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Land use classification system in Bangladesh: Inconsistencies, their planning implications, and the way forward

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Abstract

A unified land use classification system with mutually exclusive definitions of each land use category helps to avoid inconsistencies in the planning process and, most importantly, ensures effective implementation of development control tools. In Bangladesh, the planning authorities prepare land use plans by independently deciding the land use classes. This study aims to explore the nature of inconsistencies in the land use classification systems followed by different planning institutions in Bangladesh and understand their corresponding consequences. To conduct the study, land use plans prepared by different planning institutions have been collected. Based on descriptive analysis, the study shows that the types of land use classes in land use plans change over time, between administrative units, and in different parts of the country. Even authorities are not consistent in maintaining a classification system in their subsequent plans. Moreover, the plans retain ambiguous definitions of land use classes. The classification and definitions of the land use classes are not well linked with different national acts, rules, and policies relating to environmental and natural conservation, which makes it difficult to control development and protect natural, environmental, and cultural resources. This study has the potential to help us understand the importance of a unified land use classification system. Utilizing concept hierarchy, the study has also developed a system for land use classification in Bangladesh that will assist in future research, planning, and policymaking.

Highlights for public administration, management and planning:

- Land use classes were difficult to distinguish and compare because their types and definitions were inconsistent and sometimes overlapped.
- Less attention was paid by the authorities to defining and classifying land uses important for the environment and nature.
- The absence of a unified system and a lack of linkage between the classification systems and national acts or policies makes it difficult to legally protect environmental or natural resources from encroachment.
- A hierarchical system is proposed for land use classification in Bangladesh considering the shortcomings in the existing classifications.

Keywords

Land Use,
Hierarchy,
Classification system,
Spatial planning,
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1 Introduction

A land use classification system describes the names of the land use classes and the criteria to distinguish each of the classes. A clear and precise definition of land use class boundaries not only facilitates analysis of the spatial distribution of land use categories but also helps to formulate land use policies to guide development (European Communities 2001; LaGro 2005; Meinel & Hennersdorf 2002). Development authorities can accordingly prepare land use plans to ensure sustainable development.

Bangladesh, a South Asian country, got independence in 1971. The war-ravaged country adopted a sectoral planning approach for its overall devel-

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opment. During the 1960s, some traditional spatial planning practices were observed, particularly by major city development authorities. However, all of them faced severe challenges once the country experienced independence. The massive growth of the urban population and the expansion of urban areas, coupled with high population density, all started to become evident in an unplanned manner. Dhaka Improvement Trust (DIT), which is presently known as Rajdhani Unnayan Kartripakkha (RAJUK) (Capital City Development Authority), was established in 1956 and prepared the master plan for Dhaka in 1959 through British consultancy. The master plan was prepared to control the development of the capital city and regulate its land use distribution. The plan was rigid in nature. Thus, the plan could not tackle the event of independence and its associated consequences, like rapid urbanization, rural-urban migrations, etc. The authority took the fresh initiative of preparing a new land use plan for its capital city, Dhaka, during the 1980s. Unfortunately, that plan was never enacted. Meanwhile, a paradigm shift occurred (Nazem 2013). By the 1990s, RAJUK took the initiative to prepare strategic or structure plans instead of master plans for the Dhaka Metropolitan Area, covering an area of 1,528 square kilometers. Chittagong, Khulna, and Rajshahi Development Authorities (CDA, KDA, and RDA, respectively) took the same initiative for their respective cities as well. Apart from these major cities, in other municipalities where development authorities do not exist, two other national organizations, the Urban Development Directorate (UDD) and the Local Government Engineering Department (LGED), took on the responsibilities of city planning. UDD has been working since 1965, preparing plans for important towns and other municipalities. The shift from traditional master planning to strategic planning is also evident in UDD's plans. LGED initially started its journey by providing basic services in urban areas. However, over the last decade, it has directly been involved in the plan-making process. Recently, it has been involved in preparing upazila (a subunit of districts) development plans (Nazem 2013).

The brief introduction of the planning institutions clarifies that six government institutions in Bangladesh are directly involved in spatial planning practices in the country. They are preparing land use plans at the local level for specific planning areas. This study focuses on the land use classification systems adopted by the planning authorities while preparing land use plans over the decades. It is often observed that different planning authorities, while proposing land use plans, provide their own land use classifications that are not consistent with each other and also vary across time. Authorities independently decide the land use classes, which sometimes get criticized by researchers, activists, and environmentalists as such classification systems jeopardize environmental and social goals. For example, in the "Dhaka Metropolitan Development Plan (DMDP) 1995–2015" prepared under RAJUK, policies were formed for the protection of the flood flow zone and retention ponds. "Main Flood Flow Zones" and "Sub Flood Flow Zones" along the major rivers were identified in this plan. But, in the Detailed Area Plan (DAP), which should have followed the policies of the structure plan, the "Sub Flood Flow Zone" was absent and it was merged with other land use zones (Barua et al. 2016). Thus, inconsistencies are seen even within the land use plans of the same authority. Lack of clear guidelines and loopholes in land use plans eventually allow land grabbers to encroach on environmentally sensitive areas (World Bank 2008), making the land use allocation process critically complex with multiple stakeholders involved in an acutely land-scarce setting (Haque & Asami 2014).

However, a land use classification system should follow some principles that are to be sound and applicable with flexibility. It should allow for aggregation and be comprehensive so that all areas can fit within a class (Theobald 2014). The system should be applicable to different sites or regions in the geographic area under consideration. The classification system should have mutually exclusive classes without overlapping, and there should be a possibility to include new classes. Appropriate criteria should be defined according to which the uses will be put under the appropriate classes (European Communities 2001; Meinel & Hennersdorf 2002). Moreover, the land use classification system should remain unified across the country as it facilitates the comparison of land use across time and space. A unified land use classification system can be effectively used in a broad range of policies, including land use planning, statistics, and other relevant studies. The higher levels of land use in hierarchical systems, in particular, should be uniform and acceptable across the country. A unified land use classification system can also prove to be flexible in the sense that it can be used by people of different professions, including land use planners, researchers, and land evaluators, to disseminate information (European Communities 2001; Mücher et al. 1993). Unfortunately, as discussed, no standard or unified system or manual for land use classification has yet been developed in Bangladesh.

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The practice of developing a framework/system/manual for land use classification is evident worldwide from an early age to the last decade and has a long history. Some of them are for the classification of land use, and some of them are for the classification of both land cover and land use (Briassoulis 2000). For example, the ”Detroit Metropolitan Area Land Use Classification Manual, 1962,” developed by the Detroit Metropolitan Area Regional Planning Commission, is one of the most renowned classification systems. The primary objective was to develop a system that can be used easily both to indicate all of the land uses in an entire region and to analyze in detail the land uses in a small area. They also developed a coding system so that they could compare land use categories across different metropolitan areas (Detroit Metropolitan Area Regional Planning Commission 1962). US urban planners developed ”Land-Based Classification Standards, 2001” under the American Planning Association (APA), which distinguishes activity, function, structure, site, and ownership characteristics of the land in a hierarchical classification with a coding system. They considered these five characteristics of land to make it flexible for various planning applications (LBSC 2001). The Michigan Department of Natural Resources, the State of Michigan developed the ”Michigan Land Cover/Use Classification System, 2012,” which is a multilevel and hierarchical system. It classified land use and cover into about 500 categories, with higher-level categories based on land cover and use (Lusch & Goodwin 2012).
Again, some classification systems were developed in different countries for special types of land uses, such as agriculture, forests, woodlands, parks, and playgrounds, considering their importance in preservation and protection (Briassoulis 2000). The Food and Agricultural Organization (FAO) developed a widely used land use classification system, particularly for agricultural use. The FAO considered overlapping in land use classes, unclear definitions of the criteria, the absence of a definition of the unit of analysis, and the absence of quantitative class boundaries and proposed a classification system that is sound and universally applicable (Mücher et al. 1993).
Under such circumstances, the present study aims at exploring the nature of inconsistencies in land use classification systems followed by the planning authorities in the country and their subsequent consequences. This study has the potential to provide a record or proof of inconsistencies or irregularities resulting from the absence of a unified classification system. Such efforts will help relevant stakeholders realize the importance of a unified land use classification system. Furthermore, this study has also developed a system for land use classification in Bangladesh that will assist in future research, planning, and policymaking.

2 Materials and method

2.1 Data

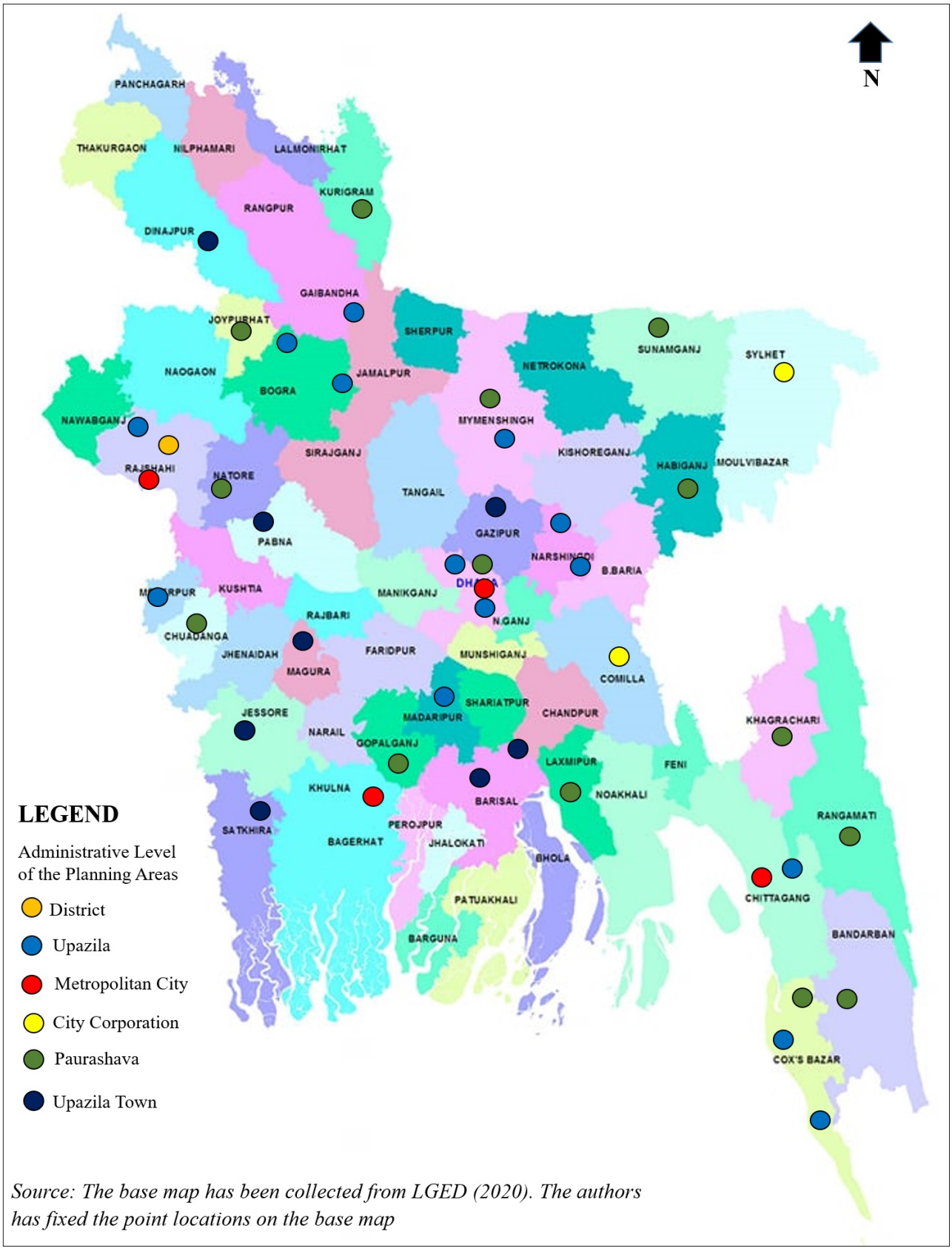
To carry out the study, 95 land use plans, including ”Traditional Master Plans,” ”Structure Plans,” midterm plans (”Urban Area Plans,” ”Rural Area Plans,” and ”Land Use Plans,”) and ”Detailed Area Plans,” prepared by six planning authorities in Bangladesh, were collected. The authorities were approached by visiting their offices and through mail. The target was to collect all the plans that the authority could provide. But certain limitations were faced while collecting these plans. Because planning in Bangladesh began relatively late, the number of land use plans is small. Adding to it, sometimes positive feedback did not come in time from the authorities. Some plans were partially collected, i.e., some plans had only land use maps with no other supporting materials or reports.

