

Environmental Impact Assessment for Rapid Urbanization in the Coastal Area of Bangladesh: A Case Study on Cox's Bazar Sadar Upazila

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Abstract Increasing a significant amount of urban area is a common phenomenon in developing countries like Bangladesh. Many pulling factors drive people to the urban area, such as better living conditions, work opportunities, citizen services. Cox's Bazar sea beach, located in Cox's Bazar Sadar Upazila, Cox's Bazar District, Chattagram division, is the world's longest sea beach and an attractive tourist spot. Over the years, urbanization has spread rapidly in this area, and this research aims to discover the significance of rapid urbanization over the climate of Cox's Bazar Sadar Upazila. The study attempts to identify the land use and land cover changes (LULC) of the Upazila over several years and evaluate the environmental impact of the rapid urbanization of the coastal area of Cox's Bazar Sadar Upazila. In this study, the overlay map method refers to the identification of land use and land cover (LULC) changes, and the method of the checklist is used to explain the local people's perception. The satellite images of the years 2005, 2010, 2015, and 2020 were got from USGS (United States Geographical Survey) and categorized by Geographic Information System (GIS) software to measure variations in land use and land cover (LULC) into five foremost land-use groups. A field survey was conducted using a questionnaire survey to collect local citizen's sentiments using the checklist methodology and analyze all the information through the Social Sciences Statistical Package program (SPSS). The urban area and the rural settlement increased by 36.79 km² and 23.39 km² between 2005 and 2020, but Salt & Shrimp farming, the bare land, the hill forest area decreased significantly by 11.12 km², 41.43 km², and 6.96 km². Besides, 66% of people in the marine drive zone, 80% of the main beach area individuals, thought that urbanization had affected this coastal area. People's views on the tariff system, energy demand, poor solid waste management, and poor drainage system are shown. An increasing number of hotels, resorts, and structures near the beach region affect the coastal ecosystem.

Keywords: EIA, urbanization, coastal area, LULC, GIS

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1. Introduction

Urbanization is a process through which an increasing ratio of people living together in a concentrated locality having a continuous collection of houses and enjoying in common the benefits of certain public utilities [1]. We can describe urbanization as shifting a considerable population toward the urban area from the rural area [2]. Therefore, urbanization is a dynamic socio-economic progression that assignments the spatial spreading of the population from the rural area to the urban area, as well as deviations in the living standards, livelihoods, and attitudes of people [3,4]. UNDESA, 2018 also reports that the growing number of urban settlements, increasing public and private investment in buildings and infrastructure, expanding economic activities, and enhancing the highest standard of public and private services are important consequences of

urbanization. Industrialization, migration, and better living standard could be principal reasons behind urbanization globally [5]. People around the world have been living in small groups since the history of human civilization. People began to live together in a wide area over the last two centuries, defined in the last century, and the initiated change of populations from a rural area to an urban area [6]. By 1800, 1900 and 1950 respectively the world's urban population was 3%, 14% and 30% besides in 1900 the number of cities that contained over 1 million people was 12, fifteen years later in 1950, this number increased to 83 cities that had a population over 1 million and projected that more than 400 cities in 2030 [5,7]. By 2050, about 68 percent of the world's population is anticipated to live in urban areas, according to the United Nations (UN), which describes how rapid urbanization can occur [8]. UNDESA Press Release, 2018 notes that by 2050, this rapid urbanization could add around 2.5B of people to the urban areas. In urbanization, push and pull influences exist

such as Better financial conditions, enough job opportunities, living standards, citizen services, pull factors behind urbanization and poverty, lack of citizen facilities, the lack of economic opportunities, and a natural disaster could be the push factor [9,10].

Bangladesh's global population rank is 8th, and Bangladesh is one of the world's overcrowded countries with hasty population growth, according to Worldometer population data 2020 [11]. The urbanization rate in Bangladesh has increased significantly over the past century, particularly after the 1971 liberation war. But the rate of population growth is in a stable statistical position; the current population growth rate in 2019 is 1.03% [12]. As the population grows, people move to the city from rural areas for civic benefits, resulting in increasing urbanization. The urban population raised faster than the rural population between 2000 and 2010, and the urban population rate increased from 24.3 percent in 2000 to 31.4 percent in 2010 [11,12,13]. The country witnessed considerable urbanization after Bangladesh's independence in 1971, leading to an increasingly urban area population [14,15]. In 1975, 1985, 1995, 2005, 2015 and 2020 the urban population rate was respectively 10%, 18%, 22.4%, 27.7%, 35.4% and 39.4% [12]. Zaman et al., 2010 notes that about half of Bangladesh's total urban population lives in four cities: Dhaka, Chittogram, Rajshahi, and Khulna [11]. Those four divisions represent four different Bangladesh regions, as Dhaka the central part, Chattogram, Rajshahi, and Khulna respectively, Eastern, North, and the Southern part [9,18,26]. Over time, the number of urban centers in Bangladesh is also increasing. There were 48

urban centers in 1901 and then 108 in 1971, 500 in 1981, 532 in 2001, and 506 in 2011 [14,15].

2. Study Area and Data Source

2.1. Study Area

Cox's Bazar Sadar Upazila, located in Cox's Bazar district, Chattogram division, Bangladesh, is the study area for this research. The area of Cox's Bazar Sadar Upazila is 228.23 km² with 196.05 km² of land area and 3.50 km² of riverine area, according to the BBS&SID report, 2011 [15]. District Statistics 2011, Cox's Bazar report stat that the total population in Cox's Bazar Sadar Upazila was 459082, with 82683 households [16]. The Cox's Bazar Police Station was established in 1959, and The Town Committee was established in 1854. The town committee was demolished in 1972 and converted into a township, and the thana converted into an Upazila in 1983. Cox's Bazar Sadar Upazila is divided into ten unions, and Cox's Bazar Municipality is divided into 12 wards and 97 mahallas. Chakaria Upazila is situated on the north, respectively the Bay of Bengal, Ramu Upazila, and Maheshkhali Upazila are situated on the South, the East, and the West. Cox's Bazar Sadar Upazila can be divided into some zones like the Tourism area, the Hill forest area, Agriculture area, Salt and shrimp cultivation area. A tourism-based urban area covers the south part of Upazila. Many residential, commercial buildings, hotels are on this part.

