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Assessment of Ecosystem Services and Disservices in Urban Environment Using Multispectral Image Analysis and Geospatial Mapping

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ABSTRACT

Ecosystem service and disservice components have a great impact on the environment as well as on urban life. The aim of the research is to assess the impact of ecosystem services and disservices by tracking the change over a span of 15 years (2005-2020) using satellite image analysis. It was conducted in wards 23 and 29 of Khulna City Corporation (KCC), an area adjacent to the river. The overall work breakdown has been rounded up in a methodological framework which cleaved into two parts focusing on ecosystem services, disservices and multispectral image analysis steps. Multispectral image analysis has been done using Normalized Difference Vegetation Index (NDVI) and Normalized Difference Build-up Index (NDBI). On the other hand, geospatial analysis has been done using Digital Elevation Model (DEM), Service Area Analysis (SAV) and other mapping tool including Geographic Information System (GIS) to show the changed impact of both ecosystem components. The study areas attain provisioning, habitat, cultural and regulatory service components and the disservice elements have been sorted out according to sources. Comparative study showed increase in the buildup area; vegetation coverage because of increasing vegetation, cultivation and gardening practices; good weather and water circulation condition and water body conservation which has significant positive impact on the area. The disservice component like poor drainage condition and solid waste management system and risky infrastructures have negative impact, need to address for the betterment of residence and environment.

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1. INTRODUCTION

The trend of the fastest growing urbanization and internationalization creating a vast impact on the environment. Some of the impacts are increased population, developing industries with poor technologies, lack of proper provisioning and strong executing authority, unawareness is the reason for the environmental deterioration. This rapid urbanization has put compelling pressure on the urban ecosystem by biodiversity breakdown, habitat loss and environmental pollution (Tian *et al.,* 2020). Urban ecosystem glues a city and helps in building up a sound life with proper health, security and other core features of livelihood of the citizens (Bolund & Hunhammar, 1999; European Environment Agency, 2011; Odum, 1989; Tzoulas *et al.,* 2007). Also, it poses a negative effect on biodiversity and ecosystem and human well-being as well (Chabay, 2018). The urban ecosystem services usually refer to the opportunities provided by the urban ecosystem and its components (Andersson *et al.,* 2007; Gómez-Baggethun & Barton, 2013). Again ecosystem service is a heavy concept that presents the contribution of an ecosystem to human well-being (Isbell *et al.,* 2017). On the other hand ecosystem, disservice can be defined as feature, mechanism and properties of an environment which have created a perceived or actual detrimental effect on human well-being (Shackleton *et al.,* 2016).

Ecosystem-based researches are mainly focused on goods and services to identify the beneficial value to the ecosystem and humans as well (de Groot *et al*., 2010). When the output of the ecosystem for humans and the environment are positive it is termed as "ecosystem

services" the component incorporates for service termed as "ecosystem service components". On the other hand, if the outputs are harmful the same ecosystem and incorporating components termed as "ecosystem disservice" and "Ecosystem disservice component" respectively (Rasmussen *et al*., 2017; Schaubroeck, 2017). The ecosystem and wellbeing are closely linked (Rasmussen *et al*., 2017). The Colombian Caribbean region is one of the most biodiverse regions in the world helping human well-being providing essential ecosystem services at the local, national and global levels (Aldana-Domínguez *et al.*, 2017; Le Saout *et al.,* 2013). Besides the study on ecosystem services, the study on ecosystem disservices is also very important to achieve sustainability and improvement of urban life in a systematic way. Identifying the relationship between and ecosystem services and disservices and addressing the root causes of disservices may enhance environmental management and ecological protection *(*Sun *et al.*, 2020). For economic disservice, a study had done in the marine ecosystem in the Polish Baltic sea defining disservices to be sea level rise, sea floods, erosion, toxic bloom, eutrophication, pollution etc. (Lyytimäki *et al.,* 2008). Another study has been done in northwest of Beijing to identify the environmental problems based on ecosystem disserve bundles for better environment management measures (Sun *et al.*, 2020).

There are many studies on ecosystem services all over the world. Hanna *et al.*, 2018 studied riverine ecosystem service to suggest effective measure to protect and manage the riverine ecosystem service bundles; Smart *et al.*, 2011 applied the ecosystem service concept to manage air quality in UK, Maskell *et al*., 2013 studied the ecosystem services in Great Britain to explore the ecosystem constaints to service delivery and biodiversity. According to (Rendón *et al.,* 2019) a linkage was buildup between the services and disservices of the existing area using a methodological framework. In Bangladesh, Islam *et al.*, studied to identify the natural and anthropogenic drivers of change that affect the ecosystem services of the Sundarbans Mangrove regions in Khulna, Satkhira and Bagerhat districts of Khulna Division based on secondary data and field interview (Islam *et al.*, 2018); Sarker *et al.* also studied on the ecosystem of Sundarbans to identify the variables which drive the mangrove biodiversity (Sarker *et al.*, 2019. Another study is done by Alam and Mohammad on applied ecosystem approach of regulation, monitoring, and management of Sundarbans as suitable means of conservation and sustainable development (Alam & Mohammad, 2018). In Khulna city-related studies regarding environmental profiling (Rabbi *et al.*, 2021) and environmental risk zone identification (Haque *et al.*, 2020) have been done. Works have been done on mapping out blue ecosystem services in the wards of Khulna city *(*Haque *et al.,* 2019) but further study on the disservices and services on land has not been yet done on Khulna city.

