36	108.57% (+)
Vegetation	2873.88	3005.46	2501.01	2760.21	2900.43	0.92% (+)
Water Body	2030.04	2491.47	2680.83	4479.93	4993.2	145.96% (+)

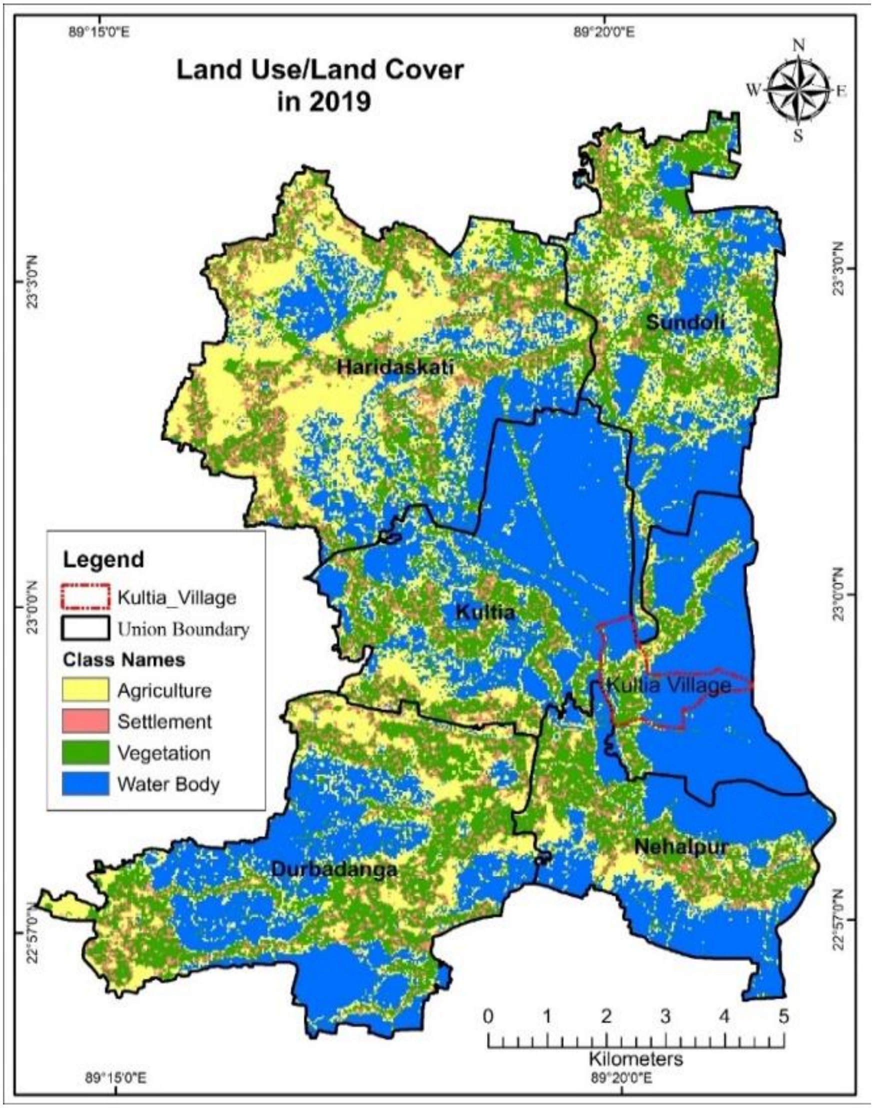

Figure 9: LULC in 2019 in the study area

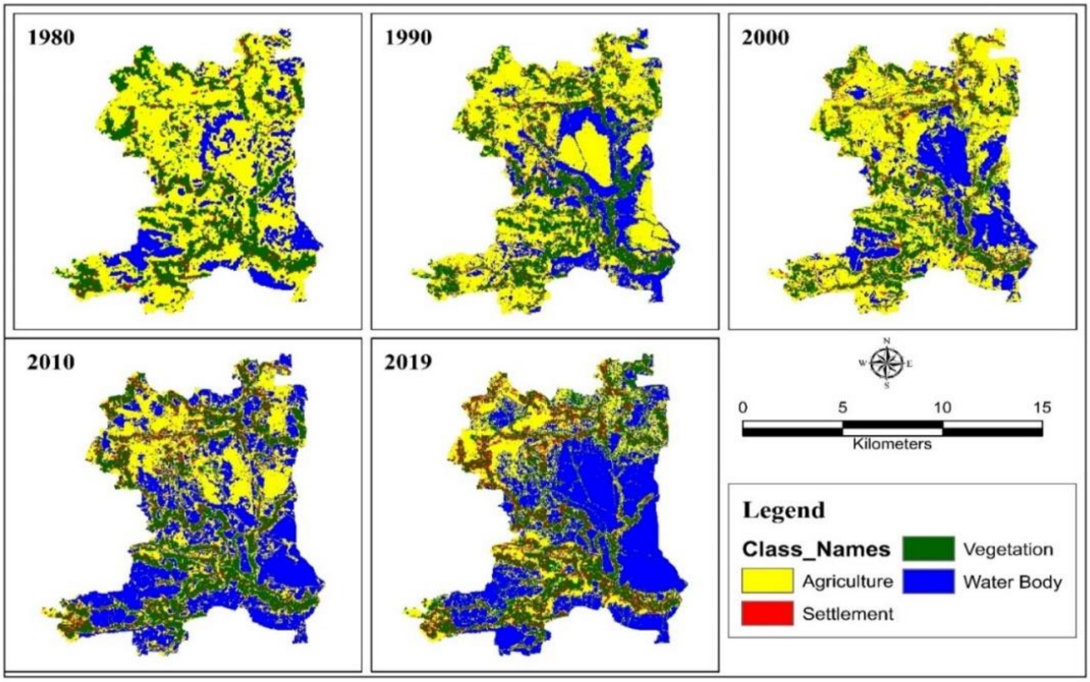

Figure 10: LULC from 1980 to 2019 in the study area

Waterlogging damaged the roads in the study area. The new road only sustains two or three years of waterlogging. Waterlogging breaks down both kucca, pucca roads. When roads go underwater, it causes damage to the roads and materials' temperament. Islam et al. (2016) show the adverse effects of waterlogging on both pucca and kucca roads in Bangladesh's coastal regions, where it substantially accelerates the degradation of road materials. Uses of gher are responsible for changing land use, but there is no other way to use the land. Through the gher, they try to utilize their land otherwise, the land gets inundated in the rainy season. The practice of utilizing land for gher-based aqua farming has been considered a strategy to cope with waterlogged areas (Chowdhury ,2018).Getting agricultural land waterlogged has been the common scenario for the last 20 years, and there is no other solution for land use during the rainy season (Gazi & Moniruzzaman, 2014).

3.4 The pitfall to change the land use

The main pitfall of changing land use is waterlogging. The main causes of waterlogging are waterlogging mismanagement and filling of the riverbed and canal. Here, waterlogging is related to the river and canal filling (Awal & Islam, 2020). Firstly, the filling of the canal and river is the main cause for creating waterlogging in this area. Sedimentation and Siltation, causing the filling of canals and the riverbeds, is 30.10% responsible, waterlogging mismanagement is responsible for 66.10 %, and lack of technical knowledge of local people is 3.80% for the pitfall to change the land use (Field survey, 2020). Waterlogging mismanagement includes irregular dredging and digging of rivers and canals. Unusual, unnecessary embankments and bridges are also causes of regular waterlogging (Hossain & Arifeen, 2017). Rivers and canals are acquired in an unplanned way by the people, which is also a reason for waterlogging. The Vabadah switch gate is another main cause of waterlogging reported by the KII respondents.