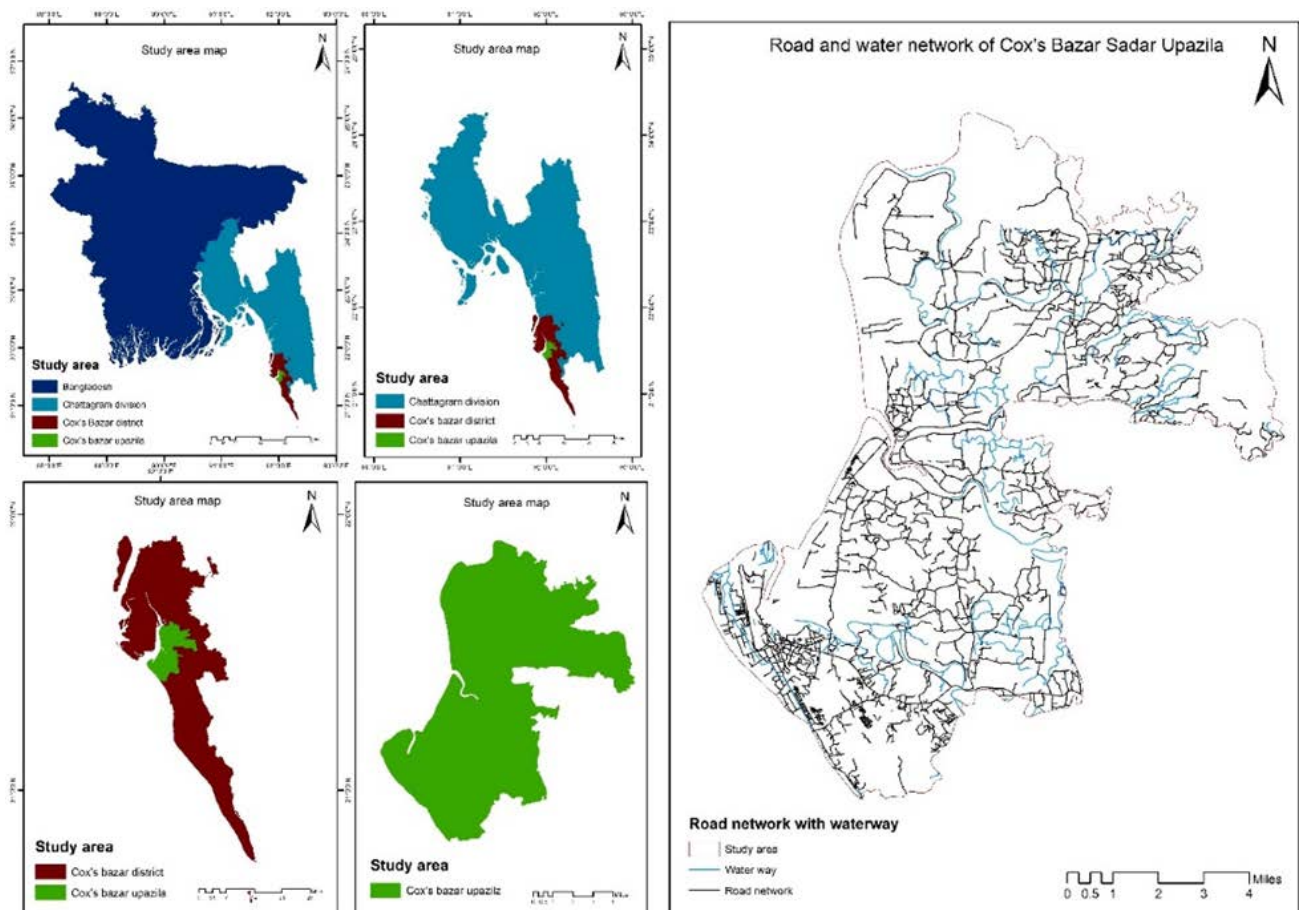


Figure 1. Study area (Cox's Bazar Sadar Upazila) (Source:Authors, 2021)

2.2. Data Source

In this study, several primary and secondary data sources are used from different sources. Primary data sources can be identified as those collected directly from the research area of the researcher, and Primary data generally collected from the source from which the data originates, and primary data often considered the best data source. The source of primary data is explicitly chosen to meet the requirements of a particular research. There are several methods for the primary data collection process example: Interviews, Surveys, Questionnaires, Observation, Focus group discussion. A total of 150 individual questionnaire surveys are taken in 3 specified important areas of Cox's Bazar Sadar Upazila. The Marine drive area, beach area, and main town area are specified as the survey area. Other primary data collected from direct field surveys and observation. Secondary has already been

collected in the past. Other researchers used primary data is used as secondary data. Several Books, Journals, Blogs, Web sites, Published and Unpublished sources, Thesis, Government records, Satellite images are the secondary data source. Data from 2005 to 2020 (15 years) is considered in this research. Four Multi-spectral Landsat satellite data from USGS are used for measuring the LULC, DEM map, Contour map, ASPECT map, and Feature map (Table 1, and Figure 6a, 6b, 6c, 6d, Figure 7a, 7b, 7c, 7d, Figure 8). This analysis considered cloud coverage under 10% on individual data analysis. Information regarding the satellite image is given below.

Using those satellite images, Land use and land cover maps (LULC), Digital Elevation Model (DEM) map, Countour maps, Aspects maps, TIN maps are prepared. The description of land cover categories is given below in Table 2.

Table 1. Information on Landsat satellite images

Year	Date	Sensor	Scene ID	Cloud cover
2005	25 th November	Landsat 5 TM	LT05L1TP136045200511252016112401T1	>10%
2010	23 th November	Landsat 5 TM	LT05L1TP136045201011232016101201T1	>10%
2015	5 th November	Landsat 8 OLI	LC08L1TP13604520151105201805201T1	>10%
2020	4 th February	Landsat 8 OLI	LC08L1TP136045202002042020021101T1	>10%

Source: US Geological Survey, 2020.

Table 2. Description of the land cover categories

Land cover types	Description
Hill Forest	Small and big Hills, Tress on hills.
River	Water bodies.
Salt and shrimp	Salt collecting areas, Shrimp farming areas.
Bare land	Agricultural land, bare soil, vacant soils.
Settlement	Human settelemetnts, trees.
Urban area	Residential area, commercial area, hotels, industrial area, road network, urban infrastructure.

3. Methods and Methodology

3.1. Methods

One of the appropriate and most common methods for identifying any kind of environmental effect is the Environmental Impact Assessment (EIA) method. The reasons for using EIA in this analysis are that EIA ensures supervisory acquiescence, offers inclusive coverage of a wide variety of social, economic, and physical impacts [17]. The EIA method also deliberates the secondary and increasing effects and the direct impacts, along with the difference between significant and marginal impacts [18]. The Checklist methods, the Networks method, the Matrices method, the Ad Hoc method, and the Map overlay technique are the five primary types of quantitative impact recognition techniques [19].

3.1.1. Checklist Method

The checklist method is an inclusive impact indicator of the environment and encourages the researcher to think critically about the consequences, also make them experts for making the decision with the limited technical

expertise when summarizing the details [11]. Scaling checklists gives an introductory level of analysis, and a weighting tool explains the integrating ecosystem functional information [17,20,21].

3.1.2. Overlay Map

An efficient visual aid is the overlay process [11]. Before implementing the project, the map overlay technique is useful as proof of current environmental conditions, both the geological and social aspects of the area underneath the study can be characterized, and the overlay technique is successful in considering sense lands, requiring human activity protection [17,20,22]. Renewable resource areas are essential to protect the environment from human activities [23].

3.2. Methodologies

To detect, anticipate, and value changes in action, EIA methodologies have been set up. The development of impact assessment methodologies focuses on the association of territorial elements with actions, precise measurements, and the necessary information for impact calculation, mitigation, restitution, and follow-up mechanisms.