This research fills the gap in several ways. The spatiotemporal change from 2005 to 2020 based on ecosystem service and disservice components and its impacts on urban life are analyzed. Spatial analysis like DEM and two indices named NDVI and NDBI using multispectral image analysis for both service and disservice components are performed here. For disservice elements identification, location-based GIS mapping was done to sort out components like open dustbins, lack of tube wells, clogged or untreated drains, and risky buildings of the area. The study also relates the services and disservices of the area using proper reasoning of the framework. These changes and figures have helped to come to a conclusion about the service and disservice elements and assess them accordingly. But the study was not free from limitations. Due to a smaller study area and limited time period, the change was not that significant . Besides the quality analysis of waterbody, existing atmosphere analysis of dust particles was not possible due to limited time and the emergence of the COVID-19 outbreak.

The principal objective of the study was to make profile of ecosystem service and disservice components of the study area. Emphasis has been given on the comparison of vegetation, build environment coverage. It was done by the NDVI and NDBI respectively. A time extent from year 2005 to 2020 was taken for the study. Here environmental service indicators were taken as ecosystem service components. It was done to assess the environmental condition by justifying their role.

2. STUDY AREA

The selected study area is ward no. 23 and 29, the two adjacent areas of Khulna City Corporation. The area fall in the the ancient part of Khulna city near the Rupsha River. These two wards of the KCC have been explored based on secondary data, google earth and google map and found that they attained more ecosystem components than other wards in terms of: 1. Provisions like edible plants, water supply, fiber and fuel and raw material and ornament and medicine resources; 2. Regulating like air Quality, Climate condition, water regulation etc. 3. Habitat or Supporting like Nursery and 4. Cultural and Amenity like recreational activity, cultural heritage, spiritual and religious inspiration. A reconnaissance survey was conducted in the wards. It was found that those these wards attain a rich amount of ecosystem service and disservice components compared to other wards of the KCC boundary. Furthermore, this study has focused on the core unit (ward) of the urban area. There are some disservice components like poor drainage construction and sewerage system, no proper solid waste management system, degradation of blue ecosystem components like water body, lack of dustbin, and risky and old infrastructures. But authorities' concern is not sufficient to solve these problems. Finally, as the area consented to the study aim appropriately, it was selected as study area. The boundary road of the area is Khan-Jahan-Ali Road, South Central Road, Upper Jashore Road and Rupsha Stand Road. The total number of households of ward 23 is 3226 and total population is 13793. The total number of households of ward 29 is 4230 and total population is 17763. The population density of the total study area is 1030 sq. km under the Khulna Sadar Thana. Ward 29 is predominately a residential area but ward 23 is a commercial area. The road network and circulation, and adequacy of utility services condition are

comparatively good but the condition of the drainage and water service are not in good condition. In the candidate study area, the earliest settlements of the Khulna were developed and many buildings are having the sign of ancient heritage. There is a Missionary Community in the area and contributes to enriching the bio-diversity of the area by means of cultivation, gardening, conservation of water bodies and ornamentation.

3. RESEARCH METHODOLOGY

Figure 1 showns the location of ward 23 and 29 in KCC boundary.

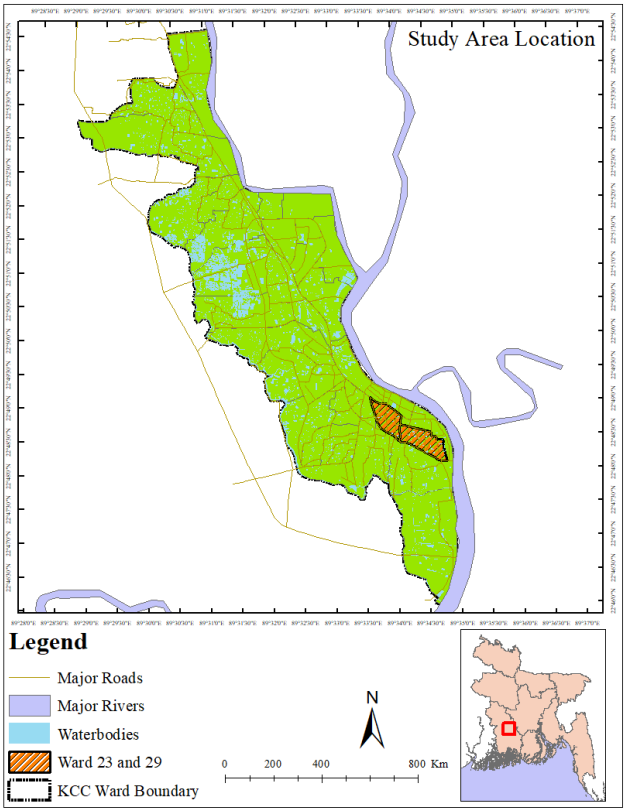

Figure 1: Location of ward 23 and 29 in KCC boundary

A . *Survey Design*

Firstly, a reconnaissance survey was conducted to know the overall environmental context and other features of the study area associated with ecosystem and environment. Data has been collected by questionnaire and checklist, prepared based on the available service and disservice components and the overall environmental condition of the study area from the observation of previous reconnaissance surveys. Among the bundle of service and disservice components, the accessible and available data were taken. The service components are water body, water supply point, agricultural land, greeneries, erosion protection, water regulation, cultural heritage and identity in the sense of place, design and belongings, spiritual and religious value, services comments, educational and scientific opportunities for formal and informal education and training (de Groot *et al.,* 2010) and the disservice components are waste dumping in the open places, risk of collapse and debris structures, sediment export on the water body (Sun *et al.*, 2020), poor drainage system, dust particles in the air. The survey based on the questionnaire was conducted in households and the checklist survey was conducted in both study areas and administration offices. Analysis was done based on the collected data. “Separation and Impact Analysis Methods” have been used where separation and discussion based on the impact of the elements were done. The desk analysis was based on a series of methods applied on the data retrieved from the field data collection. The obtained information was properly presented using mapping techniques in GIS. Further secondary data were collected from the USGS website for in-depth analysis of the study area for showing the temporal change.