Table 1 Distribution of collected plans prepared under different planning institutions according to the year of plan preparation

Time Frame (year of plan preparation)	RAJUK (City development authority for Dhaka)	CDA (City development authority for Chittagong)	KDA (City development authority for Khulna)	RDA (City development authority for Rajshahi)	UDD (Urban Development Directorate)	LGED (Local Government Engineering Department)
Before 1992	1				14	
1992 to 2005	3	2	2	3		
2006 to 2017	1	1	1		5	9
After 2017	1				40	12

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Source: The base map has been collected from LGED (2020). The authors has fixed the point locations on the base map

Fig. 1 Location of planning areas of the collected plans at different administrative levels

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Plans prepared from 1959 to 2019 were collected and arranged in four time periods to show variations over time, as shown in Table 1. These periods were decided based on the shift in planning approaches or the updating of previous plans. Before 1992, mostly traditional master plans were prepared by the authorities. Following 1992, various planning authorities such as RAJUK, KDA, CDA, and RDA began to shift away from the traditional master planning approach and provide structure plans.

From 2006 to 2017, these authorities mostly provided detailed area plans of their respective structure plans, which they provided earlier or revised. During this period, institutes like UDD and LGED started to provide strategic development plans for different upazilas, city corporations, and municipalities across the country. And lastly, the most recent plans that were prepared after 2017 included the Draft Dhaka Metropolitan Region Detailed Area Plan, 2016–2035, by RAJUK; Development Plans for Fourteen Upazilas, 2013–2033, by UDD; and development plans for different Municipalities, 2017–2037, by LGED.

As shown in Fig. 1, all of these collected plans are prepared for different areas across the country at different administrative levels, including districts, upazilas, metropolitan cities, city corporations, municipalities, and upazila towns. Plans were collected from all eight divisions of Bangladesh, which will help to analyze the land use classes across geographical locations.

2.2 Data analysis

For each collected plan, data concerning the authority, legal status of the plan, year of plan preparation, planning period, level of the plan, purpose of the land use plan, presence of hierarchy in the classification, number of levels in the hierarchy, number of land use classes, and definition of each class were analyzed to identify variations over time, geographic location, administrative units, and between or within the planning institutions or authorities. Descriptive analysis was performed on the quantitative variables using the Statistical Package for the Social Sciences (SPSS). Through the preparation of summary tables, qualitative analysis was also performed to analyze the variables, including ”purpose of land use plan”, and ”definition of land use class.” The outputs have been presented in tables and graphs.

2.3 Case studies

In order to analyze the consequences that could arise due to inconsistencies in the land use classification system systematically, some real-life experiences were included. The approach was to present some court cases that were mainly public interest litigation and were filed by organizations working for human rights and environmental justice. The cases were purposively selected to represent the consequences on environmental, natural, or cultural resources in particular.

2.4 Developing a hierarchical land use classification system for Bangladesh

A land use classification system was developed using the technique of Concept Hierarchy for nominal data. It is a sequence of mappings from low-level concepts to higher-level concepts. Though it may seem a tedious and time-consuming task for a user to manually define the concept hierarchy, many hierarchies can be implied within the database schema and can be automatically defined (Han et al. 2012). This study dealt with the nominal attribute ‘land use’ to generate a hierarchical framework. As concept hierarchy generation for nominal data requires defining the ordering among the attributes, the ordering among the attributes, i.e., ”land uses,” was identified from the hierarchies in the collected plans (Fig. 2).

3 Result

3.1 Purpose of land use plans

Land use classification depends on the purpose of the classification. With the change of purpose, land use classification varies too (Mücher et al. 1993). The purposes of the land use plans could be gleaned from 35 out of 95 of the collected plans, which were compiled in a summary table according to the level of plan and the authorities who prepared the plans. Fig. 3 provides a briefer representation of the summary table.

The collected ”Traditional Master Plan” and ”Rural Area Plan” had no discernible purpose. The purpose of land use plans did not differ depending on the level of plan or the authorities that prepared the plans. For almost all the plans, the purposes were to guide or regulate long-term growth and development in an orderly and planned manner and also to protect natural and environmental resources like agricultural land to ensure compatible and environ-

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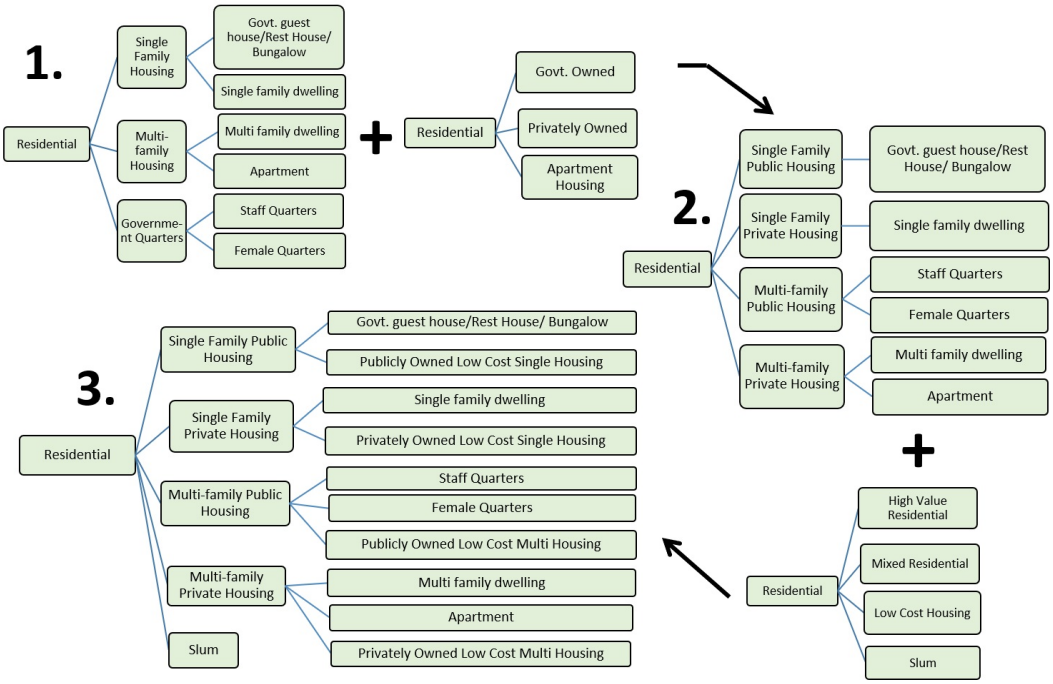


Fig. 2 Simplified example of application of Concept Hierarchy to develop the hierarchical land use classification system

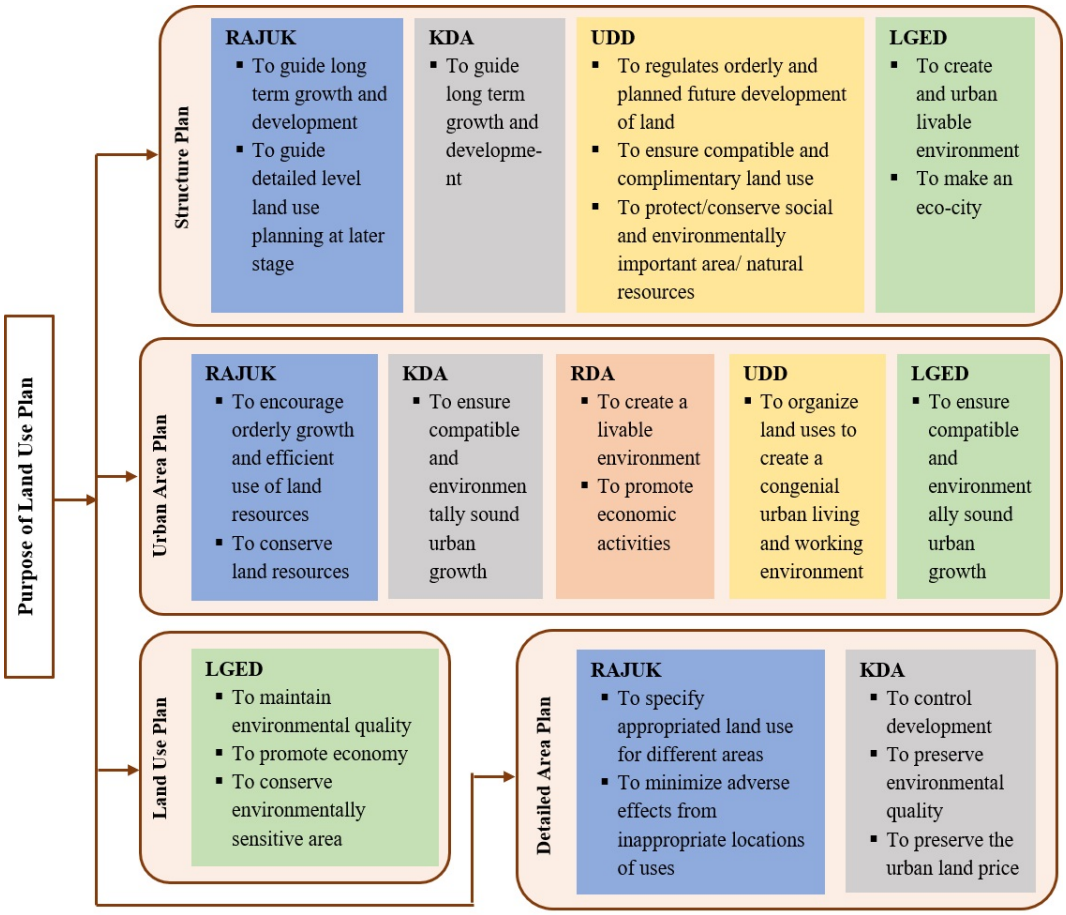


Fig. 3 Purpose of the collected land use plans according to the level of plan and different authorities

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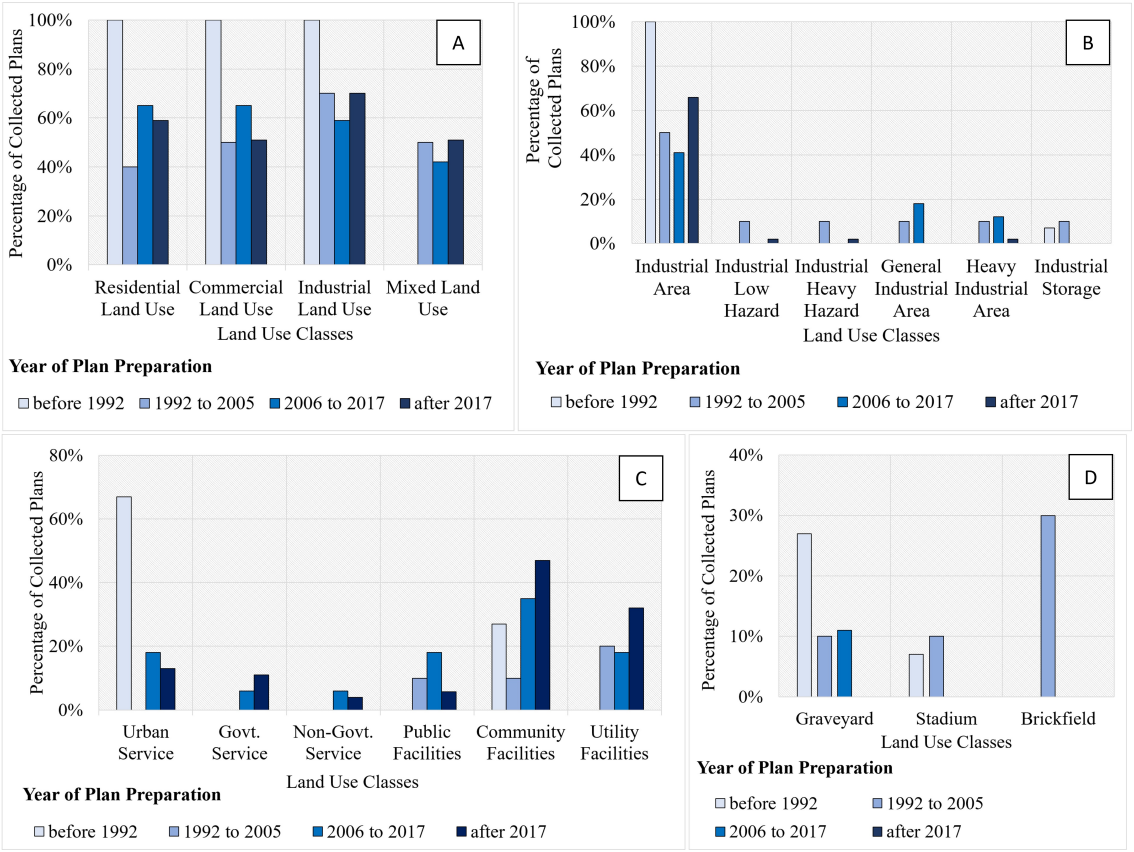


Fig. 4 A - Distribution of collected plans prepared in different years according to Residential, Commercial, Industrial, and Mixed land uses; B - Distribution of collected plans prepared in different years according to different industrial land use types; C - Distribution of collected plans prepared in different years according to different types of land use related to urban services and facilities; D - Distribution of collected plans prepared in different years according to different types of land use including Graveyard, Stadium, and Brickfield

mentally sound land use distributions. The goals of developing land use plans were consistent, and they clearly stated that promoting growth and the economy required the protection of natural and environmental resources to make our city livable.