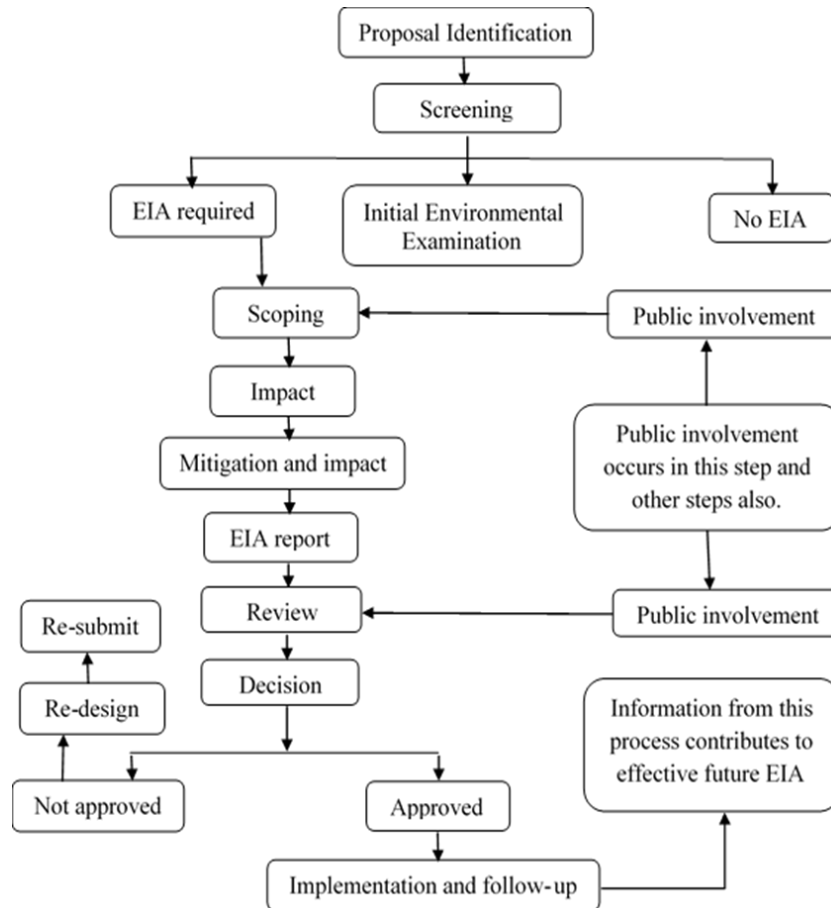


Figure 2. EIA flowchart

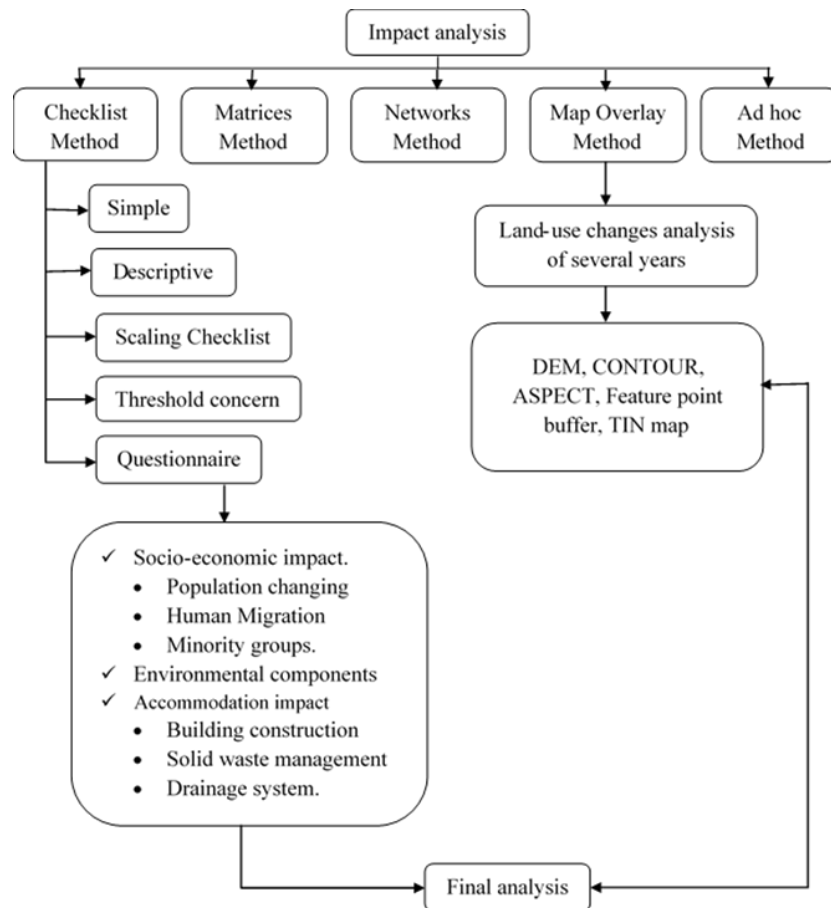


Figure 3. Flow chart of Impact Analysis

3.2.1. Screening

The first crucial decision of the Environmental Impact Assessment methods is the screening [20,24]. Screening is also intended to assess whether an EIA is needed for a proposal [20,24,25]. Therefore, the screening's conduct includes making a tentative assessment of a plan's expected environmental effect and its relative value [20]. For this reason, a certain level of the necessary information is needed about the proposal and its venue [24,26]. Depending on the laws or standards in effect, criteria on whether or not an EIA is needed will be country-specific and will also determine whether an EIA is required [24].

3.2.2. Scoping

Scoping is an early and crucial step in the preparation of an EIA. Scoping is also the method of defining critical environmental problems and can be the most significant step in an EIA [27]. The objective of scoping is to define the significant issues addressed in an EIA, the associated time and space limits of the EIA study, the information needed for decision-making, and the associated impacts and variables that need to be thoroughly assessed [20]. Several organizations, especially decision-makers, the local public, and the scientific community, are interested in deliberating on the issues to be discussed, and the scope is intended to decide their views [27].

3.2.3. Impact Analysis

Prediction work will begin after the scoping exercise has been completed and the relevant impacts to be measured have been identified [27]. A variety of EIA methodologies and methods for use in impact detection have been developed over time [20].

4. Result and Discussion

This section of the paper discusses the result and findings. According to the methodology, two methods of impact assessment on EIA are applied. Map overlay approach conducted through Land use and land cover satellite image analysis between several years; Digital Elevation Model (DEM) map, CONTOUR map, Aspect map, TIN map, and Road network map with waterbody analyzed. A questionnaire survey conducted in a field

survey shows different graphs and charts under the Checklist Method.

4.1. Map Overlay Method

By the Map overlay method, we can observe the difference between land use and land cover changes over several years with different geographical maps. Several types of map analysis methods are applied there. Satellite images and google earth data are used in this analysis, following sub-section showing those analyses.

4.1.1. Land use and Land Cover (LULC) Analysis

To get a clear picture of the past and present scenario of the land cover changes of the study area, the analysis of the LULC changes was carried out. The SFCC (Standard False Colour Composite) assumed the band combination of 5, 4, 1 during 2005, 2010 and the band combination of 7, 5, 3 during 2015, 2020 before the classification [28]. SFCC was generated to identify the training areas very quickly. A total of six training areas are selected for supervised classification, and those are Hill forest, River, Salt and shrimp, Settlement, Bare land, Urban area (Table 3). After the pre-processing and supervised classification, several land cover shown on the satellite images [29]. The shift in different land use and land cover groups in the studied areas increased and decreased over the period between 2005 and 2020 in response to different urban land use and land reclamation (Figure 3). The results showed that a pattern separated the shift in all land use land cover categories.