B. *Technical Works for Presenting the Existing Scenario*

The service range of the dustbins which were only three in number was determined by creating a buffer of about 100m which was taken from the case study of Coimbatore India. The buffer tool of ArcGIS was used for this process. For determining the elevation of the areas, a tool known as the Training Center XML(TCX) converter was used and from google earth the latitude, longitude and altitude data were extracted and inserted in the TCX converter. Then processing the Inverse Distance Weighted (IDW), interpolation tool for Digital Elevation Model, in the ward boundary the elevation map of the area was determined. Waterbody depth data were collected in the field survey and Inverse Distance Weighted was also applied to determine the overall groundwater table in the area. Coordinates observed from field survey identified in google earth tool and converted the “.kml” file from there into shapefile points in GIS to locate open waste dumping point, tube well location, existing service facilities, deteriorated water bodies and risky infrastructures in the study area. Mainly these tools have helped to bring the study area in a precise and presentable manner.

C. *Methods Used in Spatiotemporal Indexing*

For a better understanding of the change in the study area environment temporal change was observed using satellite images extracted from the U.S. Geological Survey (USGS) website and the process followed is portrayed below:

i. *Data Collection and Preparation*

For image analysis LANDSAT images from 2005 and 2020 were taken from USGS (United State Geological Survey) website. The temporal gap was taken to observe the change in buildup area, vegetation and water bodies in the survey region. A primary survey was conducted to locate the places of prominent features of the area. The two LANDSAT images were Landsat 5 TM for 2005 and Landsat 8 OLI for 2020. The change of ecosystem components selected for the study and its impact are not evidencede in a short period. For this, an extent of 15 years time span has provided the research to explicate a significant change in ecosystem components and its impact on the area. The different electromagnetic radiations or the bands produced from these two satellites were used for determining processes such as Natural Difference Vegetative Index (NDVI), Natural Difference Water Index (NDWI) and Natural Difference Built-up Index (NDBI) defined in Table 1. The survey area a clear sky and free

from clouds during the early parts of month May during which the image from 2005 was taken and from the later parts of September from which the image from 2020 was taken. Both were free from cloud covers, then again while obtaining the data cloud covers have been taken to be less than 10% downloading from USGS. For both images, the path was 138 and the row was 44 with an image resolution of 30m.

Table 1
Showing the different band numbers and their attributes of the Landsat image indices

Indices	LANDSAT 8, OLI		LANDSAT 5, TM	
	Band number	Band attribute	Band number	Band attribute
NDVI	4 and 5	Visible red and NIR	3 and 4	Visible red and NIR
NDBI	5 and 6	NIR and SWIR	4 and 5	NIR and SWIR

ii. Multi-Spectral Image Dataset

The two sets of images taken here for modifications are from 2005 and 2020 which had the sensors TM (Thematic Mapper) and OLI (Operational Land Imager) respectively. The spectral resolution for both was 30m. To detect the change in vegetation and buildup area of the location, images from 13/04/2005 of LANDSAT 5 TM and 16/11/2020 of LANDSAT 8 OLI. Superior weather condition affects its transmission and scrambling (Sannier *et al.,* 2014). For this reason, data were taken from the weather condition which would give clear and accurate visuals and the least cloud cover. One of the affecting factors of sun azimuth and elevation are the differences that happen diurnally and seasonally (Singh, 1989). That is why which season to give the best results and the best time of the day was also taken into consideration. Table 2 presents the Multi-spectral image data description, of the two images used landsat-5 Thematic Mapper (TM) and landsat-8 Operation Land Imager (OLI).

Table 2
Multi-spectral image data description, of the two images used landsat-5 Thematic Mapper (TM) and landsat-8 Operation Land Imager (OLI)

Satellite	Sensor	Path/Row	DoY	Resolution (m)	Cloud cover (%)
Landsat-5 *(13 Apr. 2005)*	TM	138/44	120	30	10
Landsat-8 *(16 Nov. 2020)*	OLI	138/44	321	30	10

iii. Calculation of Normalized Difference Vegetation Index (NDVI)

NDVI shows the position of the good vegetation of the intended area. The darkest area is the greenest area and the brightest is the least green. For NDVI calculation two bands red and near-infrared radiation bands are used in the main equation. Here, the red band absorbs the most radiation and the near-infrared band radiates the most. The band no. 3 and 4 define red and near-infrared in Landsat-5 and for Landsat-8 it is band 4 and band 5.

$$NDVI = \frac{NIR - visible\ Red}{NIR + visible\ Red} \quad (1)$$

It varies from -1 to +1, -1 refers to the least number of vegetation and +1 the best vegetation present in the area.

iv. Calculation of Normalized Difference Build-Up Index (NDBI)

NDBI shows the condition of the buildup area of the region. The brightest area has least building conditions and the darkest area has dense buildings. For NDBI also two bands are used namely the short-wave infrared band and the near-infrared band. TheLandsat-5 calculation requires band 5 and 4 and for Landsat-8 it is band 6 and band 5.

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR} \quad (2)$$

The value of NDBI also ranges from -1 to +1 where +1 refers to the dense buildup area and -1 refers to the least density of area having buildings.