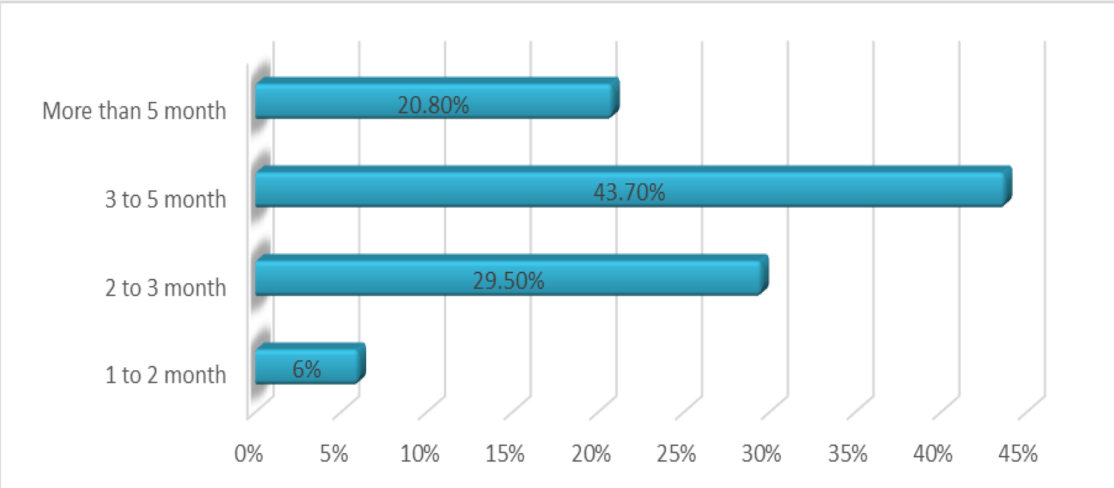

Figure 11: The pitfall to change the land use (field survey-2020)

4 Conclusion and recommendation

Water body increased by almost 3000 ha from 2030.04 to 4993.2 ha during 1980-2019. On the other hand, agricultural land decreased by 4000 ha from 6720.84 to 3112.11 ha during the same period. Their agricultural land is converted into a water body. In the study area, the maximum number of people's occupations is related to agriculture. When agricultural land is converted into a waterbody, it creates terrible situations for people as they could not be able to produce the crops in different seasons. Which influence the agriculture-related economy and it becomes limited in the study area. Various economic activities related professions, such as day labor, farming, animal husbandry, fishing, and other sources account for more than 60% of people's income, which is less than the national income standard. Therefore, LULC has a direct impact on economic and human life.

There are complaints about the dredging company's proper execution of tasks. Therefore, it is necessary to ensure that the dredging company and tendering company properly execute their tasks. Only proper dredging can minimize waterlogging problem in the study area. Drainage congestion due to siltation has made retrieving and maintaining river and drainage systems imperative. Because of embankments on the river channel and illegal capturing of the river, the flood plain became a congestion of the local drainage system. Therefore, it needs to retrieve the river channel according to the 1962 land survey Mouza map. Because local people occupy many river areas, restoring the drainage system can help increase river flow during the rainy season. Rapid channel flows can decrease the waterlogging problem and it can be managed..

The proper initiatives of the government and other institutions can solve this waterlogging problem. TRM (Tidal River Management) helps decrease waterlogging problem. However, the government needs specific policies and laws for rotationally using the 27 beels after a defined time in the study area. There have been criticisms about the execution of the TRM system in the study area. To solve this problem, proper execution according to law and order needs to be implemented in the study area. In addition, a proper survey in 27 beel for TRM to be implemented and proper long-term planning for TRM should be introduced. Regular switch gates need to be monitored and cleaned frequently to recover from waterlogging problem. Because of the switch gate, there is a prime responsibility for siltation in the riverbed, which creates waterlogging in most cases. Therefore, the switch gate needs proper cleaning and dredging in regular periods.