Table 3 shows the area occupied and the percentage of individual land cover types in Cox's Bazar Sadar Upazila during 2005, 2010, 2015, and 2020. The total study area is approximately 210 km², which is surrounded by green vegetation, salt, and shrimp cultivation [28]. From the classified image results of 2005 (Figure 6a, Table 3), we can notice that the total area of Hill forest was 37.89 km² counted 18.07% of the entire region. The urban area covered 4.5 km² (2.03%), bare land covered 75.22 km² (35.88%), river covered 3.32 km² (1.58%), settlement covered 38.07 km² (18.16%), salt & shrimp wrapped around 50.90 km² (24.28%) of the total area. The urban area was shallow in 2005 because urbanization was not enforced yet; agricultural activities such as crop, salt, shrimp cultivation, and local people lived in rural settlements.

Table 3. Land use and land cover area in Square Kilometer (km²) and Percentage.

Years	2005		2010		2015		2020	
	Area	%	Area	%	Area	%	Area	%
Hill forest	37.89	18.07	34.95	16.67	32.51	15.51	30.93	14.75
Urban area	4.25	2.03	20.88	9.96	29.81	14.22	41.04	19.58
Bare land	75.22	35.88	59.58	28.42	46.63	22.24	33.39	15.93
River	3.32	3.04	4.83	2.30	4.46	2.13	3.04	1.45
Settlement	38.07	18.16	47.02	22.43	55.87	26.65	61.46	29.32
Salt and Shrimp	50.90	24.28	42.39	20.22	40.37	19.25	39.78	18.97
Total	210	100	210	100	210	100	210	100

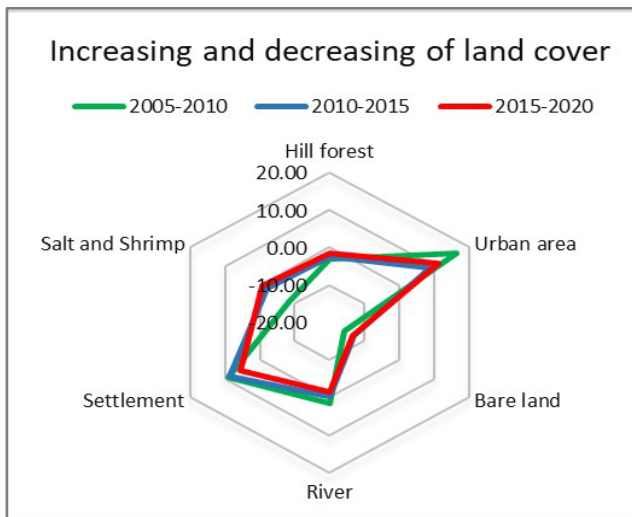


Figure 4. Radar chart on increasing and decreasing land cover

Urbanization began in 2010 as the urban area increased in greater numbers, reaching 4.25 km² (2.03% of the total

area) in 2005 and 20.88 km² (9.96% of the total area) in 2010. (Table 3, Figure 6b). The region of the Hill forest decreased compared to 2010 with 2005, the urban area increased (34.95 km², 16.67 percent), bare land decreased (59.58 km², 28.42 percent), rural settlement increased (47.02 km², 22.43 percent), the area of production of salt and shrimp decreased (42.39 km², 20.22 percent) (Table 3). The results of the categorized images shown in Table 3 and maps (Figure 6a, 6b, 6c, 6d) for the years 2005, 2010, 2015, and 2015 indicate how rapidly the urban area and rural settlement have increased, and the area of hill forest, bare land salt, and shrimp farming has decreased (Figure 4). From Table 3, In 2010, 2015,2020 urban areas respectively covered 20.88 km² (9.96%), 29.81 km² (14.22%) and 41.04 km² (19.58%). Hill forest area occupied 30.93 km² (14.75 % of total area) in 2020, 37.89 km² in 2005. Bare land area and salt & shrimp cultivation area occupied 33.39 km² (15.93%) and 39.78 km² (18.97%) in 2020, which was 75.22 km² (35.88%) and 50.90 km² (24.28%) respectively in 2005 (Table 3).