3.2 Types of land use classes

Inconsistencies in the types of land use classes are noticed while analyzing them across time, geographic location, or administrative status of the planning area. All the collected plans prepared before 1992 had "Residential Land Use", "Commercial Land Use", and "Industrial Land Use" as separate land use classes and there was no use of the category "Mixed Land Use" (Fig. 4A). With the progress of time, cities started to grow in an unplanned way which created a mixing of uses. As a result, "Mixed Land use" was found in plans prepared after 1992.

The class "Industrial Land Use" was categorized in different ways in the collected plans. It is seen that before 1992, only the class "Industrial Area/Industrial Land Use" was used in the land use plans (Fig. 4B). But, from 1992 to 2017, different categories, as shown in Fig. 4B, were used. Apart from these, storage facilities for industries used to be categorized as a separate land use class in a small percentage of the plans prepared before 2005. However, the use of such categorization is hardly noticeable in the latest plans prepared after 2017.

The land use class "Urban Service," including both urban facilities and utilities, was mainly used in the master plans prepared before 1992 (Fig. 4C). But after 1992, the use of this category declined notably as the planning authorities started to use classes like "Public Facility," "Utility Facility," and "Community Facility." In the latest plans after 2017, "Utility Facility" and "Community Facility" were mostly used. Depending on whether the services are provided by government organizations or non-government organizations, categories like "Government Service" and "Non-Government Service" were also evident in a small portion of the plan (about

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10%). Overall, the use of categories related to service has declined at present.

From Fig. 4D, it can be seen that "Graveyard," "Brickfield," and "Stadium" were used as separate classes in the older plans. "Graveyard" was used as a separate land use class in more than 25% of the collected plans before 1992. With time, the percentage decreased, and after 2017, it was no longer used as a separate land use class. In the latest plans, it was categorized under other land use classes like, "Community Facility." Similarly, the use of "Stadium" and "Brickfield" as separate land use classes is seen in the plans prepared before 2005. After that, they were incorporated into broader categories.

Table 2 Distribution of collected plans prepared from 2005 to 2017 and after 2017 by different planning authorities according to land use type "Agricultural Area" and "Conservation Area"

Authorities	2005 to 2017		After 2017	
	Agricultural Area	Conservation Area	Agricultural Area	Conservation Area
RAJUK	100%	100%	100%	0%
CDA	100%	100%	_	_
KDA	100%	0%	_	_
RDA	_	_	_	_
UDD	100%	0%	98%	0%
LGED	78%	33%	0%	75%

"Conservation Area" was found to be a relatively new land use category. Before 2005, it was not found in any of the collected plans prepared by any planning authority. But, it is important to note that, in the collected plans prepared by LGED from 2005 to 2017, 33% of them had "Conservation Area" and "Agricultural Area" as two separate categories (Table 2). On the other hand, none of the collected plans prepared by LGED after 2017, had "Agricultural Area" as a land use category. They included the agricultural land under "Conservation Area" (75% of the collected plans had this category). This blending was only visible in LGED's plans. In a country like Bangladesh, where the population growth and urbanization rates are high, agricultural land should have the highest priority. Combining them with other conservation areas may result in loopholes and the failure of their protection.

Land use categories related to flood management started after 1992. In the previous master plan, such categories were absent (Fig. 5A). However, the use of "Flood Retention Ponds" has decreased dramatically over time. Between 2006 and 2017, the class "Flood Flow Zone" was not included in the plans. In the recent plans, the use of "Flood Flow Zone" as a separate land use class is seen again, though the percentage decreased from 30% to 18%. A new category related to flood management has also been introduced and is named "General Flood Plain." Another important thing to notice is that these land uses were only found in the plans for the Dhaka, Mymensingh, and Chittagong divisions (Fig. 5B). In the collected plans of other divisions like Rajshahi or Khulna, these land uses were not found, which is quite surprising.

Some land uses are discovered for a specific geographic location. For example, "Hilly Area" is in the collected plans of Chittagong and Sylhet divisions because of the presence of hills in those parts of the country; "Tea Garden" is in the Sylhet division because lots of lands are being used for cultivating tea in Sylhet; "Char Land" and "Sand Dunes" are in the northern part of the country (Rajshahi-Rangpur) because those areas are drought-prone. "Low Tidal Zone," "Beach Area," "Sea Front Development," "Tourist Zone," etc. can be seen as separate land use classes in the collected plans of the Chittagong division because of the Cox's Bazar Sea Beach (the largest sea beach in the world) and Saint Martin Island. Thousands of tourists come to visit the Cox's Bazar Sea beach every year, which requires a lot of space for their accommodation (hotel, motel, etc.). This might have encouraged the authority to provide a separate land use class as a "Tourist Zone."

Though not much variation is noticed across different administrative areas, it was found that land use classes, including "Village market" and "Growth Center," were mainly used in the plans prepared for upazilas. Upazila included both rural and urban areas. As these uses are important for the social, cultural, commercial, civic, recreational, and industrial development of rural areas, they emerged as separate classes in the plans for rural areas.

3.3 Definitions of land use classes

Most of the collected plans lack specific definitions of land use classes. However, the types of uses permitted under various land use categories were described. Some of the collected plans (18 out of 95) also described the land use classes through hierarchical classifications. All the available definitions or descriptions were compiled according to land use classes and authorities in a summary table. While analyzing the definitions or descriptions, inconsistencies could be noticed.

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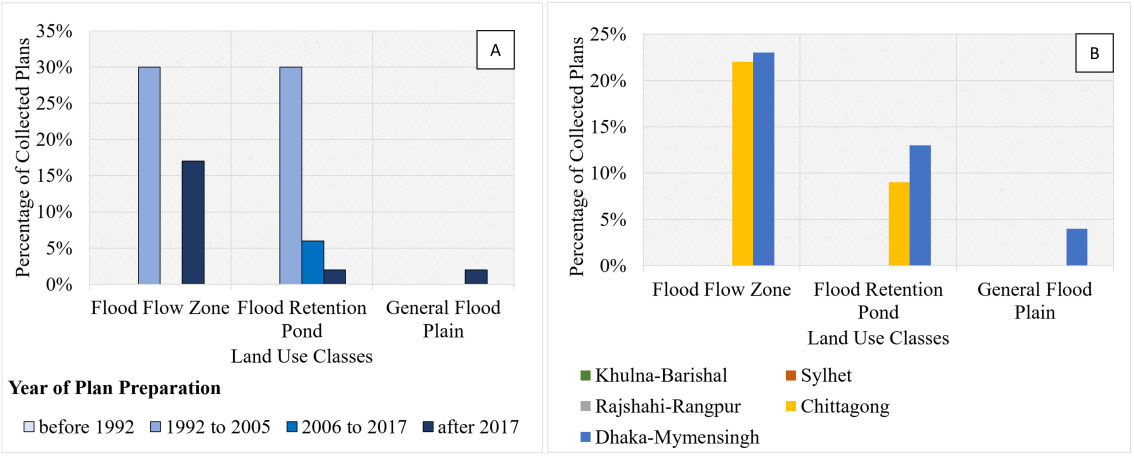


Fig. 5 A - Distribution of collected plans prepared in different years according to different types of land uses related to flood management; B - Distribution of collected plans prepared for different geographic locations according to different types of land uses related to flood management

3.3.1 Land Uses in Built-up Area

”Residential Land Use” was defined by the authorities mainly as housing, including public housing, hotels, and lodging. Though an exception is noticed in RAJUK’s DMDP: Detailed Area Plan, 2010, other uses supportive of residential communities such as schools, small shops, doctors’ chambers, open spaces like playfields, etc. were also incorporated. Though a residential area should include the above-mentioned facilities within its perimeter, however, there is a demand to be marked with these kinds of specific categories as far as detailed area plan is concerned. In the case of ”Commercial Land Use” some of the authorities included both business and office activities, while others included only business. Such variation was even evident within a single authority as well. In the case of the ”Administrative Area,” some plans included both government and non-government offices, while others included only government offices. The definition of ”Institutional Area” mostly overlapped with the land use classes ”Education and Research” and ”Administrative Area” and its definition varied within and between authorities. ”Mixed Land Use” has emerged as a growing concept, and its definition has many variations across the authorities, as described in Table 3.

In particular, the inconsistencies in the definition of ”Industrial Land Use” within RAJUK’s plans should be mentioned here. ”Industrial Land Use” was commonly defined as agglomerations of industrial activities including, manufacturing, repairs, storage, distribution, and transport operations. However, the categorization and definition of ”Industrial Land Use” varied a lot in RAJUK’s plan across time (Table 4). Here, one thing to notice is that the definition of ”Heavy Industrial Area” mentions the categorization of the ”Environmental Conservation Rule, 1997.” But only the orange-B and red categories were considered, and the other two, green and orange-A, were not taken into account. So, the classification of industrial land uses did not properly follow the national rule as well. Among other uses, there was ”Utility facility” which generally included uses related to electricity, gas, water, waste, sanitation, telecommunications, etc. But, in different plans of LGED, post office and fire services are also included in this category, though they are mainly administrative services and not utilities.

A complex situation of overlapping could be seen among land uses like ”Community Facility,” ”Assembly,” ”Recreational Facility,” ”Open Space,” and ”Religious Facility” as depicted in Fig. 6. It could be seen that the same uses were classified under different categories in different plans. The definition of the land use class ”Community Facility” was mostly not specific and often overlapped with other categories. It is vital to note that parks, playgrounds, botanical gardens, and similar open spaces are significant for urban areas to protect ecological and environmental balance (Rakhshandehroo et al. 2017; Balogh & Takacs 2011). Classifying them as ”Recreational Facility” does not express their true importance. Similarly, land uses like libraries, museums, art galleries, auditoriums, theaters, cinema halls, historic or archaeological buildings or sites, memorial structures, monuments or sculptures, etc., have social, cultural, historical, architectural, and aesthetic importance. Thus, they are important to protect from encroachment. Clas-

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Table 3 Inconsistencies in definitions of "Mixed Land Use" in land use plans of different authorities

Land Use Classes	RAJUK	KDA	RDA	UDD	LGED
Mixed Land Use	UAP, 1995–2005 - primary use residential - non-residential uses to support residential use DAP, 2010 Four types – 1. Commercial-General Industrial 2. Residential-Commercial 3. Residential-Commercial-General Industrial 4. Residential-General Industrial DAP, 2016–2035 - combining other uses with residential	- mix of residential, commercial, institutional, non-polluting small scale industries - compatibility with the surrounding environment	- mix of residential, commercial, processing, services, and small industries	- mix of residential, commercial, industrial - negative impact on residents must be minimized	- Two types – 1. Commercial predominant 2. Commercial and residential mixture

Table 4 Variation in categorization and definition of "Industrial Land Use" in land use plans of RAJUK and categorization of industries in the Environmental Conservation Rules (1997)

UAP, 1995–2005	DAP, 2010	DAP, 2016–2035	Environmental Conservation Rules, 1997
· Industrial Low Hazard – Industries with few or minimal environmental impacts or hazards; predominantly light and medium industry · Industrial Moderate Hazard – Industries with environmental damage or risk to public health and have particular infrastructural requirements	· General Industrial Area – primary location of industrial activities; incompatible with other uses, thus should be buffered · Heavy/Noxious Industrial Area – red categories industries	Heavy/Noxious Industrial Area – orange-B andred categories industries	· Green – have no or negligible environmental impact · Orange-A – have minor and temporary impacts · Orange-B – have moderately significant impacts · Red – have the most adverse impacts on the environment (Ullah & Sadik n.d.)

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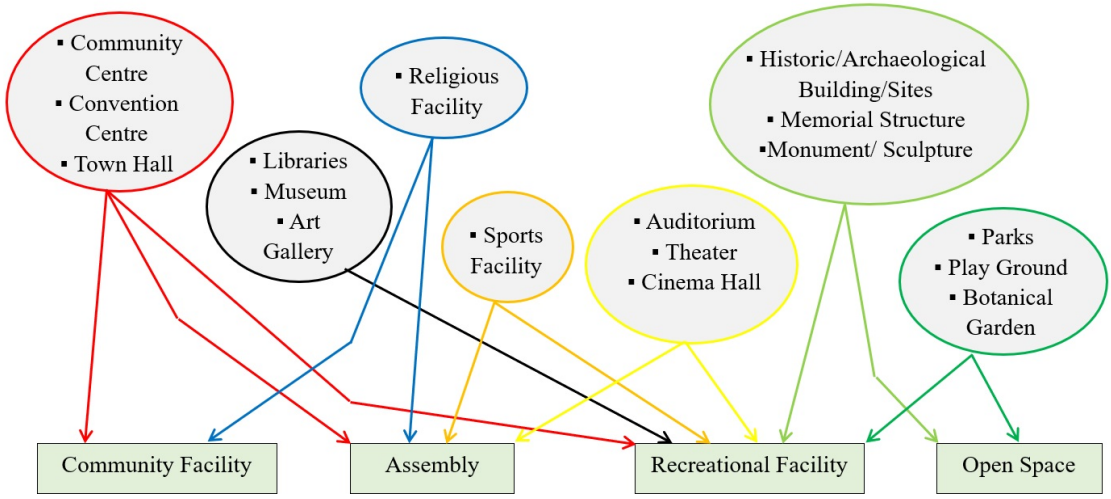


Fig. 6 Overlapping of land uses in the collected plans

sifying them as ”Recreational Facility” or ”Assembly” also does not express the need for their protection from encroachment properly.