The land use distribution for NDVI from lowest to highest was a buildup area, paved road, grassland, shrubs and dense vegetation. And that for NDBI from lowest to highest is good vegetation, shrubs, bare land, metaled surface and buildup area. The lower limit and the higher limit of the NDVI and NDBI value were not the same but it needs to be normalized the value for corresponding category selection. For this, the value of the lower limit and the higher was calculated by averaging the all-lower limits and the higher limit respectively. Table 3 presents the Land use distribution, value range and category for NDVI and NDBI indices

Table 3
Land use distribution, value range and category for NDVI and NDBI indices (Haque et al., 2020)

NDVI Value Range	Category	Land Use	NDBI Value Range	Category	Land Use
0.004 – 0.072	Very Low	Build up Area	-0.183 – -0.067	Very Low	Good vegetation
0.072 – 0.118	Low	Paved Road	-0.067 – -0.001	Low	Shrubs
0.118 – 0.167	Moderate	Grass Land	-0.001 – 0.047	Moderate	Bare Land
0.167 – 0.227	Medium	Shrubs	0.047 – 0.088	Medium	Metaled Surface
0.227 – 0.360	High	Dense Vegetation	0.088 – 0.268	High	Build up Area

Here, the change in value has been categorized from very low to high, where the lowest value defines the lowest amount of the calculated index and the highest value defines the highest amount of that calculated index. For vegetation, it showed 0.227 – 0.36 which was categorized as high. The same went for NDBI where the highest and dense buildup area had the highest range of NDBI value. Here it was 0.088–0.268, for the dense buildup area the value range was -0.183 – -0.067. The land use was from good vegetation. The overall research was mainly divided into two parts, fieldwork and desk work. Fieldwork comprised the findings of the region profile and desk work was built around imagery analysis and presenting them using mapping techniques of ArcGIS.

Methodological framework of the overall research is presented in Fig. 2. NDVI it showed -0.004 – 0.072 for the metaled road so it was categorized as very low vegetation there.

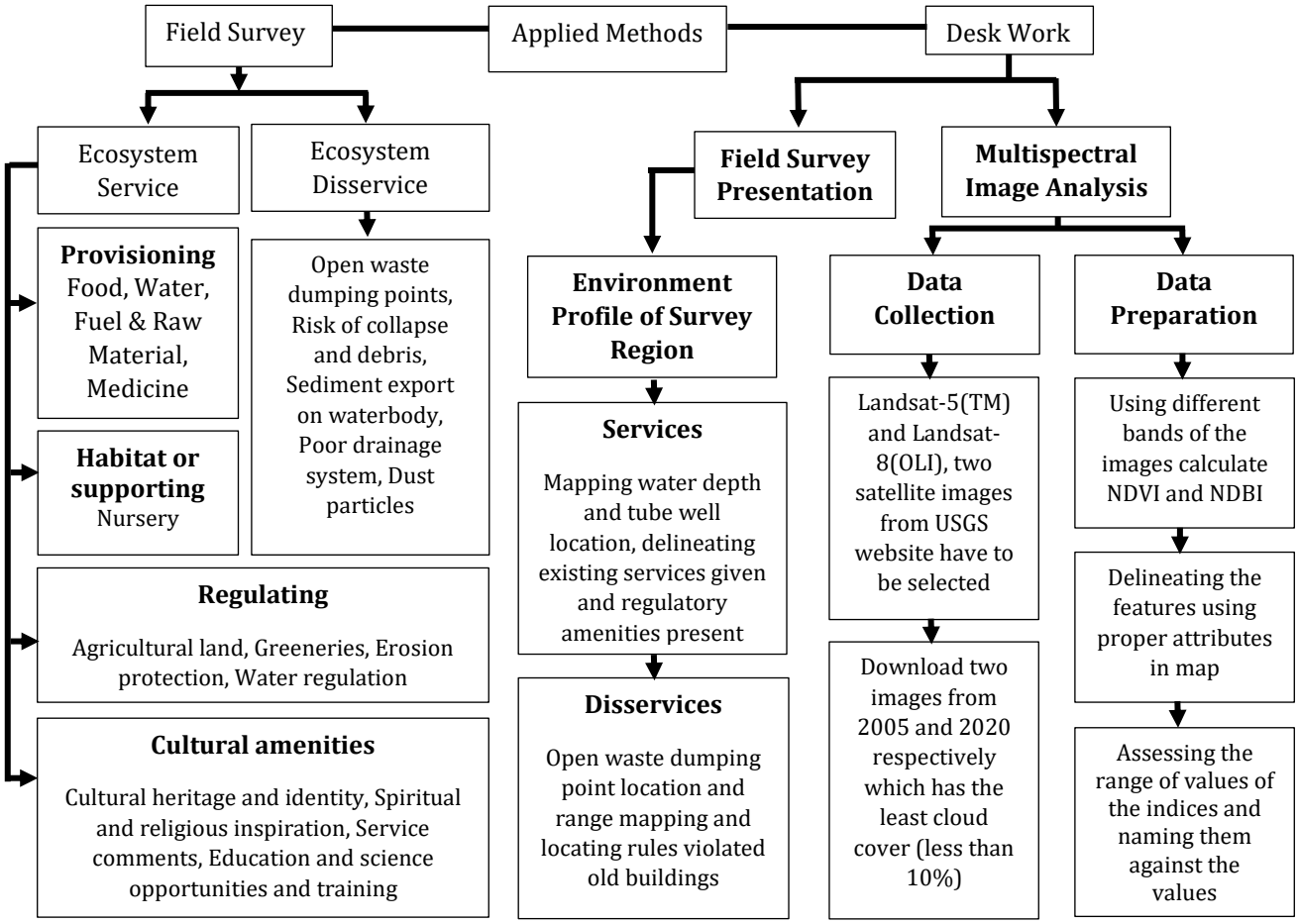

Figure 2: Methodological framework of the overall research

4. RESULT AND DISCUSSION

A. Temporal Change in Climatic Elements

The cloud coverage is positively correlated with humidity, rainfall determined by Random Effect Model (Rokonuzzaman & Rahman, 2017) but in the study area there is a negative impact on humidity as well as sunshine, and temperature is quite uncertain. Data of 2009 were taken because no compact data of 2005 was available for Khulna city. The data was collected from secondary source where meteorological data of every month from 2009 to 2020 are recorded. For ease of presentation and analysis it the twelve months have been categorized into major 4 seasons summer, monsoon, autumn and winter, and explained the findings as well. In 2020, the average precipitations between April to June and July to September are 226 mm and 589 mm, respectively which is recorded highest amount of rainfall since 2009 though there was no significant difference between the rainy day showed in Table 4. This record amount of rainfall and high visibility range for the year 2020 is correlated with cloud coverage, evaporation and declination of various kinds of pollutants for closing the industries all over the world in this pandemic situation for COVID-19. Table 4 also shows the humidity, sunny hour and sunny days which has a negative correlation with clouds coverage, precipitation, visibility range and wind speed in the year 2020 compared to 2009. Maximum and average wind speed shows a parallel relation but the trend breaks in 2019 and continued to 2020 for cyclone Foni (2019), super cyclone Amphan (2020), a heavy thunderstorm occurred in both years.