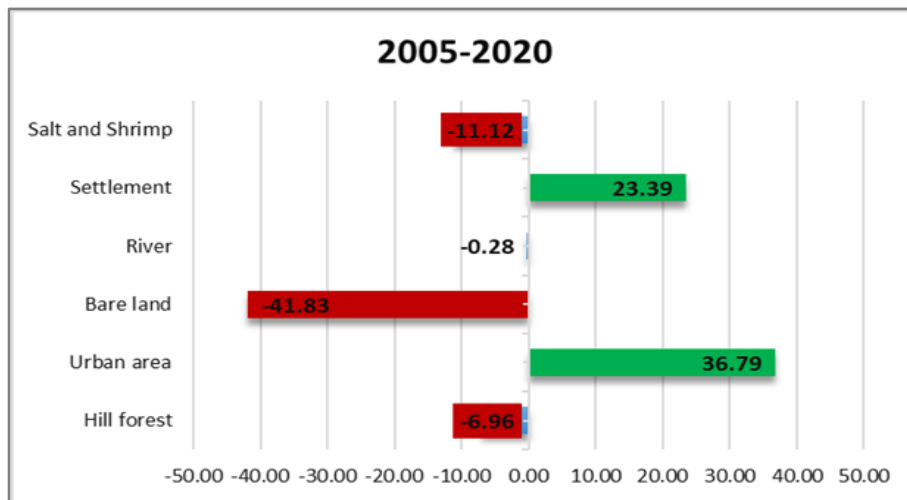


Figure 5. Comparison of land use and land cover from 2005 to 2020

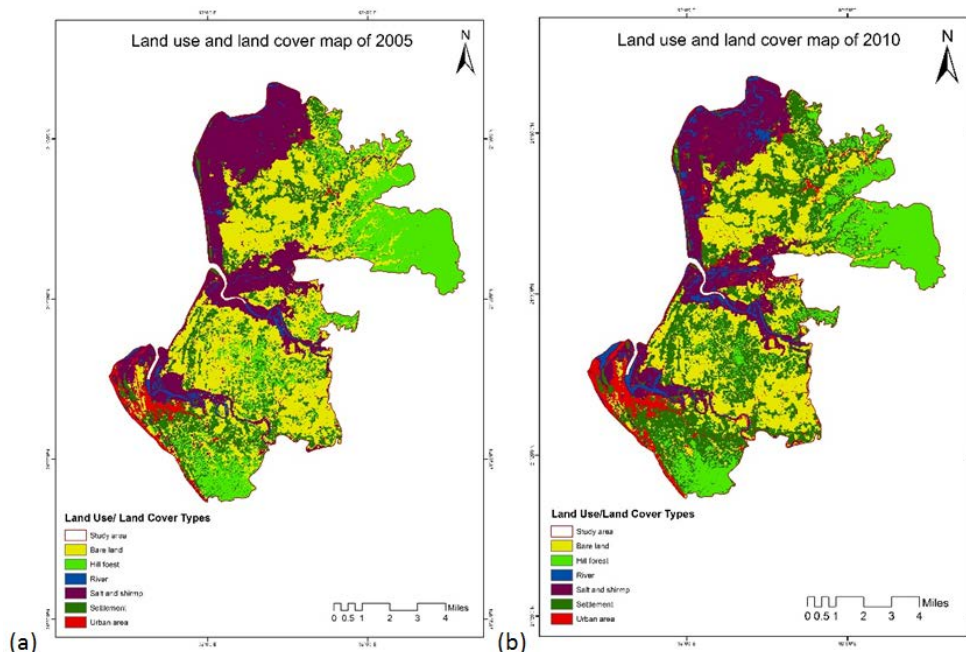


Figure 6a, b. Land use and land cover image classification of 2005 and 2010

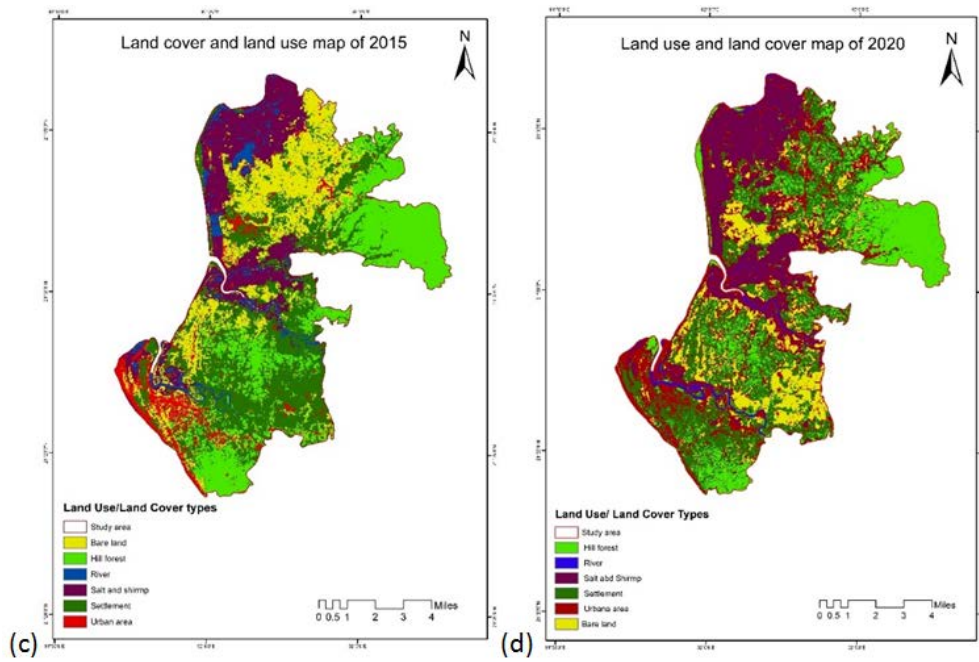


Figure 6c, d. Land use and land cover image classification of 2015 and 2020

Figure 5 showing the comparison of land use and land cover between the years 2005 to 2020. Salt and shrimp farming area decreased by 11.12 km², rural settlement increased by 23.39 km², bare land decreased dramatically by 41.43 km², the urban area increased by 36.79 km², and forests decreased by 6.96 km².

Red polygon covered the total area of the study area. Yellow, Light Green, Blue, Purple, Deep Green, and Red, respectively, are represented by Bare Ground, Hill Forest, River, Salt & Shrimp cultivation area, Rural settlement, and Urban area (Figure 6a, 6b, 6c, 6d). The portion of red and deep green has been increasing that indicates the increase of the urban area and rural settlement (Figure 6a, 6b). It decreases the light green and yellow

portion showing the decrease of Hill forest and Bare land.

The urban area has been spreading at a significant rate, Figure 6c, 6d showing that the red portion of the classified image has been increasing, representing the urban area of the study area.

4.1.2. DEM, CONTOUR, ASPECT, TIN Map Analysis

The Digital Elevation Model (DEM) can be termed as the raster files with elevation data for each of the raster cells. The DEM-based analysis is most suitable for manipulations, further analysis, area measurements [30]. The contour map can be defined as the demonstration of many curve lines on the earth's surface, and the comparative spacing between those lines designates the near slope of the surface.