3.3.2 Land Uses in the Area of Environmental or Natural Resources

“Agricultural Area” was mainly defined as primarily agricultural land or land for food supply. The variation could be seen in UDD’s and LGED’s plans, as they also included poultry and dairy. But, in KDA’s plan, it was stated that agricultural areas could be used for future urban development and could be termed ”urban deferred.” Such a proposal may result in the encroachment of valuable agricultural land. The exact definition of “Forest Area” was not available in any of the collected plans. The definition and distinction between categories, “Water Body” and “Wetland” were not comprehensible at all. According to the definition, most of the collected plans included rivers, canals, ponds, tanks, beels, lakes, streams, drains, and all others in the category of “Water Body.” The definition or categorization of “Wetland” was almost ignored. The definition of classes related to flood management, including “Flood Flow Zone” and “General Flood Plain” had gone through several changes within RAJUK’s plans (Table 5). RAJUK DMDP, 1995–2015: Structure Plan and Urban Area Plan (UAP), 1995–2005 divided “Flood Flow Zone” into “Main Flood Flow Zone” and “Sub Flood Flow Zone.” But the following Detailed Area Plan (DAP), 2010, which should have followed the Structure Plan and Urban Area Plan, had only the class “Flood Flow Zone.” From Table 5, one thing to highlight is that the definition of “Flood Flow Zone” in DAP, 2010 only refers to the previous “Sub Flood Flow Zone”.

In the proposed DAP, 2016–2035, of RAJUK, the classification and definition of areas related to flood management used a different approach. A new class, “General Flood Plain” was used in this plan, which could not be found in any other collected plans of any authorities. In this plan, the flood flow zones are defined based on the factor of water flow or velocity, which is also different from previous plans. On the other hand, in UDD’s plan, they defined “Main Flood Flow Zone” and “Sub Flood Flow Zone” based on the height of water during flooding after analyzing the hydrology of the project area. So, the height of the two zones varied depending on the project area.

As demonstrated above, inconsistencies in the land use classification among the authorities as well as the lack of distinct definitions of land use classes can create problems while planning for an area. These incompatibilities affect not only the concerned authorities but also the people living in those areas. The lack of proper definition creates loopholes in the plan, which makes the whole project questionable. Furthermore, the local politically powerful group takes advantage of these loopholes to take undefined land for economic purposes. It results in complete chaos in the environment, which affects the normal lives of the residents. To sort out the problems, the people then complain to the court, hoping that the court will provide them with justice. But as the land use classifications are not well linked with different national acts, rules, and policies relating to environmental and natural conservation, the court often cannot provide the verdict in favor of the residents of the area, and the accused groups

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Table 5 Inconsistencies in the definition of categories related to flood management in land use plans of RAJUK

UAP, 1995–2005	DAP, 2010	DAP, 2016–2035
· Main Flood Flow Zone – areas, either permanently (river) or seasonally flooded (flood lands) · Sub Flood Flow Zone - areas either temporarily or seasonally flooded (flood lands)	· Flood Flow Zone - area flooded during the monsoon	· General Flood Plain - during the rainy season overflow water is stored; after rainwater goes back to the river; water does not have velocity or flow · Main Flood Flow Zone - area remains flooded most of the time; flood water has velocity or flow; the direction of flood flow follows the direction of river flow · Sub Flood Flow Zone - area generally not flooded; flood water has velocity or flow; may get flooded in case large scale of flooding occurs

can get away cheaply. Some court cases are given below to show the exact scenario of how the interested group is taking advantage of the definition of the land classes, or the lack of it, to be exact.

3.4 Court cases: Example of consequences

3.4.1 Case 1: Purbachal New Town

Purbachal New Town is RAJUK's largest planned township in Bangladesh, located in Dhaka's outskirts at Narayangonj and Gazipur districts, between the Balu and Sitalakhya rivers. The implementation period of the project was from 1995 to 2030. RAJUK had the intention to develop the area as a self-contained township with all modern facilities and opportunities. But environmentalists were against this project because it destroyed the area's biodiversity and natural beauty (Mahmud 2013-08-05; Zaman 2016).

Accordingly, a case was filed in 2013 under writ petition No. 8098 of 2013 by different organizations and associations working for environmental protection, human rights, and legal aid. The petitioners claimed that if the Purbachal New Town Project at Barakau Mouza (mouza- a small administrative unit with a jurisdiction list number) and Parbartha Mouza under Gazipur district were allowed to be implemented following its layout plan, it would affect a vast amount of wetland and dense forest. The petitioners presented a record that a land use map named "Existing Land Use Map of Gazipur Part" was prepared jointly by Data Expert Ltd., RAJUK, and the local community, which showed 486.77 acres of the two Mauzas were covered by "Mixed Forest", 190.73 acres by "Forest" and 629.70 acres were "Cultivable Land." But later, RAJUK prepared another map with the same title, which showed 486.77 acres of land as "Homestead Vegetation" instead of "Mixed Forest." Thus, a vast amount of mixed forest was labeled "Homestead Forest," and the layout plan was prepared with distorted land use statistics. The respondents included RAJUK, the secretaries of relevant ministries representing the Government of Bangladesh, representatives from the local government, the project directors, and others. They argued that this was a commercial forest owned by private individuals, not a government-owned, reserved, or protected forest. Unfortunately, the court could not consider the land use map presented by the petitioners as it did not have the seal or signature of any authority. Though the respondents were directed not to modify, change, or remove any part of the core forest or other environmentally important spaces (BELA v. Bangladesh & others 2013). This case indicates how the interest groups can change the land use classes to fulfill their desires, as there is no concrete or legal document to point towards their misdeeds.

3.4.2 Case 2: Modhumati Model Town (MMT)

The project of a satellite township named "Modhumati Model Town (MMT)" was untaken by a private limited company, Metro Makers and Developers Limited (MMDL), near Amin Bazar within mouza Bilamalia and Baliarpur, Dhaka. This project area is located within DMDP SPZ-17 and is designated in the DMDP Structure Plan, 1995–2015, as a "Sub Flood Flow Zone." Again, according to Volume II of the DMDP, which contains the "Urban Area Plan, 1995–2005," this zone is low-lying, cut across by the Turag River and its Khals, and is designated as a flood plain by the Structure Plan. According to the DMDP, land development in such zones will be controlled and can be compatible with rural nature or rice-growing areas. Regardless, MMDL began filling the earth in a significant portion of the zone in order to implement that unauthorized, non-permitted satellite township. Such ac-

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tivity violated the ”Town Improvement Act, 1953,” as well as the master plan, the ”Wetland Conservation Act, 2000,” and the ”Environment Conservation Act, 1995,” as it was ecological destruction.
Though RAJUK did not stop the project, they did reject the player for project approval in 2003 and warned the earth-filling work to stop. Under writ petition No. 5103 of 2003 against RAJUK, MMDL claimed that they had conducted a survey through the Institute of Water and Flood Management (IWFM) and Bureau of Research Testing and Consultation, and the survey reported that the project does not lie in the flood flow zone. They claimed that the project area was above the flood plain. Following this situation, the action was taken against them by the Bangladesh Environmental Lawyers' Association (BELA) under writ petition No. 4604 of 2004, which also conducted a field survey and found that MMDL had been continuing with their earth-filling activities despite prohibition. Finally, under Civil Appeal No. 256 of 2009, the Supreme Court directed the restoration of the area to its original position along with compensation to the third-party purchasers (MMDL vs. BELA & others 2009). This case shows why it's important to have clear and specific definitions of land use classes and how the lack of a clear definition can put environmentally important land at risk of being destroyed.

3.4.3 Case 3: Four rivers surrounding Dhaka

The four rivers surrounding Dhaka, named Buringanga, Turag, Balu, and Shitalakkha, have significant contributions to the progression of the economy and maintenance of the ecological balance of the city. So, the protection of these rivers is of utmost importance while preparing land use plans. But these rivers had gone through drastic reductions in water due to illegal encroachment, earth filling, temporary structures, housing projects, etc. Apparently, a case was filed under writ petition No. 3503 of 2009 for their protection by organizations and associations working for environmental protection and human rights. The respondents were the secretaries of relevant ministries, the director generals of relevant government departments, the Deputy Commissioners of Dhaka, Narayanganj, and Gazipur Districts, and others, all representing the Government of Bangladesh.
According to the petitioners, the concerned authorities were not even certain about the exact territory of the rivers, though they agreed that the original territory is demarcated in the CS records and maps. In this context, the petitioner highlighted that the definition of ”river” needs to be realized by following certain acts or rules. According to ”The Port Rule, 1966,” ”bed of navigable waterway” includes both ”foreshore” and ”bank.” The subsoil between the high and low water marks is referred to as the ”foreshore.” According to the ”Port Act, 1908,” in the case of sea and river port areas, ”foreshore” is any part of land thereof that is 50 meters extended from the highest level of water to the riverbank, and in the case of areas other than river or seaport, ”foreshore” is any part of land thereof that is 10 meters extended from the highest level of water (Bangladesh Water Act 2013). ”Bank” indicates the land that confined the water of the waterway in its channel, and it extends above the high watermark (HRPB vs. Bangladesh & others 2009). Such definitions are not followed by any development authority while preparing land use plans for the city. These river lands are not demarcated as an integral part of the river, which needs conservation in plan preparation, and the lack of it induces illegal occupation of riverbank and foreshore. As the final verdict, the respondents were directed to survey the rivers' area, build boundary pillars and walkways, plant trees, remove encroachments, etc. to protect the rivers, along with the declaration of them as Ecologically Critical Areas (ECA) (HRPB vs. Bangladesh & others 2009).

3.4.4 Case 4: Lal Dighi Area

Lal Dighi Area, a historic and heritage site, is situated in Ward 32 of Mouza Andarkilla, Kotowali, Chattogram. The site has a water reservoir named Lal Dighi, a small park, and an adjacent open space named Laal Dighi Maath. The Dighi (water reservoir) is also used as a source of water for local people and a resting place. Chattogram City Corporation started the unlawful filling of the Dighi with the intention of constructing a swimming pool in its southern part. Apparently, a case was filed against them by BELA under writ petition no. 4039 of 2010 as they violated applicable laws, ignored the ecological, historical, and cultural significance of the Dighi, and denied public utility and service. According to the petitioner, building a swimming pool would change the nature of the deghi and turn it into a closed amenity, creating a barrier to public access. It would no longer have the characteristics of a historic place. The construction of the swimming pool also violated the ”State Acquisition and Tenancy Act, 1950,” the ”Environment Conservation Act, 1995,” and the ”Open Space and Water Body Conservation Act, 2000.”

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The respondent argued that the proposed swimming pool would not destroy the bio-diversity of Lal Dighi and would boost economic welfare. But a swimming pool can never be an alternative to a historical water body. Simply replacing a water body with another water source for economic benefit does not necessarily satisfy overall human welfare and development. The case of Lal Dighi represents the importance of proper definition and categorization of historic sites to prevent their encroachment (BELA v. Bangladesh & others 2010).

3.4.5 Case 5: Sonadia Island

On April 19, 1999, by issuing a gazette notification, the Ministry of Environment and Forest declared the 12,138.2716 acres of the forest area of Sonadia Island in Sonadia-Ghotibhanga Mouza, Kutubjom, and Cox's Bazar as an "Ecologically Critical Area (ECA)". Although the deteriorating condition of the island was eventually reported in different daily newspapers, According to the article, the 9000 acres of forest area on the island, locally known as "Para Bon," was being cleared by local influential people. As a result, the land had lost its natural nature of forest, which used to serve as a habitat for birds and wild animals and protect people in the adjoining coastal area from natural disasters. Following these, a case was filed under Writ Petition No. 4286 of 2003 by BELA, and an investigation was carried out. In the investigation, it was found that the land of Sonadia Island was decided to be declared "Reserve Forest" by the government in 1985 under the "Forest Act, 1927," but the procedure was never completed. On the other hand, on May 3, 1999, the Ministry of Environment and Forestry issued another notification excluding 2121.96 acres of the Sonadia Island from ECA based on the ground that this part was "Reserve Forest" and under the management of the forest division. As a result, 2121.96 acres of forest were neither ECA nor reserved. Taking advantage of such administrative loopholes, businessmen and influential people started clearing the forest for their anti-environment business activities, including shrimp cultivation and hazardous activities. Also, the Secretary, the Ministry of Land, and the Deputy Commissioner at Cox's Bazar were attempting to lease the land to influential people, showing the land as barren and fit for shrimp cultivation. Locals also protested the situation in 2002, calling for the protection of forest areas from shrimp cultivators who were causing serious environmental degradation throughout the island. The court issued a Rule Nisi requiring the respondents, representing the government of Bangladesh, to show cause as to why they should not be directed to protect the island as an ECA. This case represents that giving proper specification and definition of land is of the utmost necessity, as without the government declaring the area as ECA or reserved, there were no other standards or manuals to protect the land from land grabbers (BELA v. Secretary, MoEF & others 2003).