Table 4
Yearly change in the meteorological attributes

Components	Jan-Mar		Apr-Jun		Jul- Sept		Oct-Dec	
Year	09	20	09	20	09	20	09	20
Max. Avg. Temp (°c)	32	31	36	36	31	32	28	30
Min. Avg. Temp (°c)	18	19	27	26	26	27	19	21
Avg. Precipitation (mm)	3	27	70	226	200	589	40	322
Rain Days (No.)	6	17	50	69	91	91	20	30
Avg. Wind Speed (km/hr.)	8.3	8.6	11.5	14.87	9.4	14.7	7.1	8.3
Max. Wind Speed (km/hr.)	8.3	14.2	11.5	22.4	9.4	20.7	7.1	12.4
Visibility (km)	9.8	9.8	9.6	9.3	7	8.7	9.2	9.6
Cloud (%)	6	15	23	46	55	67	14	32
Humidity (%)	145	148	206	202	271	236	222	146
Sunny Days (No.)	81	74	30	22	1	1	69	31
Sunny Hr. (hr.)	258	282	352	206	214	143	226	191

B. Ecosystem Service Components

The more diversity in vegetation indicates the more enriched ecosystem and this rich ecosystem serves us a healthier environment in urban areas where life is stagnant in between the buildup areas, pollutions and so on. The NDVI and NDBI analysis represent a comparison from the year 2005 to 2020, it evident that the vegetation and building area playing an important role as ecosystem service components which is further described by image analysis in the next subsection.

i. Temporal Change in Vegetation Coverage

The comparative changes in vegetation type from the year 2005 to 2020 of KCC wards 23 and 29 are shown in Figure 3. From Table 5 ward 23 shrubs type vegetation increases by 225 km^2 and others decreased for predominately rooftop gardening and ground gardening. Table 5 also shows grass and dense vegetation land transformed into the buildings (mainly residential area) and the roof of the maximum buildings are adorned with different shrub type vegetation (filed observation). Inward 29 grassland, shrubs and dense vegetation increased by 1260, 1728 and 819 km^2 respectively from the year 2005 to 2020. This increased amount of vegetation indicates the area holding a rich ecosystem developed over time and that is resulted for mainly 3 reasons observed in filed survey, 1) The people of the Christian Missionary planting more shrubs, grass, dense vegetation like mango tree garden for beautification, eating, medicine, shade and other service purposes; 2) vegetation (grass, shrub and dense vegetation) growing on the surface of water body and edges more than before; 3) Rooftop gardening and road side plantation. As the band uses to develop NDVI mainly used for identification of vegetation, for rooftop gardening, road side planation and plants on the edge and surface of water body all seems as vegetation land rather than water body or build or paved area and for this the result from Table 6 shows significant amount of decrease in build area but the scenario is not real for both wards.

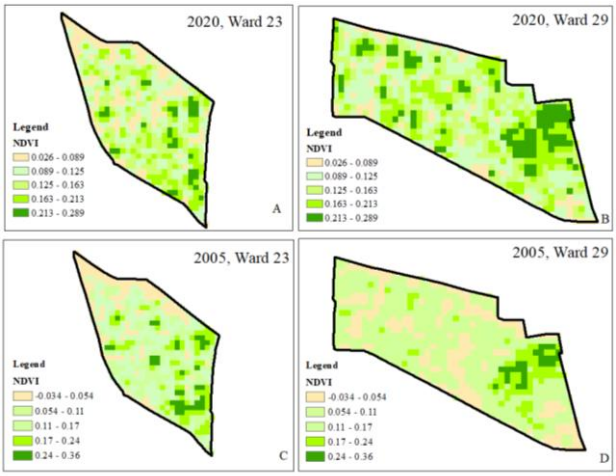

Figure 3: Normalized Difference Vegetation Index, (A) 2020, ward 23; (B) 2020, ward 29; (C) 2005, ward 23; and (D) 2005, ward 29

Table 5
Change in Vegetation Coverage from the Year 2005 to 2020

NDVI Value Range	Land Use	Area (km^2) Ward 23		Area (km^2) Ward 29	
		2005	2020	2005	2020
-0.04 – 0.09	Build-up Area	1044	1152	1764	180
0.09 – 0.13	Paver Road	1602	1512	2952	729
0.13 – 0.17	Grass Land	1494	1269	1197	2457
0.17 – 0.24	Shrubs	684	909	648	2376
0.24 – 0.36	Dense Veg.	324	306	243	1062

Table 6
Change in Build-up Area from the Year 2005 to 2020

NDBI Value Range	Land use	Area (km^2) Ward 23		Area (km^2) Ward 29	
		2005	2020	2005	2020
-0.293 – -0.098	Good veg.	306	297	324	315
-0.098 – -0.047	Shrubs	657	1008	873	738
-0.047 – -0.012	Bare Land	1494	1647	1755	1368
-0.012 – 0.19	Paved Surface	1647	1431	2205	2448
0.19 – 0.268	Buildup Area	1116	837	1647	1935

ii. Temporal Change in Building Areas

Changes in buildup areas represented in Figure 4 from the year 2005 to 2020 of KCC ward 23 and 29 indirectly

playing a role as an ecosystem service component. In ward 29, the paved surface and build-up areas have been increased by transforming the vegetation land and bare land but most of the buildings are modern residential buildings with rooftop gardening. The study area symbolizes the ancient settlement in the whole Khulna region near the river bank and most of the buildings are old-fashioned, reused for other purposes like schools, madrasas are often covered or beautified with vegetation and the new buildings are densely adorned with vegetation (Field observation). For this reason, the result of ward 23 was somehow distorted and it is false fully showing the increased amount of Bare Land and Shrubs and decrease amount of Metaled Land and Buildup Area whereas ward 29 and ward 23 are one of the most prominent developing commercial areas of Khulna city. So, the increased amount of build areas with vegetation are playing the role of a great ecosystem service component as a whole.