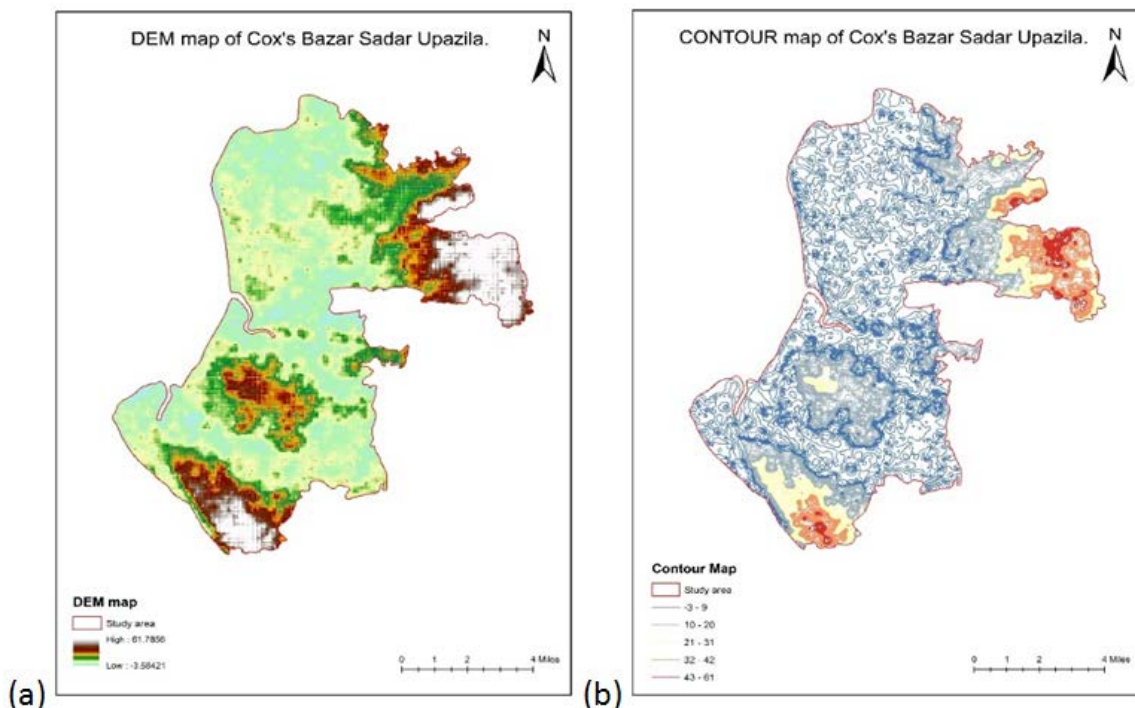


Figure 7. (a) Digital Elevation Model (DEM), 7(b) CONTOUR map

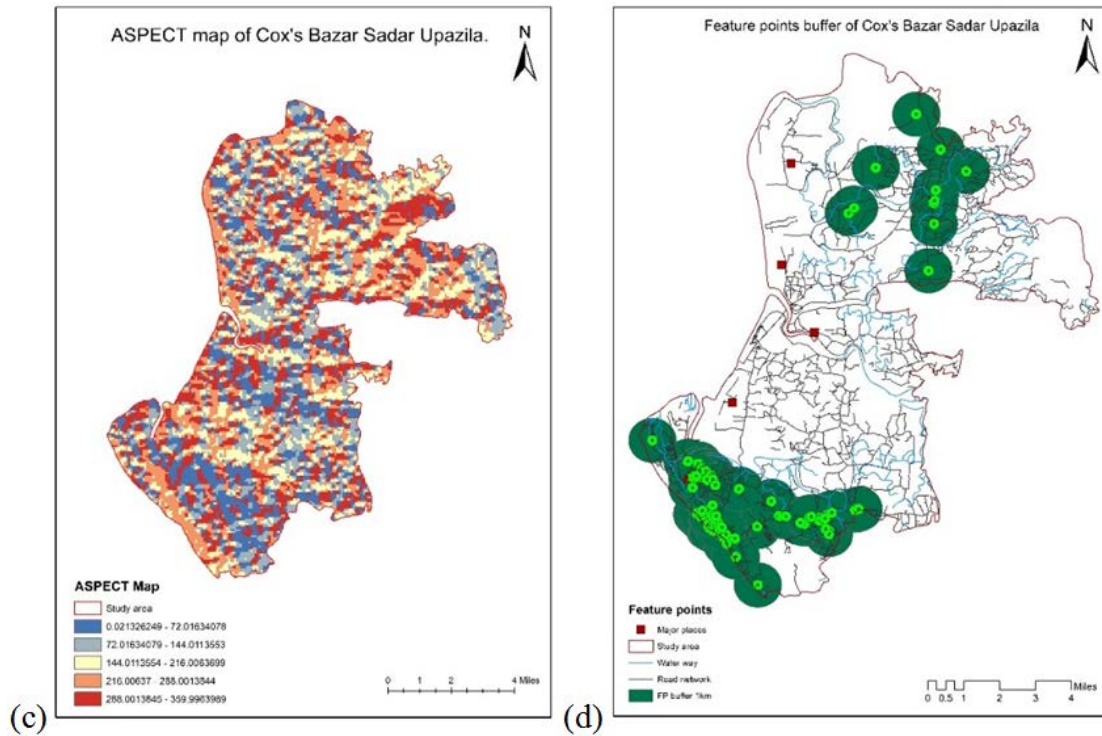


Figure 7. (c) ASPECT map 7(d) Buffer (2km) of the Feature point of the study area

Digital Elevation Model (DEM) map of Cox's Bazar Sadar Upazila shows the surface elevation that clearly explains surface character. As in our study area, there are few hill forest areas with green vegetation, and this hilly green vegetation is visible on the DEM map. The white portion of the figure shows the big hill forest zone, while the red and deep green part represents the small-sized hill forest zone (Figure 7a). The contour map is visualizing the height of different surface areas from the mean sea level (Figure 7b). It is imperative to understand the contour line of the surface. The aspect (direction) and degree (steepness) of the terrain slope are shown by an aspect-slope map [31]. When the land is level, it means there is no slope, no aspect, but considering mountains, there is all directions (north-facing, south-facing, east-facing, west-facing) are open [32].

The figure is representing the aspect map of the study area. Different detection of earth surface area is showing in this map. The digital point of many vital features like Hospitals, police stations, educational institutions, citizen service centers, etc., is represented in the figure with the road network. An area of a 2 km buffer is applied to understand the maximum facilitated zones. Top vital features and services are clustered into two-zone. One is the main Sadar area, and another is near the Salt and shrimp cultivation zone—figure showing clustered road network among those two zones.

The GIS community has been using Triangular Irregular Networks (TIN) as a digital way of representing surface morphology for many years, and it is also a type of digital geographic data based on vectors generated by triangulating a set of vertices [33]. By a tessellation of non-overlapping triangles, with elevations at their corners, the triangulated Irregular Network represents a topographic elevation surface. Develop a network of triangles; the vertices are connected with a bunch of edges, and there are distinct interpolation methods to develop these triangles, such as Delaunay triangulation or distance

ordering [33]. Wikigis, 2018 states that The rendering of the triangular facets readily produces three-dimensional visualizations [34]. The points can be widely spaced in regions with little variance in surface height, while the point density increases in areas with more extreme variation in size [35,36].

4.2. Checklist Method

A total of 150 questionnaire surveys were conducted in three different places in Cox's Bazar Sadar Upazila; those three areas are the Merine drive zone, the main beach zone, and the central town zone.

4.2.1. Marine Drive Zone

Marine drive area is the most southern part of the Upazila. However, the marine drive area is covered with hill forest vegetation and rural settlement, but many people move towards this area because of so close to the main urban area. Lots of hotels and resorts have been constructing in this zone. People have been Cutting down hills and trees, and buildings are rising rapidly.

Almost 66% of people felt that Cox's Bazar Sadar Upazila's rapid urbanization affected the coastal area near the marine drive zone (Figure 9a). The coastal environment has been damaging by urbanization, and people are moving towards this area as it provides a better living environment with nature. Another evidence over the matter that people are moving towards this area is the increasing amount of vehicles. Around 60% of people thought that the number of vehicles increased significantly, 30% of people felt minor changes, and 10% felt no vehicle number changes. On the other hand, 72% of people said a new transportation system should be introduced in this area. Among all newly constructed buildings, around 58% are residential structures, and 32% are hotels (Figure 9d). The facts are that 42% of them (58%) not following the

building construction law (Figure 9b). Around 74.19 % of people are not satisfied with the area's existing solid-waste management system (Figure 9c). There is no drainage

network in this area; people are much happy with the natural drainage system. Local people predict that this area may be the next suburban area of this Upazila.