4 Hierarchical land use classification system in Bangladesh

The result of the study shows that existing land use classification systems in Bangladesh have many inconsistencies due to the lack of a unified system. The land use classes were not consistent, which makes it difficult to compare land uses across time and space and also affects relevant studies. Classification systems need to be mutually exhaustive, which requires that each class be classified under only one group without any overlap (European Communities 2001; Meinel & Hennersdorf 2002). But overlapping was evident as well in the collected plans. Definitions of land uses were mostly absent, which makes it difficult to identify them precisely. The authorities had the unified purpose of both promoting growth and development and protecting the environment and nature while preparing the land use plans. But the purposes were not properly reflected in their plans. They merely provided detailed classifications and specific definitions of land uses with environmental and natural importance. Again, the land use classifications were not well linked with different national acts, rules, and policies relating to environmental and natural conservation. For example, the "National Forest Policy, 1994" provided classifications and definitions of forests in Bangladesh, which were not followed by any authority. The "Environmental Conservation Rule, 1997" has provided a classification of industries based on their environmental impacts, which were mentioned very briefly. The "Bangladesh Water Act, 2013" also provides definitions of water resources like wetland, khal, beel, foreshore, haor, baor, etc., which should have been addressed as well in the land use plans. Moreover, as seen from the case studies, due to the lack of linkage with national acts or policies and the lack of a standard manual with precise definitions and classifications, it becomes difficult to take legal measures while different interest groups create encroachment on the areas of environmental or natural resources. These case studies prove

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that it is impossible to stop people from acquiring lands that have environmental or historical values unless those lands are defined in an impeccable way. So, there is no question that the country needs a unified system for land use classification. Accordingly, this study has proposed a classification system using the method discussed in section 2.4. The guiding principles for developing the system were as follows:

- Developing a classification system for land use requires setting objectives or purposes (Kaiser et al. 1995). According to the results of the study, the purpose of the developed system should be to promote not only development and economic growth but also the protection of environmental and natural resources. Accordingly, the developed system not only detailed the land use classes related to built-up areas but also areas that are subject to long-term maintenance of natural resources such as agricultural land, water bodies, forests, etc. Furthermore, the classifications in national acts and policies were also incorporated to provide a legal basis.
- The developed system should be compatible with existing systems (European Communities 2001; Meinel & Hennersdorf 2002; LUCAS 2015), so existing classification systems were taken into account while developing it (see Section 2.4). Otherwise, it may be difficult for the stakeholders to readily adapt to it.
- The classification system should be flexible enough to apply to all regions and sites in the country. In this regard, a hierarchical system (three levels) was developed because it allows for greater flexibility in collecting and identifying information, as well as the addition of new classes as needed. A hierarchical system can also assist in addressing the existing overlap, as it will allow inputting a particular use under a particular class in the hierarchy (European Communities 2001; Meinel & Hennersdorf 2002; LUCAS 2015).
- Each class of all three levels (primary, secondary, and tertiary) has been referenced with coding. The code is composed of six digits (000000), and each level is referred to with two digits. The code was constructed as such so that it can offer flexibility for any addition of new land uses in the future.

Accordingly, the authors have developed a three-level hierarchical system for land use classification in Bangladesh, as attached in the Supplement 1, along with definitions for each of the land uses at the primary and secondary levels. The tertiary level detailed the secondary level based on the use of structure or plot and are self-explanatory.

4.1 Criteria for Determining Primary Level Classes

”Residential Land Use”, ”Commercial Land Use,” and ”Industrial Land Use” are the basic land use classes in built-up areas and had a relatively high frequency in the plans (65%, 62%, and 73%, respectively). They must, without a doubt, be included in the proposed system as primary level classes.
”Institutional Area” had a very low percentage (7%) in the collected plans, and its specification was not clear as well (see Section 3.3.1). It contained land uses connected to ”Administrative Land Use” in some plans, and ”Education and Research” or ”Health Facility” in other plans. Again, ”Administrative Land Use”, ”Education and Research,” or ”Health Facility” also had a high percentage. They were therefore suggested as distinct primary-level classes. ”Public Facility“ was used in only 7% of the collected plans (Fig. 7). According to the definition, it included ”Administrative”, ”Institutional area”, ”Community Facilities”, ”Health Facilities”, ”Utility Facilities”, ”Defense and Security” and ”Transport and Communication”. Similar to the previous category, ”Urban Service” included usage associated with urban services and utilities despite having a very high percentage (26%). Therefore, rather than being a single class, these are an amalgam of other classes.
As mentioned in Section 3.3.1, the plans include overlapping situations for categories including ”Community Facility,” ”Assembly,” ”Recreational Facility,” ”Open Space,” and ”Religious Facility.” As a result, the suggested system did not include any categories that did not imply a precise definition. These uses were suggested to be included in three land uses, including ”Indoor Public Assembly,” ”Restricted and Special,” and ”Open Space.” All types of open spaces, including outdoor sporting facilities like stadiums, swimming pools, tennis courts, basketball courts, golf courses, and others, were included under the ”Open Space” category so that they could be preserved as urban open spaces. Indoor sports facilities were categorized under ”Indoor Public Assembly”. Other uses with social, cultural, historical, architectural, and aesthetic importance that need preservation and protection in the long run were categorized under the ”Restricted and Special” class (Supplement 1). Finally, ”Utility Facility” was incorporated with transporta-

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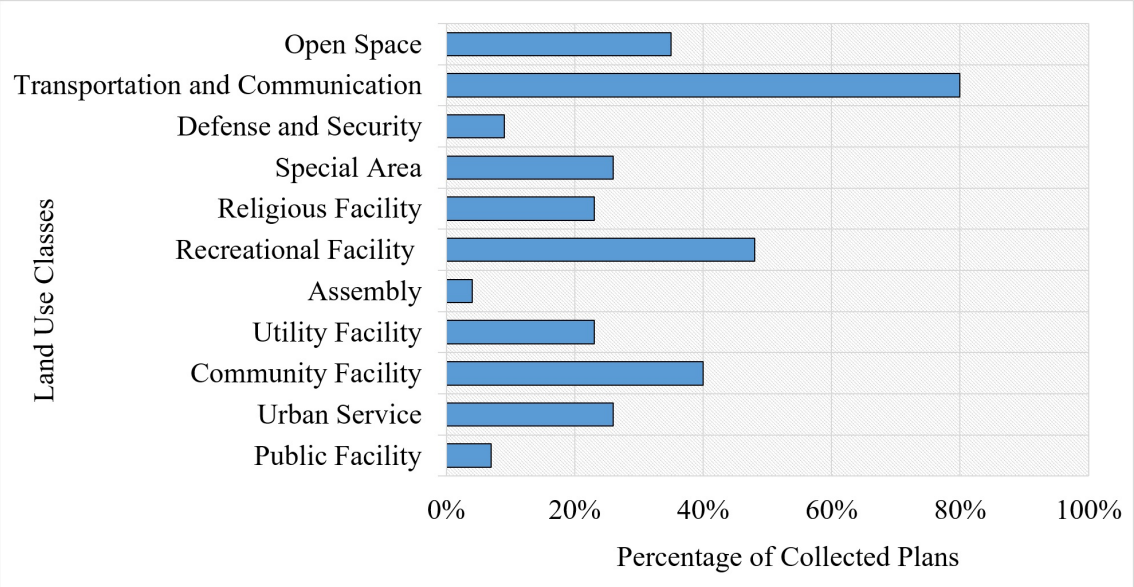


Fig. 7 Distribution of collected plans according to different land use classes in built-up areas

tion and communication as construction, maintenance, and operation of all these networks affect each other (TAC 2013). So, in planning, they should be considered together for maintaining efficiency.
After determining the primary level classes for built-up area, other land uses related to natural resources identified from the collected plans were incorporated as primary level classes as ”Agricultural Land Use”, ”Forest”, ”Water Body”, ”Wetland”, ”Flood Management Area”, and ”Other Geographic Area”. They were further divided into secondary-level classes, which will allow us to identify them and defend them against encroachment and destruction.

4.2 Criteria for determining secondary and tertiary level classes

4.2.1 Land Uses in Built-up Area

Table 6 describes the criteria used to determine the secondary level classes. It also provides a comparison of hierarchies in the existing plans and the proposed system.

Table 6 Criteria for determining the land use classes at secondary level in built-up area

Primary level classes	Criteria for secondary level classes		Secondary level classes
	Hierarchies in the existing plans	Proposed classification system	
01. Residential	- Classified based on density, ownership, and nature of development - Classified randomly without following any criteria in some plan - Besides, included informal settlements, i.e., slums	- Followed the criteria of density and ownership, considering their importance in planning and development (Rohe 1982; Towers 2002; Wilkinson & Reed 2008; Gordon & Whitehead 2016) - Included slums as their incorporation in government policy and planning is recommended (Hossain 2014; Barua et al. 2014)	0101. Single Family Public Housing 0102. Single Family Private Housing 0103. Multi-Family Public Housing 0104. Multi-Family Private Housing 0105. Residential Hostel 0106. Residential Care Homes

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Table 6 Criteria for determining the land use classes at secondary level in built-up area

Primary level classes	Criteria for secondary level classes		Secondary level classes
	Hierarchies in the existing plans	Proposed classification system	
02. Commercial	- Classified based on types of sale (services or goods) and scale of establishments (large floor area or a small floor area) - Besides, included commercial hotels	- Followed the criteria used in existing plans - Additionally, incorporated Central Business District (CBD), as it needs special consideration in planning and development considering its importance and special characteristics (Tang & Yeung 2005; APA 1959)	0201. Central Business District 0202. Hotels 0203. General Wholesale 0204. General Retail Selling/Showroom 0205. General Service 0206. Large Market/Bazar
03. Industrial	- Classified based on the types of products they produce, like food processing and manufacturing industries, garment industries, chemical industries, paper industries, cottage industries, metal industries, tanneries, etc.	- Incorporated the classification of Environmental Conservation Rules, 1997. These categories consider the environmental impacts of the industries, which is important to consider while zoning industries in urban areas (Patnaik 2018; Kustysheva 2017). - Besides, included family cottage industries as a separate class that are not subject to environmental clearance and thus not listed in the rule	0301. Family Cottage Industry 0302. Green Category 0303. Orange-A Category 0304. Orange-B Category 0305. Red Category
04. Administrative	- Classified based on different legislative and executive, judicial, or diplomatic activities in the country	- Followed the existing plans but classified the legislative and executive activities as central government and local government following the administrative structure in Bangladesh (Panday 2019) - Included other non-government administrations like NGOs, CBOs, worker associations, etc. as a separate class	0401. Central Government Office 0402. Local Government Office 0403. Court 0404. Correctional 0405. Embassy 0406. Others Administration
05. Education, Research and Training	- Classified based on level of education	- Followed the existing plans but classified ”Madrasas” as a different category as they have separate objectives and focus on Islamic education (Abdalla et al. 2004) - Incorporated research and training institutions and centers to make it a catch all category of learning, teaching, and training	0501. School 0502. College and University 0503. Madrasa 0504. Research Institute 0505. Training Institute and Centre
06. Health Facility	- classified depending on in-patient service or out-patient service	- Followed the existing plans	0601. Hospital 0602. Rehabilitation 0603. Health Centre
07. Indoor Public Assembly	- N/A	- Classified based on purpose of indoor gathering	0701. Indoor Social Assembly 0702. Indoor Religious Assembly 0703. Indoor Sports Assembly 0704. Emergency Assembly
08. Restricted and Special	- Included military establishments and Key Point Installation (KPI)	- Along with military establishments and Key Point Installation (KPI), incorporated another class for uses special to cultural and heritage (as discussed in Section 4.2)	0801. Defense and Security 0802. Culture and Heritage 0803. Key Point Installation

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Table 6 Criteria for determining the land use classes at secondary level in built-up area

Primary level classes	Criteria for secondary level classes		Secondary level classes
	Hierarchies in the existing plans	Proposed classification system	
09. Transportation, Communication and Utility	- Classified randomly	- Classified transport network separately following the classification of roads approved by the Planning Commission in Bangladesh (JICA n.d.; LGED 2010) - Classified transport facilities, telecommunication facilities, and utility facilities as separate classes	0901. Transport Network 0902. Transport Facility 0903. Communication 0904. Utility Facility
10. Open Space	- Only incorporated ecological open spaces like parks, etc.	- Along with ecological open spaces, also classified open spaces used for 'outdoor sports activities' and 'social and religious activities' as separate classes, considering their value in reducing surface runoff and increasing groundwater recharge (Hu et al. 2020)	1001. Ecological Open Space 1002. Open Space for Sports 1003. Social and Religious Open Space
11. Mixed Use	- Classified randomly	- Did not classify it at a further level, as numerous combinations of mixed use are possible	-

Under the secondary level classes, the tertiary level was developed by incorporating all types of uses from the collected plans, at structure level/plot level, based on concept hierarchy.

4.2.2 Land Uses in the Area of Environmental or Natural Resources

As mentioned before, existing land use classifications merely provided detailed classifications and definitions of land uses with environmental and natural importance. Thus, the proposed framework develops the hierarchical system for these land uses, incorporating the classification of relevant organizations working in the country and the classification of relevant acts and rules.