In fact, proper switch gate management can reduce the probability of waterlogging problem in the study area. A new channel for water passing could be a recommendation. Because the present channel, water cannot pass through but gets stagnant in the study area. Therefore, the possibility of creating a new channel between the Kultia Muktesori River and the Noapara Voyrab River then this channel will be most effective for decreasing waterlogging during the rainy season. Voyrab River is a more active river asthe water carrying capacity is higher in this region. In addition, this study suggests that implementing a new channel will help to carry the stagnant water properly. Although it will help decrease the regular waterlogging problem. Unfortunately, almost every bridge and culvert are small, blocking water during waterlogging. So, a wide bridge and culvert construction is an ultimate need of the study area. However, the implementation of wide bridges and culverts can reduce the problem. Fisherman creates embankments and blocks the local channel that helps to prevent waterlogging. Finally, regular observation and clearing of channel paths are needed. All these steps will help to reduce the problems caused by waterlogging.

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5 References

Adri, N. and Islam, I., (2012). Vulnerability and coping strategies in a waterlogged area: A case study from Keshabpu, Bangladesh. *International Journal of Environment*, *2*(1), pp.48-56.

Alam, M.S., Sasaki, N. and Datta, A., (2017). Waterlogging, crop damage and adaptation interventions in the coastal region of Bangladesh: A perception analysis of local people. *Environmental Development*, *23*, pp.22-32.

Awal, M. A., & Islam, A. F. M. T. (2020). Water logging in south-western coastal region of Bangladesh: Causes and consequences and people's response. *American Journal of Geosciences and Remote Sensing, 3*(2), 61–70. https://doi.org/10.11648/j.ajgr.20200302.11

Awal, M.A., (2014). Waterlogging in southwestern coastal region of Bangladesh: local adaptation and policy options. *Science Postprint*, *1*(1), p.e00038.

Bangladesh Bureau of Statistics (BBS)., 2011. *Population and Housing Census 2011, JESSORE*. Dhaka: Bangladesh Bureau of Statistics (BBS) Statistics and Informatics Division (SID) Ministry of Planning, pp.83-647.

Bangladesh Forest Department. (2016). *Bangladesh Forest Department Report.* Available at: http://bfis.bforest.gov.bd/library/wp-content/uploads/2018/11/75.pdf [Accessed 7 Jul. 2024].

Barmon, B. K., & Rahman, S. (2012). Energy productivity and efficiency of the 'gher' (prawn-fish-rice) farming system in Bangladesh. *Proceedings of the ICE - Energy*, 164(3), 147–153. https://doi.org/10.1680/ener.2012.164.3.147

Barnett, T.P., Pierce, D.W., Hidalgo, H.G., Bonfils, C., Santer, B.D., Das, T., Bala, G., Wood, A.W., Nozawa, T., Mirin, A.A. and Cayan, D.R., (2008). Human-induced changes in the hydrology of the western United States. *science*, *319*(5866), pp.1080-1083

Barrett-Lennard, E. G., (2003). The interaction between waterlogging and salinity in higher plants: Causes, consequences and implications. *Plant and Soil*, 253, 35-54.

Congalton, R. G. (1991). A review of assessing the accuracy of classifications of remotely sensed data. *Remote Sensing of Environment*, 37(1), 35-46. https://doi.org/10.1016/0034-4257(91)90048-B

Das, S., & Rouf, M. A. (2023). Impact of waterlogging on land use, biodiversity, and ecosystem services in Tala upazila, Bangladesh. *Khulna University Studies, 20*(2), 71–84. https://doi.org/10.53808/KUS.2023.20.02.1123-ls

Bastawesy, M., Ali, R.R., Deocampo, D.M. and Al Baroudi, M.S., (2012). Detection and assessment of the waterlogging in the dryland drainage basins using remote sensing and GIS techniques. *IEEE journal of selected topics in applied earth observations and remote sensing*, *5*(5), pp.1564-1571.

Gazi, M. A. H., & Moniruzzaman, S. M. (2014). Impact of water logging on agriculture and food security: A case study in Satkhira, Bangladesh. *International Journal of Surface and Groundwater Management*, 1(1), 29–32.