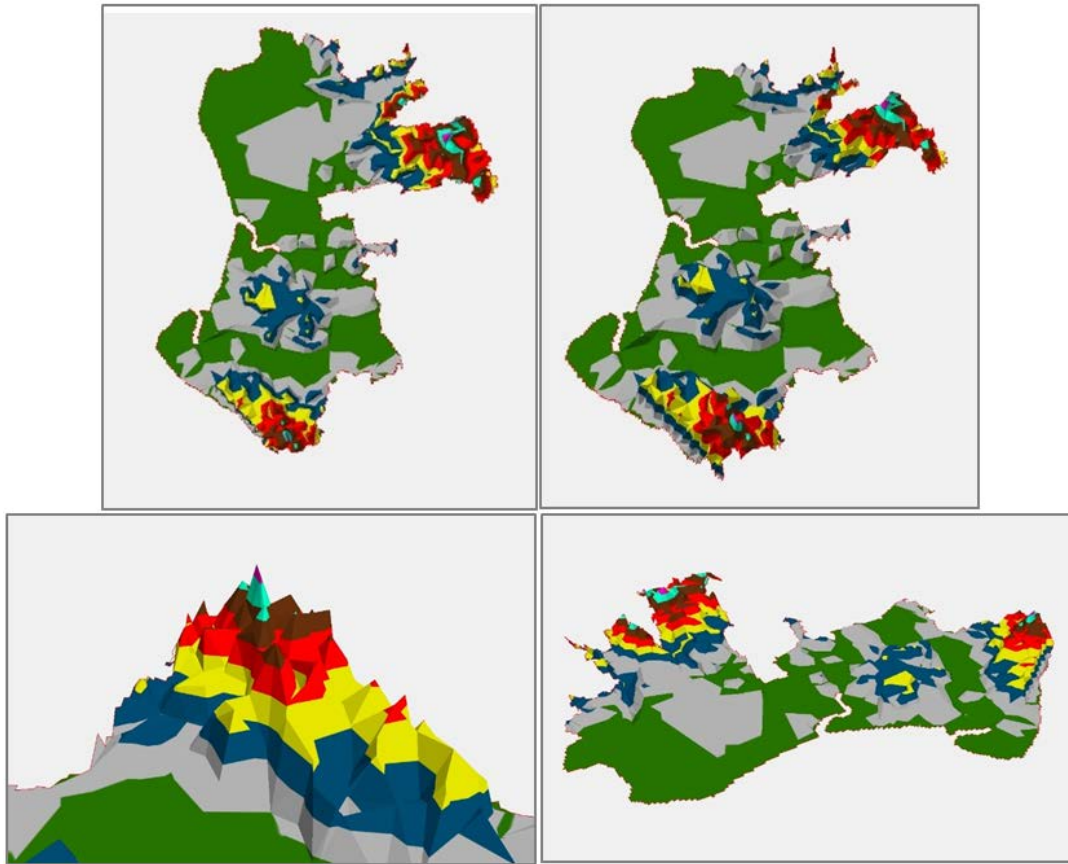


Figure 8. Triangular irregular networks (TIN) surface of the study area with the hill forest area

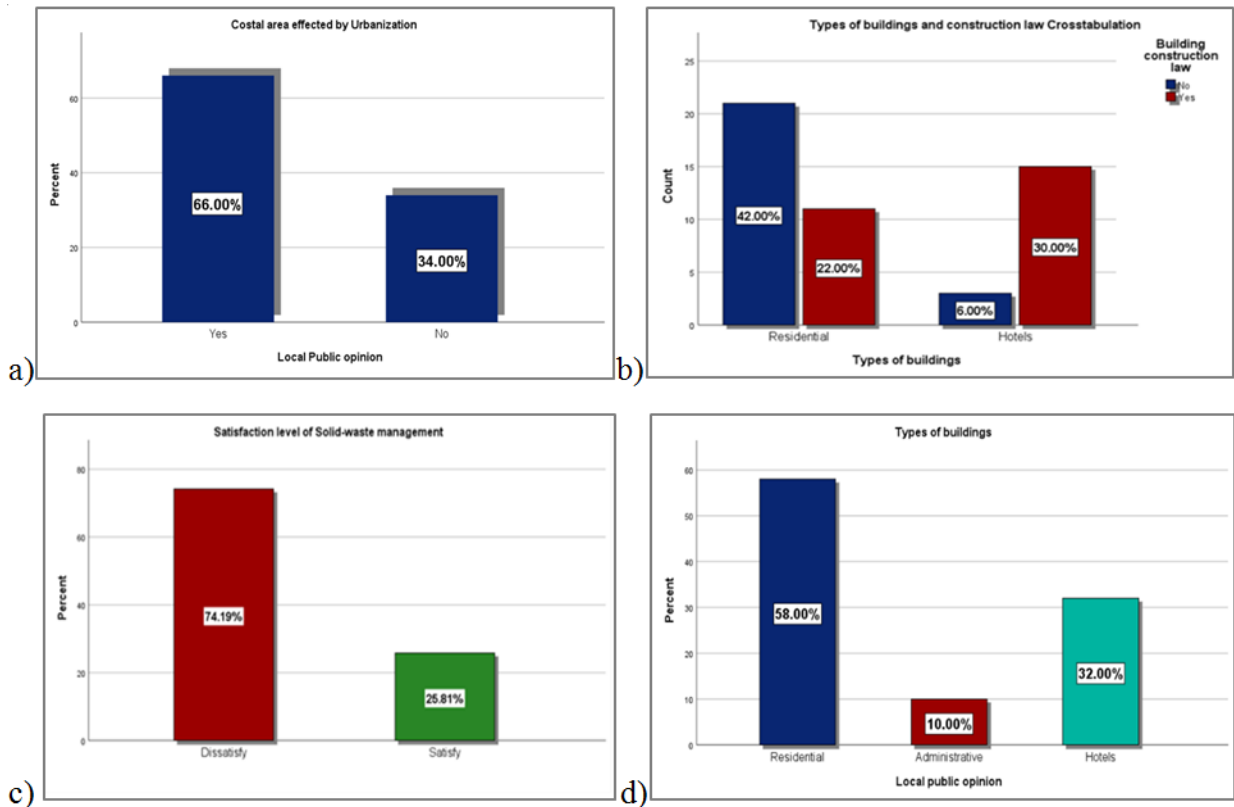


Figure 9. Local public opinion 9(a) About the impact of urbanization in the coastal area. 9(b) If the constructing buildings following building construction law. 9(c) Satisfaction level over solid waste management 9(d) Types of buildings

4.2.2. Main Sadar Area

The urban center of the Upazila is situated in the main Sadar area and packed with a vast population along with a significant number of residential, commercial buildings. Tourism and commercial activities make this area denser. All kinds of citizen and tourism facilities are available in this area.

Land use activity has been changing by the rapid urbanization according to 70% of people's opinion (Figure 10a). This urban area has been changing so dynamically, 42% of the people felt that the Sadar area

should introduce a new transportation system (Figure 10b). Local people are not happy with the current drainage system. Almost 48% of the local people felt that the existing drainage system is terrible; 24% of people said it "very bad" (Figure 10c). This considerable population and buildings require a tremendous amount of energy demand (According to figure 10d, 54% of people want a new energy system). The local people's living standard has been changing dramatically, maximum of them switch their profession from farming, fishing to business.