Agricultural Land Use: Agricultural land use was classified at the secondary level following the existing plans based on the types of production. Among them, "Crop Land" and "Aquaculture" were classified into tertiary levels, unlike the existing pans. Crop Land was classified based on the cropping pattern, which indicates the sequence of crops or "crops and fallow" on a given land in a year (Nasim et al. 2017; BBS 2020). Aquaculture was classified following the classification of "Department of Fisheries," which is based on habitat (FAO n.d.; DDOF 2020).

Forest: None of the collected plans further divided "Forest" areas into different categories. According to the "National Forest Policy, 1994," the "Forest Act, 1927," and the classification given by the Forest Department, the proposed system classified "Forest" (FAO 2014; Forest Department 2017; Khan et al. 2006; Kanan 2016; Rahman 2016). It is important to mention that "Village Forest", also known as "Rural Homesteads," was included under "Forest" due to their reasonable contribution to the total demand for forest products, unlike the collected plans where rural homesteads were classified as residential area (Forest Department 2017; Khan et al. 2006).

Water Body, Wetland, and Flood Management Area: Among the collected plans, 82% had the class "Water Body" and 13% had "Flood Flow Area", but only 2% had the category "Wetland". The definition and distinction between these categories were not comprehensible either. According to definitions and hierarchies, most of the collected plans included rivers, canals, ponds, tanks, beels, lakes, streams, drains, and all others in the category "Water Body". On the other hand, the class "Wetland" is used in national acts including the "Bangladesh Water Act, 2013" and the "Playground, Open Space, Park, and Natural Water Reservoir Conservation Act, 2000". The Ministry of Water Resources also uses the term "Wetland". These sources have defined "Wetland" as the area where the water table is always at or near the surface and is subject to periodic flooding, including rivers, canals, beels,

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haors, baors, ponds, flood plains, and other water reservoirs. According to their definitions, all water resources are ”Wetland”, and they made no distinction as ”Water Body” or ”Flood Flow Area”.
However, considering the frequent use of the terms ”Water Body” and ”Flood Flow Area”, the proposed system included all three of them and distinguished them based on their unique characteristics. ”Water Body” can be distinguished as the area that has water flow all year round, unlike wetlands, as wetlands are subject to seasonal dry conditions (Byomkesh et al. 2008; Lusch & Goodwin 2012; James et al. 2001). Wetlands are important as the most productive ecosystem, as a high concentration of plants, fish, amphibians, reptiles, birds, mammals, and invertebrate species are dependent on them. They share both aquatic and terrestrial environmental characteristics, yet they cannot be distinguished as one of them (Byomkesh et al. 2008; Ministry of Water Resources 2016; Varma et al. 2014). Finally, the category ‘Flood Management Area’ has been proposed in the framework to identify areas that are subject to inundation during extreme tidal events and rainfall events, unlike ”Water Body” and ”Wetland” (CCC 2012; Ast & Barua 2011). As a low-lying riverine country, Bangladesh has a variety of water resources locally known as dighi, beel, haor, baor, etc., which have been included in the secondary levels (Nahar et al. 2018) (see Supplement 1 for definitions).
Other Geographic Area: This category includes the area of thin soil, sand, or rock identified from the collected plans. They generally have little or no vegetation cover and are generally barren. Though, these areas do not support intense human activity or agricultural production, they are still important for tourism, as biological or cultural heritage, and subject to protection (Lusch & Goodwin 2012; James et al. 2001; Biswas et al. 2012).

5 Conclusion

This study aimed to identify the inconsistencies in the existing land use classification systems in Bangladesh. Based on quantitative and qualitative analysis of the collected land use plans prepared by planning authorities in the country, it can be concluded that land use classes are not consistent across time and geographic location. They do not have precise definitions as well. The same land uses are classified under different categories in different plans, which implies that the planning agencies had different ideologies while formulating the land use classifications. The authorities have a similar purpose in making land use plans, which is to regulate future development while protecting natural or environmental resources. Yet, the existing land use classification systems mostly focus on the built-up area and hardly allow detailed definition and classification of land uses with environmental or natural significance. As a result, natural and environmentally valuable lands like water bodies, wetlands, forests, flood flow zones, etc. often get subject to destruction and encroachments, which has been demonstrated more clearly in this study using five real-life court cases. These cases show how it is difficult to take measures for the protection of these lands because of the lack of a unified system with precise definitions as well as because the classifications are not well linked with different national acts, rules, and policies on environmental and natural conservation. This study provides evidence to policymakers of the irregularities and inconsistencies that occur because of the country’s lack of a unified land use classification system.
The study has proposed a hierarchical system for land use classification that was developed considering the flaws in the existing classification. One of the main problems with the existing land use classification is the land classes are not mutually exclusive. Concept hierarchy is found to be helpful in proposing a new hierarchical system. In the proposed system, the three-level hierarchy has been introduced making land use classification system more specific to any user. Special consideration is given while classifying areas of environmental and natural resources, which are supported by national acts and rules relevant to environmental conservation and protection. This will create a firm base to take legal steps against those who violate the rules and create encroachment. Definitions are given for the first two levels of the hierarchy, which will help to avoid confusion that exists in the present plans.

Conflicts of Interests

The author has no conflict of interest to declare.

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Supplementary material

Supplement 1 Proposed land use classification system for Bangladesh

Primary Level	Secondary Level	Tertiary Level	
01. Residential	0101. Single Family Public Housing	010101. Bungalow	
		010102. Government Guest house/Rest House/Circuit House	
		010103. Publicly Owned Low-Cost Single Housing	
01. Residential	0102. Single Family Private Housing	010201. Single family dwelling	
		010202. Privately Owned Low-Cost Single Housing	
01. Residential	0103. Multi-Family Public Housing	010301. Staff Quarters	
		010302. Workers Quarters	
		010303. Female Quarters	
		010304. Publicly Owned Low Cost Multi Housing	
01. Residential	0104. Multi-Family Private Housing	010401. Multi Family Dwelling	
		010402. Apartment Housing	
		010403. Privately Owned Low Cost Multi Housing	
01. Residential	0105. Residential Hostel	010501. Student Hostel	
		010502. Bachelor Hostel/Mess	
01. Residential	0106. Residential Care Homes	010601. Orphanage	
		010602. Retirement Home	
		010603. Children Care Centre	
01. Residential	0107. Slum		
02. Commercial	0201. Central Business District		
02. Commercial	0202. Hotels	020201. Hotel	
		020202. Motel	
		020203. Resort	
		020204. Rest house	
02. Commercial	0203. General Wholesale	020301. Food Wholesale	020307. Construction Material Wholesale
		020302. Electronics Wholesale	020308. Sanitary item wholesale
		020303. Hardware Wholesale	020309. Paper Wholesale
		020304. Chemical Wholesale	020310. Mixed Wholesale
		020305. Lather Product Wholesale	020311. Others Wholesale
		020306. Cloth Wholesale	
02. Commercial	0204. General Retail Selling/Showroom	020401. Restaurant	020424. Gift shop
		020402. Food Hotel	020425. Sports Equipment 020426. Electronic Device
		020403. Coffee House	020427. Furniture Store 020428. Plastic product
		020404. Bakery	020429. Pottery Shop
		020405. Confectionary	020430. Utensil
		020406. Fast Food	020431. Ceramic Items
		020407. Tea Stall	020432. Books, Paper, News Paper, Magazines and Stationary
		020408. Grocery Store	020433. Cycle Store/ Showroom
		020409. Tiles/Marble	020434. Motorcycle Store/Showroom
		020410. Sanitary Product	020435. Car Shop/Showroom
		020411. Glass	020436. Motor Parts
		020412. Aluminum	020437. Engine Oil
		020413. Door	020438. Pharmacy
		020414. Paint	020439. Pet Shops
		020415. Rod/Cement	020440. Audio/Video Cassette/CD/DVD
		020416. Iron and Steel Shops	020441. Funeral items
		020417. Lather product	
		020418. Cloths and Boutiques	
		020419. Cosmetics	
		020420. Jewelry shops	
		020421. Shoe Store	
		020422. Watch Shops	

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Primary Level	Secondary Level	Tertiary Level	
		020423. Spectacles	
02. Commercial	0205. General Service	020501. Bank	020515. Studio/ Color Lab 020516. Courier
		020502. Insurance	020517. Lawyer and Notary
		020503. ATM booth	020518. Ayurveda Medicine
		020504. Money Exchange	Centre
		020505. Beauty Parlor	020519. Doctor Chamber
		020506. Barber shops	020520. Dentist Chamber
		020507. Laundry and Dry Cleaning	020521. Engineering Services
		020508. Tailor Shop	020522. Architectural Services
		020509. Fitness Centre	020523. Vehicle repair
		020510. Banner and Rubber Stamp	020524. Tier/Tube Repair
		020511. Customer Care	020525. Battery/CNG repair
		020512. Cyber Café	020526. Rickshaw/Van Repair
		020513.Electronics/Computer Service Centre	020527. Wielding Shops
		020514. Phone-fax photocopy-printing	020528. Bathhouse
02. Commercial	0206. Large Market/Bazar	020601. Departmental Store	
		020602. Shopping Mall/Centre	
		020603: Shopping Market	
		020604. Kitchen Market	
		020605. Neighborhood Kitchen Market	
		020606. Hut Market/Growth Centre	
03. Industrial	0301. Family Cottage Industry	030101. Handcraft	
		030102. Pottery	
		030103. Fabric Printing	
		030104. Others	
03. Industrial	0302. Green Category	Industries under Green Category as per The Environment Conservation Rules, 1997	
03. Industrial	0303. Orange-A Category	Industries under Orange-A Category as per The Environment Conservation Rules, 1997	
03. Industrial	0304. Orange-B Category	Industries under Orange-B Category as per The Environment Conservation Rules, 1997	
03. Industrial	0305. Red Category	Industries under Red Category as per The Environment Conservation Rules, 1997	
04. Administrative	0401. Central Government Office	040101. Parliament	040105. Government Ministry /Division/Department Offices 040106. Government Owned Agencies/ Companies Offices
		040102. President’s Offices	040107: Others
		040103. Prime Minister’s Offices	
		040104. Armed Forced Offices	
04. Administrative	0402. Local Government Office	040201. Deputy Commissioner’s Office	040206. Pourashava Office
		040202. District Council Office	040207. Councilor Office
		040203. Upazila Sadar Office	040208. Union Council/Parishad Office
		040204. Upazila Headquarter	040209: Others
		040205. City Corporation Office	
04. Administrative	0403. Court	040301. Supreme Court	
		040302. Civil Courts	
		040303. Criminal Courts	
		040304. Specialized Courts and Tribunals	
04. Administrative	0404. Correctional	040401. Jail	
		040302. Detention Centre	
		040303. Juvenile Detention Centre	
04. Administrative	0405. Embassy	040501. Embassy	
		040502. High Commission	
		040503. Chancery	
		040504. Consulate	
04. Administrative	0406. Others Administration	040601. Professionals Association	040606. Political Party Office
		040602. Club	040607. Freedom Fighter Association
		040603. NGO	040608. Volunteer Organization
		040604. CBO	
		040605. Workers Association	
05. Education, Research and Training	0501. School	050101. Government and Non-Government Primary School	050104. Kindergarten

Primary Level	Secondary Level	Tertiary Level	
		050102. Government and Non-Government Secondary School	050105. Pre-School
		050103. Government and Non-Government High School	050106. Special School for Disabled
05. Education, Research and Training	0502. College and University	050201. Government and Non-Government College	050210. Public Science and Technology University 050211. Private Science and Technology University
		050202. Government and Non-Government High School and College	050212. Public Dental College
		050203. Law College	050213. Private Dental College
		050204. Quasi Government College	050214. Public Homeopathic Medical College
		050205. Poly-technique Institute/ School and College	050215. Private Homeopathic Medical College
		050206. Public University	050216. Public Medical College
		050207. Private University	050217. Private Medical College
		050208. Public Agricultural University	050218. Public Veterinary University
		050209. Private Agricultural University	050219. Private Veterinary University
			050220. Open University
05. Education, Research and Training	0503. Madrasa	050301. Alia Madrasa	
		050302. Quaumi Madrasa	
		050303. Maktab	
		050304. Independent Madrasa	
05. Education, Research and Training	0504. Research Institute	050401. Agricultural Research	
		050402. Economic Research	
		050403. Medical Research	
		050404. Social Research	
		050405. Science/Technology Research	
		050406. Other Research	
05. Education, Research and Training	0505. Training Institute and Centre	050501. Nurse Training Institute	050506. Computer training
		050502. Physical Training Institute	050507. Music/Dance School
		050503. Polytechnic Institute	050508. Painting/Arts school
		050504. Teachers Training Institute	050509. Driving school
		050505. Vocational Training Centre	050510. Tuition/coaching Centre
			050511. Others
06. Health Facility	0601. Hospital	060101. General Public Hospital	060104. Specialized Private Hospital
		060102. Specialized Public Hospital	060105. Upazila Health Complex
		060103. General Private Hospital	060106. Animal Hospital
06. Health Facility	0602. Rehabilitation	060201. Psychiatric Rehabilitation	
		060202. Drug Addict Rehabilitation	
06. Health Facility	0603. Health Centre	060301. Community Clinic	060304. Physiotherapy Clinic
		060302. Diagnostic Centre	060305. Vaccine Centre
		060303. Maternity Clinic	060306. Veterinarian Clinic
07. Indoor Public Assembly	0701. Indoor Social Assembly	070101. Community Centre	
		070102. Convention Centre	
		070103. Town Hall	
07. Indoor Public Assembly	0702. Indoor Religious Assembly	070201. Mosque	070204. Pagoda
		070202. Temple	070205. Majar/Dorgah/Khankah
		070203. Church	070206. Religious Centre
07. Indoor Public Assembly	0703. Indoor Sports Assembly	070301. Indoor Swimming Pool	070305. Indoor Basketball Court
		070302. Indoor Tennis Complex	070306. Other indoor sports facilities
		070303. Gymnasium	
		070304. Indoor Stadium	
07. Indoor Public Assembly	0704. Emergency Assembly	070401. Cyclone Shelter	
		070402: Others	
08. Restricted and Special	0801. Defense and Security	080101. Air Force	080104. Army
		080102. Ansar Camp	080105. Navy
		080103. BGB	080106. Police Station