Guozhen, L.I.U., ZHANG, Q., Shi, P.E.N.G. and Pei, L.I.U., (2018). Flood and Waterlogging Disaster Management System in Shenzhen River Basin. In *MATEC Web of Conferences* (Vol. 246, p. 01092). EDP Sciences.

Hasan, M. K., & Rahman, M. S. (2015). Land use change and urbanization in Gazipur district, Bangladesh: A case study of homestead areas. *Journal of Urban Management*, 4(2), 72–82. https://doi.org/10.1016/j.jum.2015.06.003

Hassan, M.S. and Mahmud-Ul-Islam, S., (2014). Detection of waterlogging areas based on passive remote sensing data in Jessore District of Khulna Division, Bangladesh. *International Journal of Scientific and Research Publications (IJSRP)*, *4*, p.12.

Hossain, M. A., & Arifeen, H. M. (2017). Water logging hazard at northern part of Padma Bridge adjacent area. *International Journal of Geology, Earth & Environmental Sciences, 7*(1), 47–54. Retrieved from https://www.cibtech.org/J-GEOLOGY-EARTH-ENVIRONMENT/PUBLICATIONS/2017/VOL_7_NO_1/07-JGEE-007-HOSSAIN-WATER-AREA.pdf

Huang, Y., Lin, J., He, X., Lin, Z., Wu, Z., & Zhang, X., (2024). Assessing the scale effect of urban vertical patterns on urban waterlogging: An empirical study in Shenzhen. *Environmental Impact Assessment Review*, 106, 107486.

Irfan, M., Hayat, S., Hayat, Q., Afroz, S., & Ahmad, A., (2010). Physiological and biochemical changes in plants under waterlogging. *Protoplasma*, 241, 3-17.

Islam, A. N., Chowdhury, M. S. R., & Uddin, M. T. (2016). Impacts of waterlogging on road infrastructure and agricultural land in coastal areas of Bangladesh. *Journal of Environmental Management*, 179, 58-65. https://doi.org/10.1016/j.jenvman.2016.04.017

Islam, M. S., Rahman, M. S., & Alam, M. S. (2020). Impacts of climate change on waterlogging in the agricultural fields of Bangladesh. *Agricultural Water Management*, 232, 105991. https://doi.org/10.1016/j.agwat.2020.105991

Kabir, G., Hossain, G., & Rahman, S. (2019). The effect of prolonged waterlogging on fish farming and agricultural practices in flood-prone areas. *Bangladesh Journal of Environmental Science*, 34(1), 85-98. https://doi.org/10.1080/13669877.2019.1580125

Karim, R. and Mondal, R., (2017). Local stakeholder analysis of tidal river management (TRM) at Beel Kapalia and the implication of TRM as a disaster management approach. *Hydrology*, *5*(1), p.1.

Khan, M.S., and Hossan, M.A., (2021). Waterlogging and its' impacts on livelihood: A study from Jashore Sadar Upazila, Jashore, Bangladesh. *Journal of Tropical Resources and Sustainable Science (JTRSS)*, *9*(1), 58–66. https://doi.org/10.47253/jtrss.v9i1.711

Mizanuzzaman, M., (2017). Economic Analysis of vulnerability and capacity: A study of water logging, Bhobodah, Keshabpur, Jessore. *American International Journal of Social Science Research*, *1*(1), pp.33-41.

Pan, J., Sharif, R., Xu, X. and Chen, X., (2021). Mechanisms of waterlogging tolerance in plants: Research progress and prospects. *Frontiers in Plant Science*, *11*, p.627331.

Paul, A., Nath, B., Abbas, M., Islam, H. and Mallick, B., (2014). Land use change monitoring of Hari-Teka River basin, Jessore, Bangladesh using remote sensing and GIS. *Int. J. Adv. Remote Sens. GIS Geogr*, *2*, pp.1-8.