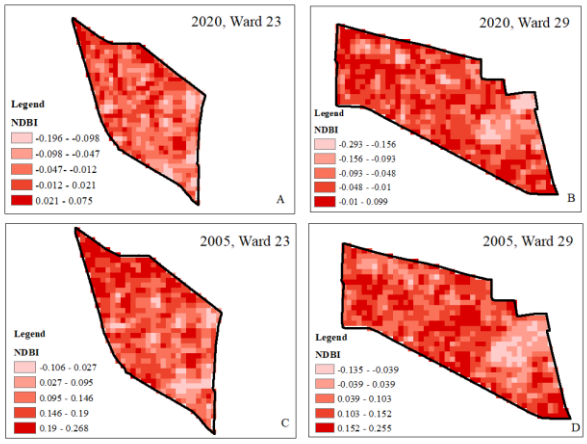

Figure 4: Normalized Difference Build-up Index, (A) 2020, ward 23; (B) 2020, ward 29; (C) 2005, ward 23; and (D) 2005, ward 29

Assessment of the component of four category indicators present in our study area and their importance discussed in the following points:

iii. Provisioning Service Indicators

Food, water body and water supply point and ornament species, these three are present in our area of the six indicators. Edible plants in both rooftop gardens and ground gardens, and animals from 2 poultry farms, fish storage farms serve food. The 50 water bodies in the area with an average depth of 7-8 ft. Minimum 4-5 ft. is enough for healthy aquaculture (Staff, 2018). These water bodies holding a rich aquaculture of them maximums are leased and private-owned, both of which are used for fisheries purpose. Ground water through road side community tube well and private electric motor means of water supply. Ornament species often use for beautification of every residences and institutions is like a characteristic of the area.

iv. Habitat or Supporting Indicators

Nursery is the only supporting service component present in the area. There are two big nurseries that cultivate and conserves different local species of flower, fruit and other

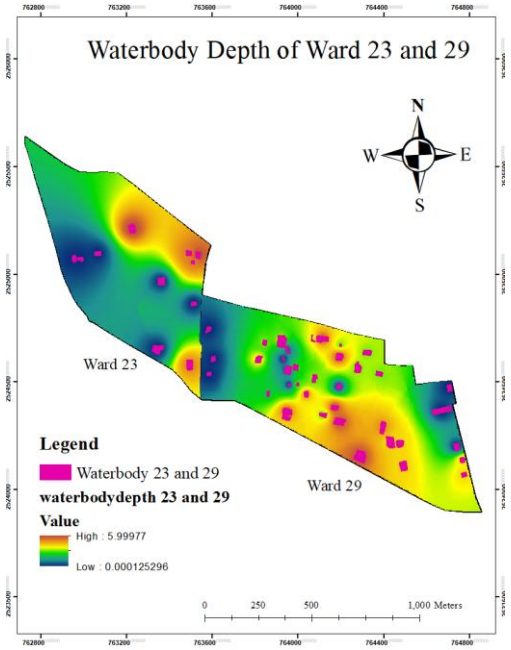

Figure 5: Waterbody depth

ornament species for commercial purpose or for scientific experiment for production of the healthy and superior plant, preservation of rare species and conserve the bio-diversity (Field observation) which enriching the ecosystem of the area.

iv. Regulating Service Indicators

Agricultural land, greeneries, erosion protection of the water bodies and water regulation are present as regulating service indicator. Under the ownership of the Christian missionary, most of the agricultural and vacant land