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Primary Level	Secondary Level	Tertiary Level	
08. Restricted and Special	0802. Culture and Heritage	080201. Libraries	080206. Cinema Hall/Cineplex 080207. Historic/Archaeological Building/Sites
		080202. Museum	080208. Memorial Structure
		080203. Art Galleries	080209. Monument/ Sculpture
		080204. Auditorium	
		080205. Theater	
08. Restricted and Special	0803. Key Point Installation		
09. Transportation, Communication, and Utility	0901. Transport Network	090101. National Highways	090107. Embankment cum Road
		090102. Regional Highways	090108. Railway (Broad gauge)
		090103. Zila Roads	090109. Railway (Meter gauge)
		090104. Upazila Roads	090110. Bridge and Culvert
		090105. Union Roads	090111. Floating Bridge
		090106. Village Road	
09. Transportation, Communication, and Utility	0902. Transport Facility	090201. Airport	090210. Mahendra/Jeep/ Tourist Car Stand
		090202. Ferry Terminal	090211. MRT/BRT Depot/Terminal
		090203. Launch/Boat/Steamer Terminal	090212. Rail Station
		090204. River Port	090213. Passenger Shading
		090205. Bus Depot	090214. Ticket Counter
		090206. Bus Terminal	090215. Toll Plaza
		090207. Truck Terminal	090216. CNG/petrol station
		090208. Taxi Terminal	
		090209. Rickshaw/Tempo/Tom Tom Stand	
09. Transportation, Communication, and Utility	0903. Communication	090301. Telephone Exchange	
		090302. Telecom Tower	
		090303. Radio Station	
		090304: TV Station	
		090305. Information and Sarver Centre	
		090306. Switching Centre	
09. Transportation, Communication, and Utility	0904. Utility Facility	090401. Overhead Water Tank	090408. Power Station/Electricity Sub Station
		090402. Water Pump House	090409. Solar Park
		090403. Water Treatment Plant	090410. Transformer Station
		090404. Waste Treatment Plant	090411. Rainwater Harvesting Centre
		090405. Sewerage Pumping Station	090412. Waste Recycling Plant
		090406. Drainage Pumping Station	090413. Waste Transfer Station
		090407. Gas Transmission Station	
10. Open Space	1001. Ecological Open Space	100101. Central Park/City Park	100106. Zoo
		100102. Neighborhood Park	100107. Botanical Garden
		100103. Children Park	100108. Urban Green Belt/Green Way
		100104. Amusement/Theme Park	100109. Trail
		100105. Ecological Park	
10. Open Space	1002. Open Space for Sports	100201. Play Lot	100206. Outdoor Tennis/Basketball etc.
		100202. Play Ground	100207. Golf Court
		100203. Play Field	100208. Others
		100204. Outdoor Stadium	
		100205. Outdoor Swimming Pool	
10. Open Space	1003. Social and Religious Open Space	100301. Eidgah	
		100302. Graveyard	
		100303. Crematorium	
		100304. Carnival/Fair Ground	
		100305. Others	
11. Mixed Use			
12. Agricultural	1201. Crop Land	120101. Single Crop	
		120102. Double Crop	
		120103. Triple Crop	
		120104. Quadruple Crop	
		120105. Fallow Land (Current Fallow and Culturable Waste)	
12. Agricultural	1202. Dairy and Poultry Farming		

Primary Level	Secondary Level	Tertiary Level
12. Agricultural	1203. Aquaculture	120301. Freshwater Aquaculture
		120302. Brackish Water Aquaculture
		120303. Fish and Shrimp Hatchery
12. Agricultural	1204. Ornamental Horticulture	
12. Agricultural	1205. Sericulture	
12. Agricultural	1206. Apiculture	
12. Agricultural	1207. Nursery	
13. Forest	1301. Reserved and Protected Forests	130101. Hill Forest
		130102. Mangrove Forest
		130103. Plain Sal Forest
		130104. Swamp Forests
13. Forest	1302. Un-classified State Forest (USF)	
13. Forest	1303. Village Forest	
13. Forest	1304. Afforestation Schemes	130401. Riverside afforestation
		130402. Mangrove/Coastal Afforestation
		130403. Others Afforestation
14. Water Body	1401. River and Stream	
14. Water Body	1402. Estuaries	
14. Water Body	1403. Canal/Khal/Drain	
14. Water Body	1404. Lake/Dighi and Baor	
14. Water Body	1405. Pond	
14. Water Body	1406. Natural Water Fall	
14. Water Body	1407. Water Reservoirs	
15. Wetland	1501. Beel	
15. Wetland	1502. Haor	
15. Wetland	1502. Marshes	
15. Wetland	1504. Foreshore	
16. Flood Management Area	1601. Flood Flow Area	
16. Flood Management Area	1602. Flood Plain	
16. Flood Management Area	1603. Detention Pond	
17. Other Geographic Area	1701. Beaches	
17. Other Geographic Area	1702. Sand Dunes	
17. Other Geographic Area	1704. Hills and Mountains	

Definitions of Land Use Classes

01. Residential: Residential Land Use covers the area used predominantly for residential purposes for all types of structures and ownership. Residential Land Use can occur as an integral part of other uses like housing for the military, housing for workers at colleges and universities, and in business districts. Such residential use will be categorized under the appropriate institutional or commercial categories, of which they are a part (Lusch & Goodwin 2012; LBSC 2001; SEMCOG 2012; James et al. 2001).
• 0101. Single Family Public Housing: Single Family Housing includes freestanding single structures built to contain single housing under public ownership (Lusch & Goodwin 2012; LBSC 2001).
• 0102. Single Family Private Housing: Single Family Housing includes freestanding single structures built to contain single housing under private ownership (Lusch & Goodwin 2012; LBSC 2001).
• 0103. Multi-Family Public Housing: Multi-Family Housing includes structures with multiple housing units under public ownership (Lusch & Goodwin 2012; LBSC 2001).
• 0104. Multi-Family Private Housing: Multi-Family Housing includes structures with multiple housing units under private ownership (Lusch & Goodwin 2012; LBSC 2001).
• 0105. Residential Hostel: Residential Hostel includes structures of residential facilities for students and bachelors who are unrelated individuals (Lusch & Goodwin 2012; LBSC 2001).
• 0106. Residential Care Homes: Residential Care Homes includes residential facilities for elderly, orphans, and children who are unrelated individuals (Lusch & Goodwin 2012; LBSC 2001).
• 0107. Slum: Slums include clusters of housing units occupied by low-income group of people developed informally and unsystematically (Wendt 1997; Hossain 2014).
02. Commercial: Commercial Land Use includes those structures used predominantly for the sale of goods and services to individuals and other businesses. Along with the main structure, other supporting structures and uses, including parking, shading, guard house, landscape area, etc., are all included in this category (Lusch & Goodwin 2012; LBSC 2001; SEMCOG 2012; James et al. 2001).
• 0201. Central Business District: Central Business Districts are the main centers of business and service activities in a city. They can be identified by the highest density, highest land value/rest, and concentration of top-end business employment (Lusch & Goodwin 2012; Tang & Yeung 2005).
• 0202. Hotels: Establishments under this category serve as short-term (day or week) lodging or accommodation for travelers and visitors operated on a commercial basis (Lusch & Goodwin 2012; LBSC 2001).
• 0203. General Wholesale: General Wholesale includes those establishments that sell goods to other businesses and are normally operated by warehouse facilities. They have little or no display of merchandise (LBSC 2001).

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• 0204. General Retail Selling/Showroom: Retail Selling/Showroom renders retail business activities to people with a single or small group of stores. They are accompanied by a display of merchandise. They are generally found on the major roads (Lusch & Goodwin 2012; LBSC 2001).
• 0205. General Service: This category includes a single or small group of structures with single or multiple tenants rendering service activities to people. They are generally found on the major roads (Lusch & Goodwin 2012; LBSC 2001).
• 0206. Large Market/Bazar: Large Market/Bazar includes a single structure or group of structures over a large amount of floor space, accompanied by the display of merchandise. Large markets and bazaars serve a variety of business (retail and wholesale) and service activities and have multiple tenants. In urban areas, they are usually supported by a common parking lot (Lusch & Goodwin 2012; LBSC 2001; SEMCOG 2012).
03. Industrial: Industrial Land Use involves a wide variety of uses, including manufacturing, assembly, finishing, warehousing, mining, distribution, and packaging. Different industrial developments like SEZ, EPZ, industrial parks, cottage industries, other industrial clusters, etc. will be included under this category (Lusch & Goodwin 2012; LBSC 2001; SEMCOG 2012; James et al. 2001).
• 0301. Family Cottage Industry: Cottage industries producing goods by full-time or part-time labor of family members with capital investment not more than Taka 5 (five) hundred thousand and those that are not listed in the Environment Conservation Rules (1997). Thus, they will be outside the purview of the Environmental Clearance Certificate (Bangladesh 1997).
• 0302. Green Category: Green Category industries have positive environmental impacts or negligible negative impacts. They require no arrangement regarding environmental pollution control and are thus free of pollution; (Ullah & Sadik n.d.; Bangladesh 1997).
• 0303. Orange-A Category: Orange-A Category industries have minor and mostly temporary environmental impacts. Effluent discharge arrangements need to be incorporated while applying for an Environmental Clearance Certificate (Ullah & Sadik n.d.; Bangladesh 1997).
• 0304. Orange-B Category: Orange-B Category industries have moderately significant environmental impacts for which mitigation measures are easily identified. They are subject to an environmental examination, feasibility study, pollution minimization plan, and environmental management plan for obtaining a location clearance certificate and an environmental clearance certificate (Ullah & Sadik n.d.; Bangladesh 1997).
• 0305. Red Category: Red Category industries are subject to significant adverse environmental impacts. They are subject to an environmental examination, feasibility study, pollution minimization plan, environmental impact assessment, and environmental management plan for obtaining a location clearance certificate and an environmental clearance certificate (Ullah & Sadik n.d.; Bangladesh 1997).
04. Administrative: Administrative land use covers all public and private administrative functions, including executive, legislative, judicial, or diplomatic activities of the government and different private bodies associations (LBSC 2001).
• 0401. Government Office: Government Office comprises of central government administration, including prime minister's offices, president's offices, parliament, armed force offices, offices of various government ministries, divisions, departments, agencies/companies, and others (Panday 2019).
• 0402. Local Government Office: Local Government Office comprises local government administration at division, district, upazila, city corporation, pourashava, union, ward, and village level (Panday 2019).
• 0403. Court: Court refers to the land use that comprises all judicial functions, including all courts and tribunals that are responsible for ensuring law in society.
• 0404. Correctional: They are government institutions that are provided for the confinement, correction, and rehabilitation of offenders sentenced by the court (LBSC 2001; Panday & Mollah 2011).
• 0405. Embassy: This category represents offices of diplomatic representatives in the country (LBSC 2001).
• 0406. Others Administration: Besides public administration, different private or local bodies administrations have been included in this category.
05. Education, Research and Training: This land use category serves teaching, learning, training, and research activities (LBSC 2001).
• 0501. School: This category includes all government, non-government, and special schools at the pre-school, primary, and secondary levels of education (LBSC 2001).
• 0502. College and University: This category includes different colleges and universities that provide academic or technical courses and grant degrees, certificates, or diplomas (LBSC 2001).
• 0503. Madrasa: Madrasa refers to those institutions especially established for Islamic education and culture (Abdalla et al. 2004).
• 0504. Research Institute: Establishments under this category conduct research or analysis in cognitive, physical, engineering, or life sciences (LBSC 2001).
• 0505. Training Institute and Centre: Establishments in this category provide different technical, vocational, or professional training that leads to job specific certification (LBSC 2001).
06. Health Facility: Health Facility provides healthcare and medical services at all levels, from preventive to surgical (LBSC 2001; SEMCOG 2012). When an entire building is used for medical services, it is classified as a "Health Facility", but when an office building has multiple tenants and some of them are medical service providers, it is classified as "Commercial" category.
• 0601. Hospital: Hospitals are those that provide medical, diagnostic, and treatment services to inpatients with serious medical conditions. They often have physician, nursing, and accommodation services for patients. Though hospitals can also provide outpatient services, they mainly focus on inpatient services. Animal hospitals have also been included in this category (LBSC 2001; SEMCOG 2012).
• 0602. Rehabilitation: Establishments under this category provide medical, diagnostic, treatment, and monitoring services to inpatients with mental illness or drug abuse disorders (LBSC 2001; SEMCOG 2012).
• 0603. Health Centre: Establishments under this category provide non-emergency services to outpatients (LBSC 2001; SEMCOG 2012).
07. Indoor Public Assembly: This category includes the indoor assembly of people for social, religious, sports, and emergency purposes (Lusch & Goodwin 2012).
• 0701. Indoor Social Assembly: Indoor Social Assembly covers those establishments where people gather indoors for group activities, public information, social support, and other purposes (LBSC 2001).
• 0702. Indoor Religious Assembly: Indoor Religious Assembly includes indoor gatherings for practicing religious beliefs and activities (LBSC 2001).
• 0703. Indoor Sports Assembly: Establishments under this category provide indoor sports facilities (Lusch & Goodwin 2012; LBSC 2001).
• 0704. Emergency Assembly: Emergency Assembly includes those establishments where people gather indoors in case of disasters like cyclones, floods, etc.
08. Restricted and Special: Establishments under this category need special treatment and protection against encroachment due to their social, political, national, cultural, historical, architectural, and aesthetic importance.
• 0801. Defense and Security: This category refers to the uses that need to be protected for public safety and security. They are mostly different military establishments.
• 0802. Culture and Heritage: This category involves those uses that need to be protected because they are the nation's and/or city's cultural, historical, architectural, and aesthetic importance or heritage.
• 0803. Key Point Installation: Key Point Installation refers to any institution/industry/structure specified by the Ministry of Home Affairs that is important for the country's war/combat strength/capacity/efficiency or national economy, and the destruction and damage of those will harm the country's war or defense strength/capacity/efficiency and national economy (Ministry of Home Affairs 2013).
09. Transportation, Communication, and Utility: This category involves all those networks and structures that serve people's movement, communication, and utility (Lusch & Goodwin 2012; LBSC 2001; SEMCOG 2012; James et al. 2001).
• 0901. Transport Network: Transportation network refers to the spatial network of lines that allow the movement of people or goods by way of air, rail, or water (LBSC 2001).
• 0902. Transport Facility: This category includes terminal facilities, shading facilities, filling stations, and other facilities related to transportation.
• 0903. Communication: Communication involves long distance information transmission facilities related to radio, telephone, television, cellular phone, etc. (Lusch & Goodwin 2012; LBSC 2001).
• 0904. Utility Facility: Utility Facility involves the generation, processing, treatment, storage, and distribution of power, gas, water, and waste (Lusch & Goodwin 2012; LBSC 2001).
10. Open Space: Open spaces include those sites that serve a variety of outdoor recreational, cultural, and social activities and are subject to conservation for their natural and environmental qualities. The open spaces will have uses that do not require structures (Lusch & Goodwin 2012; James et al. 2001).