Rahaman, M., Hossain, N., Nurain, A., Sarker, P. and Ichihara, S., (2020). Investigation on causes and effects of waterlogging in the southern part of Bangladesh. *Management of Sustainable Development*, *12*(2).

Rahman, M. M., & Islam, M. S. (2022). Assessment of land use/land cover changes and agricultural vulnerability in Bangladesh. *Remote Sensing Applications: Society and Environment, 28*, 100752. https://doi.org/10.1016/j.rsase.2022.100752

Rahman, M. R., & Alam, M. A. (2022). Waterlogging and its effects on the livelihoods of rural farmers: A case study in southern Bangladesh. *Environmental Management and Sustainability*, 11(2), 129-142. https://doi.org/10.1080/17526080.2022.2043887

Rahman, M.M., Akteruzzaman, A.K.M., Khan, M.M.H., Jobber, A. and Rahman, M.M., (2009). Analysis of waterlogging problem and its environmental effects using GIS approaches in Khulna City of Bangladesh. *Journal of Socioeconomic Research and Development*, *6*(2), pp.572-577.

Rahman, S., & Barmon, B. K. (2012). Energy productivity and efficiency of the 'gher' (prawn-fish-rice) farming system in Bangladesh. *Energy*, 43(1), 1–8. https://doi.org/10.1016/j.energy.2012.04.023

ScienceDirect Topics. (n.d.). *Accuracy assessment*. Retrieved June 17, 2025, from https://www.sciencedirect.com/topics/earth-and-planetary-sciences/accuracy-assessment

Sengupta, S., Rahman, S., & Hossain, M. A. (2021). Effects of land-use changes pattern on tree plantation: Evidence from gher land in Bangladesh. *Environmental Science and Pollution Research*, 28(12), 15478–15489. https://doi.org/10.1007/s11356-021-13746-5

Shaibur, M.R., Nahar, N. and Rahman, M.H., (2018). Probable relationship between climate change and cropping pattern in Jashore district, Bangladesh. *Journal of Jessore University of Science and Technology ISSN*, *2521*, p.5493.

Singh, A. (2020). *Landsat-based land use and land cover change detection: A case study of the Ganges River basin*. Remote Sensing Applications: Society and Environment, 17, 100212. https://doi.org/10.1016/j.rsase.2020.100212

Tawsif, S., Paul, S.K., & Khan, M.S., (2024a). Livelihood vulnerability assessment of slum dwellers in Rajshahi, Bangladesh: Capital indices-based approach. *Journal of Environmental Studies and Sciences*, 1-18.

Tawsif, S., Paul, S.K., & Khan, M.S., (2024b). Changing pattern of livelihood capitals of urban slum dwellers during COVID-19 pandemic. *International Journal of Human Capital in Urban Management*, *9*(1), 101-118.

Valipour, M., (2014). Drainage, waterlogging, and salinity. *Archives of Agronomy and Soil Science*, 60(12), 1625-1640.

Xie, S., Liu, L., Zhang, X., Yang, J., Chen, X., & Gao, Y. (2019). Automatic land-cover mapping using Landsat time-series data based on Google Earth Engine. *Remote Sensing*, 11(24), 3023. https://doi.org/10.3390/rs11243023

Yan, M., Yang, J., Ni, X., Liu, K., Wang, Y., & Xu, F., (2024). Urban waterlogging susceptibility assessment based on hybrid ensemble machine learning models: A case study in the metropolitan area in Beijing, China. *Journal of Hydrology*, 630, 130695.

Zhang, Y., Liang, T., & Dong, H., (2024). Melatonin enhances waterlogging tolerance of field-grown cotton through quiescence adaptation and compensatory growth strategies. *Field Crops Research*, 306, 109217.

Zhang, Y., Liu, H., & Zhao, W. (2021). *Comparison of supervised and unsupervised classification for land cover classification using Landsat TM imagery*. Journal of Applied Remote Sensing, 15(2), 024504. https://doi.org/10.1117/1.JRS.15.024504