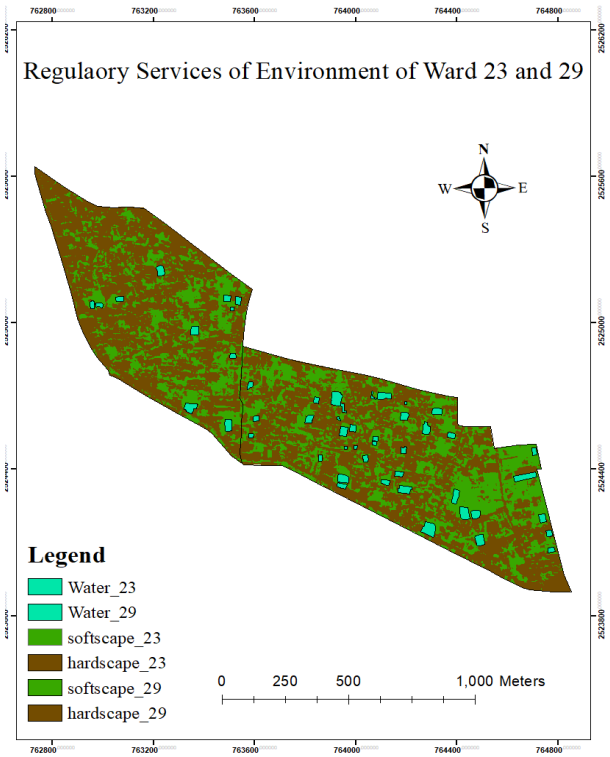

Figure 6: Regulatory services: Land use

cultivates vegetables, fruits, ornament species, herbal species and trees produce wood in both wards serving the people in many ways and holding a rich biodiversity culture trend. Other private vacant land in front of residential building and agricultural land use for gardening and cultivate vegetable or native fruits, shrubs and ornament species. There are four categories of greeneries based on height in our area such as 1. Big trees like mango, coconut, palm and herbal trees; 2. Medium height trees of fruits and flowers 3. Shrubs like flowers, ornament and darnel species. Except 3 water body 47 are embanked by soil and others are embanked by concrete. The soil type of the area is fine graded that tend to erode. Naturally developed grass and different big and medium height trees planted to prevent erosion of the earthen embankment. These water body are playing a vital role of regulating the water circulation and draining the storm water in the area. The old developed drainage condition of the area is very miserable. Blocked and broken drains are all full of waste and water cannot be drained out effectively through drains and resulted quick water logging and pollution. The amount of annual precipitation is 1736mm which is quite high but for the water bodies in the area water logging do stay more than one day even if in heavy rainfall condition. Regulating indicator presented in the study area serving a good environment effectively.

v. Cultural & Amenities Service Indicators

Cultural and amenities indicators of the area are 1. Cultural heritage and identity in the sense of place and belongings, 2. Spiritual and religious inspiration, 3. Education and science opportunities and training, 4. Dustbins 5. Amenities. Study area have the ancient settlement near the Rupsha river symbolizing the traditional Bengali architecture on building patterns and designs of old residential and religious buildings, educational and administrative institutions and restaurants are now playing the role as a sense of heritage and identity for the present generation. Presently the buildings have no warrior or public building are converted the use such as the old office of the General Deputy Postmaster of Khulna division converting to the museum, some residence like "White House" in ward 23 converted to a restaurant. Many mosques, two Hindu temples and one Church and graveyard of Christian serve as the religious and spiritual inspiration to the people of the study area. There are many schools, two colleges and one orphanage as an educational center in the area. Local Government Engineering Department is an experiment center that experiments with construction materials, road circulation and handles local level physical development. "Karitash" operated by Christian Missionaries and "BRAC" these two NGOs provide technical and skill development training and "AVA Center" serves as the training center of the people of the area. The area has all necessary urban amenities and utilities and dustbins for collection.

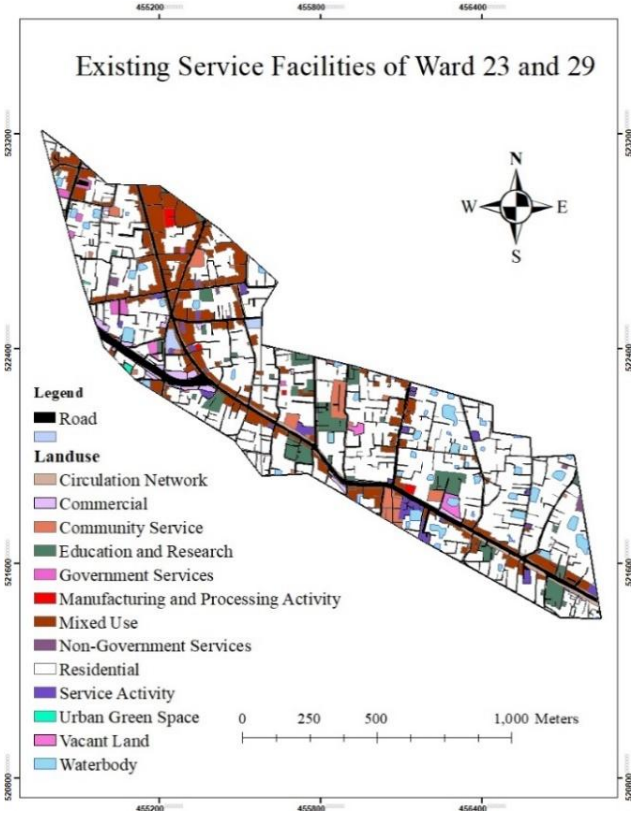

Figure 7: Service facility distribution

C. Ecosystem Dis-service Components

The study area has different disservice component that is not convenient, risky and hazardous in some cases. The following disservices are present in our study area:

i. Open Waste Dumping Points

There are only three waste dumping points in which a few amounts of people, are insufficient for gathering the waste generated by the people of the area. Moreover, the dustbins are open, Privatization of waste management systems,

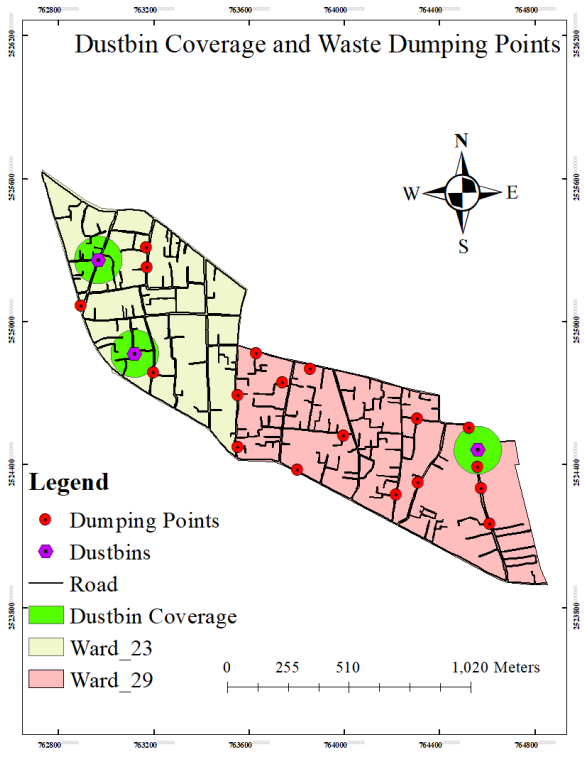

Figure 8: Maps showing waste dumping points and their range with pictures of those areas

irregularity of waste collection, just one-time waste collection per day and insufficiency of dustbins people throw waste in road sides, drains, water bodies and open spaces that so much unhealthy and in case of unmanaged clinical waste it is hazardous for the people of the area. Identification of the location of all the open waste dumping points have been done and 4 of them are beside the hospital and the clinical waste was kept open and scattered. In this pandemic situation this can cause severe health hazard for the people.

ii. Sediment Export on Water Body and Water Quality Degradation

Sediment export on some water bodies resulted from land filling, silt comes from water runoff and nearby contractions reduce the depth of the water body, toxic chemical contamination and degrades the water quality which is unhealthy for the aquaculture in some cases and posed threat to the ecosystem in the water body. Different types of water hyacinths, darnel species and waste in the surface of the water body (Location: 763928.16mE, 2524686.99 mN Figure 9(A) and 764065.21mE, 2524692.17 mN Figure 9(B) also degrades the water quality which can destroy the function of the water body and the ecosystem in it.