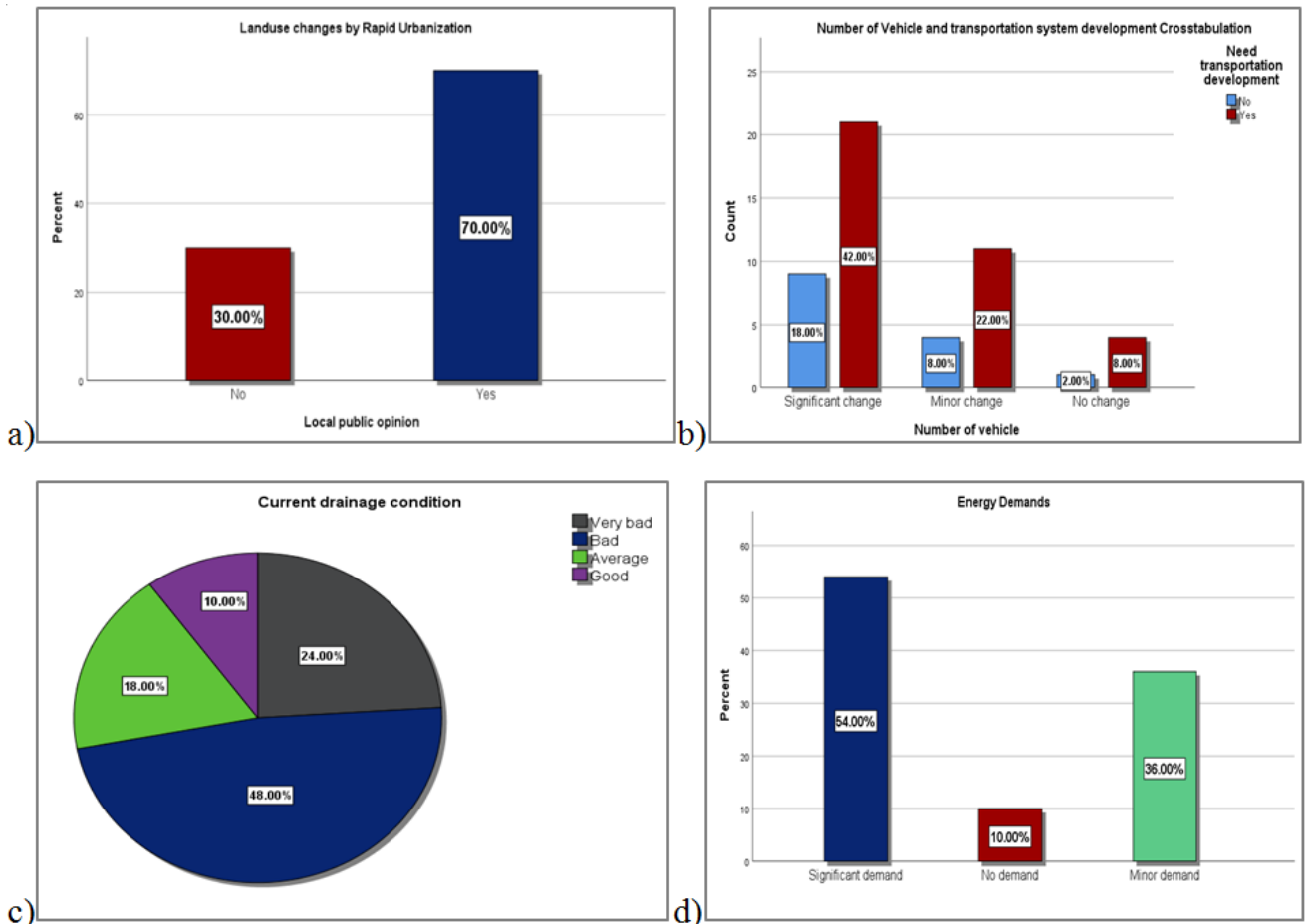


Figure 10. Local public opinion about 10(a) Land use changed by urbanization. 10(b) Crosstable between the number of vehicles and required a new transportation system. 10(c) Satisfaction level on current drainage condition 10(d) Energy demands

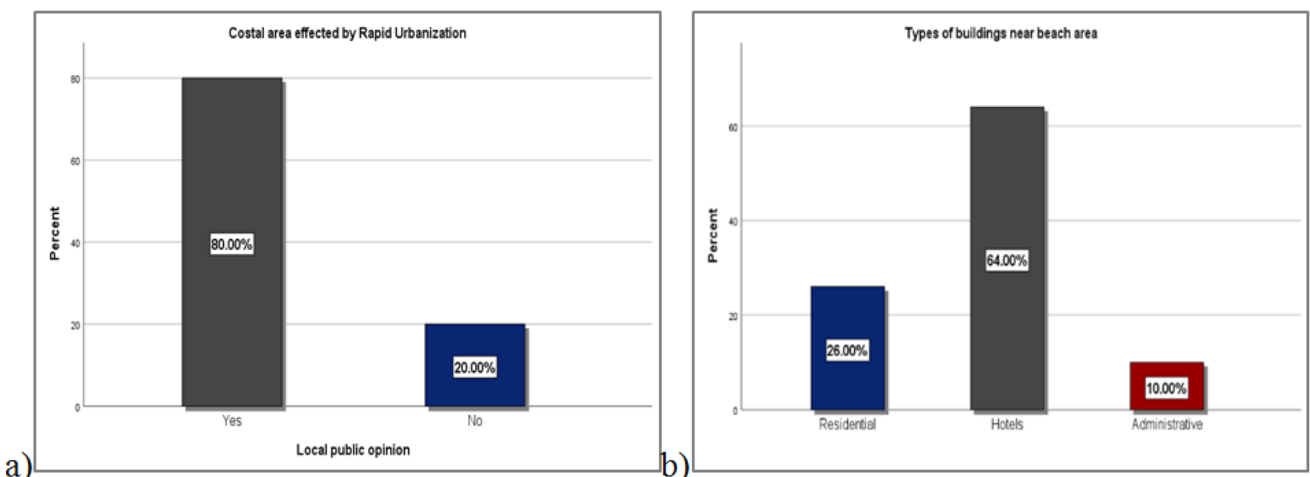


Figure 11.: Local people's opinion on 11(a) Coastal area is affected by urbanization. 11(b) Types of buildings construing much

4.2.3. Main beach Zone

This place is a prominent tourist spot, and with stunning natural sea beach views, it can also be said to be the most visited tourist spot worldwide. Over the past ten years, many commercial buildings, high-rise hotels, and buildings have been built in this area. The climate dramatically influences this portion of the research area.

According to the questionnaire survey, 80% of respondents say that urbanization affects the coastal region. The main sea beach area is dealt with by throwing plastic waste created by tourists and cutting down trees randomly to develop new hotels and markets.

5. Key Findings

The Hill forest area has decreased over the years 2005, 2010, 2015, and 2020, urban and rural settlements have increased, bare land and the area of cultivation of salt and shrimp has decreased. Bare land decreased by 41.83 km² from 2005 to 2020, while urban land rose by 36.79 km². People are moving significantly from the central urban area towards the Marine Drive zone (the southern part of the Upazila). Many Residential houses, Hotels, and resorts have been growing in the marine drive area. Local people felt that the coastal area was influenced by urbanization (66 percent in the sea drive region and 80 percent in the central beach region), and 70 percent felt that the land-use changes were affected by urbanization. According to residents' opinion, traffic levels and road networks have risen in an unplanned manner, and people often demand a newly built traffic network. The drainage system of Main Sadar and the main beach area did not satisfy the local population (74.19 percent of people are not happy in the Main Sadar region). Besides, this unplanned rapid urbanization has dramatically impacted the coastal climate.

6. Conclusion

Cox's Bazar sea beach is one of the busiest tourist spots in Bangladesh. Many local people depend on this beach area's tourism, and people have been moving towards the urban area and coastal area for better livings. This research is elaborating how badly the environment has been affecting over the years. Results show the Urban area of the study area is increasing at a significant rate (Urban area increased 36.79 km² between 2005 to 2020), Bare land is decreasing dynamically (Bare land decreased 41.83 km² between 2005 to 2020). Searching for better living people has been spreading in the urban area. People have been moving towards the southern part of the Upazila (Himchori region) as this area is vacant and near to the main city. More and more hotels, resorts have been constructing by cutting down lots of trees and cutting hills. This unplanned urbanization has become a curse for the environment and also for the natural species. Urbanization does increase the living standard, but we should not forget about the environment as well. Our coastal habitat has been affecting significantly, and unplanned urbanization should be taken under control and conserve our environment.

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