• 1001. Ecological Open Space: This category includes different parks, zoo, botanical garden, urban green belt etc. which have ecological importance and serve recreational purposes.
• 1002. Open Space for Sports: These open spaces are used for outdoor sports activities, including playgrounds, play fields, play lots, outdoor swimming pools, outdoor stadiums, golf courts, etc. (Lusch & Goodwin 2012).
• 1003. Social and Religious Open Space: This kind of open spaces includes fair/carnival ground, graveyard, crematorium, eidgah etc. which are used for social and religious activities (Lusch & Goodwin 2012).
11. Mixed Use: Mixed Use means when there is a mixture of more than one primary level of urban land uses, when each of them is substantial enough to attract their own market and none of the uses predominates (Lusch & Goodwin 2012; PIA 2009; Ghosh 2017; Hoppenbrouwer & Louw 2005).
12. Agricultural: Agricultural land use refers to the use of land for the production of food, fiber, fur, or wool, including growing crops and plants, raising animals, and harvesting fish (Lusch & Goodwin 2012; LBSC 2001; James et al. 2001).
• 1201. Crop Land: Crop lands are used to grow all kinds of crops, including cereal crops, tuber crops, oilseed crops, pulse crops, vegetable crops, fruit crops, species crops, fiber crops, and sugar crops (Chowdhury & Hassan 2013).
• 1202. Dairy and Poultry Farming: This category comprises animal raising for the sale of animals and animal products like milk, meat, eggs, and wool. Activities like keeping, grazing, breeding, or feeding animals are carried out here. Slaughterhouse is also considered in this category (Hamid 2017; LBSC 2001).
• 1203. Aquaculture: Aquaculture refers to those areas used to raise fish where some kind of intervention is applied in the rearing process to increase fish production, such as holding in captivity, feeding, regular stocking, protecting from predators, etc. (FAO n.d.; LBSC 2001)
• 1204. Ornamental Horticulture: Ornamental Horticulture comprises land used to grow or produce flowers and decorative plants and their seeds (Lusch & Goodwin 2012; Hossain et al. 2009).
• 1205. Sericulture: Sericulture includes the rearing of silkworms for the production of raw silk. This land use includes activities including the cultivation of food plants to feed the silkworm and reeling the cocoons to unwind the silk filaments (Ishtiaque et al. 2014; Pateriya 2020).
• 1206. Apiculture: Apiculture comprises establishments that raise bees, collect and sell honey, sell queen bees, packages of bees, and other bee products (LBSC 2001).
• 1207. Nursery: This land use is for the production of trees, plants, shurbs, etc., which will be transplanted later (Lusch & Goodwin 2012; LBSC 2001).
In the case of 'Forest', along with primary and secondary level classes, the definition of tertiary level classes under the secondary level 'Reserved and Protected Forests' has also been described because they are not self-explanatory.
13. Forest: Forests are defined as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ". Again, areas under reforestation, which are expected to reach a canopy cover of 10% and a tree height of 5 m, are also included in forests as they are temporarily unstocked as a result of human intervention or natural causes but are expected to regenerate into forests (Forest Department 2017).
• 1301. Reserved and Protected Forests: This category includes forests that have been declared reserved forests or protected forests in the "Forest Act, 1927" and are under the control of the Forest Department. They are the property of the government.
• 130101. Hill Forest: Hill forests are evergreen forests developed over tertiary hills, spread over the hilly areas of Sylhet, Habiganj, Chattogram Hill Tracts, Chattogram, and Cox's Bazar. Major produce includes large saw logs, poles, firewood, thatching material, and bamboo (Forest Department 2017; Khan et al. 2006; FAO 2014).
• 130102. Mangrove Forest: Mangrove forests are naturally developed in the active delta of the river Padma along the coast of the Bay of Bengal, located in the south-west in Khulan, Bagerhat, and Satkhira. Major produce includes timber, poles, firewood, pulpwood, and thatching material (Forest Department 2017; Khan et al. 2006; FAO 2014).
• 130103. Plain Sal Forest: Plain Sal forests are moist deciduous forests naturally developed in the Pleistocene terrace located mainly in the Central region in Gazipur, Tangail, Comilla, Sherpur, and Mymensingh. Small patches can also be found in Dinajpur, Rangpur, Thakurgaon, Naogaon, and Panchagarh in the north-west region. Major produce includes Sal, short-rotation exotics for poles, posts, and firewood (Forest Department 2017; Khan et al. 2006; FAO 2014).
• 130104. Swamp Forests: Swamp forests are inundated seasonally by fresh water and are mainly located in Sylhet and Sunamganj districts in the northeastern part. They support freshwater fisheries and are vital spawning grounds. Hijal and Koroch are the main species of the forest (Forest Department 2017; Khan et al. 2006; FAO 2014; Kanan 2016).
• 1302. Un-classified State Forest (USF): Forests not classified as reserved or protected and not managed by the Forest Department, but rather under the control of district councils located in hill tract districts. Major produce includes bamboo, thatching material, and firewood (Forest Department 2017; Khan et al. 2006; FAO 2014).
• 1303. Village Forest: Village Forests are those areas classified as "Village Forests" in the "Forest Act, 1927" for which the government may assign to any village community the rights of government to or over any land that has been constituted a reserved forest.
Village Forest includes the immediate surrounding area of rural dwellings. They are land owned by a family and used for the production of trees, plants, animals, and fish when continuous interaction takes place among man, trees, livestock, soil, and water. They are scattered throughout the country. Major produce includes timber, bamboo, poles, posts, and firewood (Forest Department 2017; Khan et al. 2006; FAO 2014).
• 1304. Afforestation Schemes: Apart from the previous categories, all types of afforestation schemes, including mangrove/coastal afforestation, riverside afforestation, roadside afforestation, etc., are also included under "Forest".
14. Water body: Water body includes those areas that are predominantly and permanently covered with water (Lusch & Goodwin 2012; James et al. 2001).
• 1401. River and Stream: River and Stream are channeled flows of water on the earth's surface with verities of size, geometry, and sediment type. They are the product of natural processes and irregular open channels. They gathered and separated through their watershed (Cushman 2014; James et al. 2001).
• 1402. Estuaries: Estuaries are formed when fresh water from rivers and streams mixes with salty sea water. They have sea at one side and river/stream at another side and are influenced by both aquatic realms (Rahman 2019; Bangladesh Water Act 2013).
• 1403. Canal/Khal/Drain: Canal/Khal/Drain means any passage of inflow or outflow of water. They can be both natural and artificial. They are connecting channels of rivers (Ishtiaque et al. 2014; Bangladesh Water Act 2013).
• 1404. Lake/Dighi and Baor: Lakes are non-linear enclosed water bodies with no direct access to the sea. Baor means an oxbow-shaped lake where the water course has become stagnant over time (Bangladesh Water Act 2013; James et al. 2001; Lusch & Goodwin 2012).
• 1405. Pond: Ponds are also non-linear enclosed water bodies that are smaller than lakes (Lusch & Goodwin 2012).
• 1406. Natural Water Fall: Natural water fall or spring is a vertical or near-vertical fall of water in a river course (Goudie 2019).
• 1407. Water Reservoirs: Water reservoirs refer to the artificial enclosure of water for irrigation, water supply, power generation, flood control, and other purposes, which can be separated from other water bodies by the presence of dams, levees, and other water control structures (James et al. 2001).
15. Wetland: Wetland means those low-lying areas where the water table is at or near the surface for a significant part of the year. They are the transitional areas between terrestrial and aquatic ecosystems. They generally become dry during the winter season (Byomkesh et al. 2008; Ministry of Water Resources 2016; Varma et al. 2014).
• 1501. Beel: Beels are natural depressions that remain inundated over the year and partially or entirely remain dry for a certain period of the year. They accumulate surface run-off water through internal drainage channels (Hossain et al. 2009; Rahman & Haque 2008; Bangladesh Water Act 2013).
• 1502. Haor: Haor means any saucer-shaped, large, shallow depression created naturally in between two separate rivers. They are generally larger than beel (Bangladesh Water Act 2013; Nahar et al. 2018).
• 1503. Marshes: Marshes are wetlands, which are mostly dominated by reeds and grasses and can be found at the edge of water bodies (Burton & Uzarski 2009).
• 1504. Foreshore: Foreshore means any area lying in between the high water marks and the low water marks during the ordinary spring tide of the year. According to the Port Act, 1908, in the case of sea and river port areas, a foreshore is any part of land thereof that is 50 meters extended from the highest

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level of water to the river bank, and in the case of areas other than river or sea port, any part of land thereof that is 10 meters extended from the highest level of water (Bangladesh Water Act 2013)(Bangladesh Water Act 2013).
16. Flood Management Area: Flood Management Area includes those that are subject to flooding due to extreme tidal or rainfall events.
• 1601. Flood Flow Area: Flood flow areas are those lands that get flooded due to rainfall and where water has flow or velocity in the direction of river flow.
• 1602. Flood Plain: Flood plains are areas adjacent to water bodies and wetlands, that are subject to inundation by lateral overflow of water from those bodies or wetlands with which they are associated. Here, flood water does not have flow or velocity (Tockner & Stanford 2002).
• 1603. Detention Pond: Detention ponds are manmade and usually dry. They slow down the flood flow during rainfall events and hold water for a short period of time. They reduce the peak runoff rate in urban areas (ARC 2016; LCCD n.d.).
17. Other Geographic Area: Other geographic areas include barren land with little or no vegetation cover that is subject to tourism and cultural or biological heritage and thus must be conserved (Lusch & Goodwin 2012; James et al. 2001; Biswas et al. 2012).
• 1701. Beaches: Beaches refer to the area of sloping accumulations of sand and gravel, excluding foreshore. If it contains plantation or vegetation cover, this category must not be used (Lusch & Goodwin 2012; Bangladesh Water Act 2013).
• 1702. Sand Dunes: A sand dune is a mount, hill, or ridge of sand formed when windblown sand is trapped by beach grass or other stationary objects. They are not permanent (Lusch & Goodwin 2012).
• 1703. Hills and Mountains: Hills and mountains are differentiated based on the mean sea level elevation of the highest landform, which is 200–500 m for hills and more than 500 m for mountains. If they contain plantations or vegetation cover, this category must not be used (Biswas et al. 2012).

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