Figure 9: Water quality degradation on two areas A and B of the existing area

iii. Poor Drainage System

Open, blocked with a waste, broken slab of close drain resulted from poor construction method, damage of construction material for ending of the lifecycle of the construction material, poor maintenance, poor service capacity and abuse of the drains. The impact of the poor drainage system is waterlogging, insects bore for blockage, insect-borne diseases in the summer and winter (No water runoff happen then) season can cause a health hazard and mainly the drains are not functioning well. The area being low lying also posed negative effects.

iv. Violation of Rule and Risk of Collapse and Debris

Under the "Bangladesh Water Act 2013" Article S20 and S21states that structure is not allowed to be constructed above or in the embankment of the water body which would changes the water flow and deteriorated the water quality. But the office of the ward 29 is situated above a water body and a mosque is constructed close to embankment. Waste generated from the office and adjacent mosque continuously deteriorating the water quality. The slab of the drain which is mainly used for footpath are often broken. Old damaged residential building are still used by people which is very risky, can cause severe accident like death due to the collapse of the structures. The map in Figure 11 shows the risky old building which is still used for different purposes which were about four in number. The area being an old area the presence of old buildings was a unique characteristic of the region and the Figure 10 (a, b, c) shows some pictures of the risky buildings and structures on the survey region.

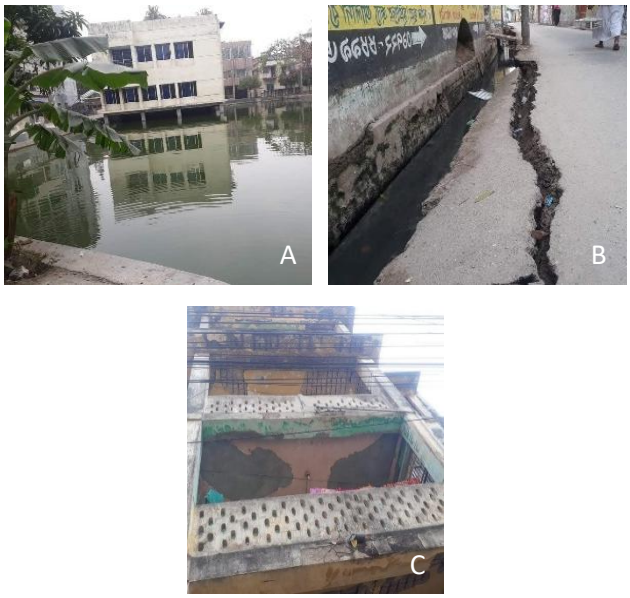

Figure 10: Violation of Rule and Risk of Collapse and Debris

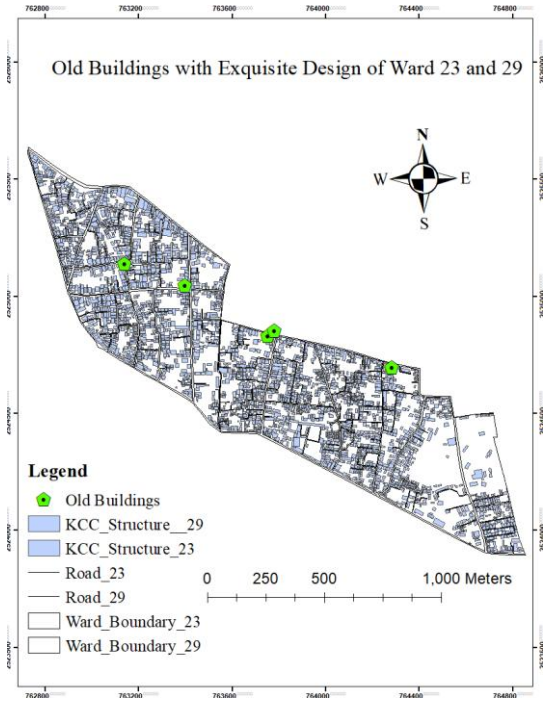

Figure 11: Risk prone old building location

5. CONCLUSIONS

The vegetation coverage of the area has shown satisfactory result over the year and indicates that improvement of a diverse and enriched ecosystem through increased vegetation, cultivation and gardening practices. With increase of buildup area, the rooftop gardening practice also indirectly balancing the impact of reduction of the

vegetation land in the ecosystem. The environmental service components have positioned the environment of the study area at a satisfactory level which ultimately is a positive sign for the urban environment and also balance the ecosystem as well. But the disservice element of the study area like open waste dumping points and drains, risk of collapsed and debris, sedimentation and water quality degradation, violation of rule are very inconvenient for people, environment and ecosystem of the study area. In some cases, it might pose a threat to people and street animals as well. The study addressed the change in environmental condition of the area over the years through imagery analysis but certain scopes were yet to be touched where blue ecosystem condition could have been analyzed. Also, in depth field data were not been able to be collected due to COVID-19 pandemic. So, the research is open for further investigation and analysis of both land and water ecosystem services sorting out the disservices and finding solutions for better overall environment condition.

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