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AN INVESTIGATION INTO THE LAND USE PATTERN OF DHAKA: IDENTIFYING ACTIVITY NODES FOR A COMPACT CITY

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With Dhaka's urbanization, there is a need to develop policies aimed at respecting the city's natural environment, preserving open spaces, and targeting new growth into a compact city, where promoting polycentric nodes could be one of the sustainable planning strategies. For such a strategy in Dhaka's context, identifying the nodes that generate daily urban activities can provide useful directives, as they play crucial roles in facilitating accessibility to create dense, mixed-use, and pedestrian- and transit-friendly urban centres. With this rationale, this study investigated the land use pattern of Dhaka to identify potential activity nodes for compact city planning. At first, sixteen activity nodes were identified by analysing the city's key land use distribution pattern, along with the existing transportation nodes. Then, the land use composition around the identified nodes was examined. The findings show that while most of Dhaka's activity nodes exhibit moderate to reasonable levels of land use mix, they are mostly unplanned, and lack adequate planning and cohesive design to ensure a pedestrian- and transit-friendly compact city. The nodes identified and their attributes will help policymakers formulate specific urban design and planning strategies for Dhaka's nodal development.

***Key words*: activity node, compact city, Dhaka, land use pattern, urban centre, urban design, urban morphology.**

INTRODUCTION

Dhaka is constantly expanding, with about 17.6 million people within its 1528 km^2 metropolitan region and is expected to have nearly 26 million people by 2035 (Ahmed *et al*., 2018). To accommodate the fast-growing population, the city's current growth pattern is creating a high stress on the limited resources. As a result, the water bodies, cultivated land, vegetation, and low-lying lands in Dhaka have been reduced significantly for urban expansion. Existing research shows that lowlands and wetlands have mainly contributed to Dhaka's urban expansion, threatening the city's hydrological environment (Ahmed *et al*., 2012). Also, enormous population growth has impacted the city's streets, urban patterns, open spaces, housing, and various service sectors, along with its social, environmental, and economic conditions (Ahmed *et al.*, 2014a). Dispersed development patterns and congestion created by an inadequate transportation system have deteriorated the citizens' mobility and quality of life.

Various urban professionals and authorities have considered compact development as a sustainable option for Dhaka's growth (Adnan *et al.*, 2009; Imon, 2001; Mahtab-uz-Zaman and Lau, 2000; RAJUK, 2015). Compact development is a component of compact city policy where the latter is typically defined as a well-designed, connected city with higher densities around public transport nodes and lower densities in less connected areas to establish a clear urban boundary, control urban sprawl and discourage automobile use (OECD, 2012; The Urban Task Force, 1999). One of the primary spatial strategies undertaken in the Draft Dhaka Structure Plan (2016-2035) involved the identification of several key focal points, or 'centres', within the urban area, which would be intensely built and provide major public functions by accommodating growth in a compact manner (RAJUK, 2015). These identified 'centres' are major transport nodes and business/retail points equipped with appropriate densities, services, and facilities in order to

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make them attractive living places (RAJUK, 2015). Most activity patterns in urban centres are focused on nodes, which are the areas of public interaction, or the intersections of various urban activities (Morshed, 2018). They play a significant role in ensuring efficient mobility, diversity, and quality of life for citizens, as they provide directives on orienting and engaging in various urban activities. However, such nodes were identified in the Draft Structure Plan primarily in outer urban areas, with less emphasis on the core city. In this regard, to undertake suitable planning initiatives for nodal development, the activity nodes of the core city need to be identified. This calls for paying attention to the core city's existing urban fabric, since it reflects its physical, socio-economic, and cultural dimensions.

The compact city model is often practised with nodes that aim to achieve sustainability goals (Bibri *et al*., 2020). Such nodes are characterized by medium to high-density mixed-use developments providing a walking and transit-friendly environment (Filion and Kramer, 2012). Most of these nodes tend to be transportation nodes, whereby the public's perceived image of a city or region is usually concentrated along with the connecting physical networks (Cheng *et al*., 2013). For their unique potential to provide accessibility at different levels, the spatial pattern of these activity nodes is crucial for assessing the city's morphology and future growth. Nodal development is preferred for achieving intensification while aligning it with public transit services (Filion and Kramer, 2012). To successfully implement the compact city strategy in Dhaka, existing nodes and their land use patterns need careful investigation to ensure a transit-friendly built environment with accessible services and facilities. Therefore, this research focuses on identifying potential activity nodes in Dhaka for compact city development. Overall, this research has two objectives. The first one is to identify the major activity nodes of Dhaka from the existing land use distribution and public transport nodes. The second one is to assess the land use composition around the identified nodes from a compact city perspective.

LITERATURE REVIEW

Concept of a compact city

Compact cities commonly refer to high-density urban settlements that promote central area revitalization, develop mixed land use, contain rural area development, promote public transportation facilities, and concentrate developments around transportation nodes (Abdullahi *et al*., 2015). A compact city strategy ensures that all parts of the city, even the more remote, quieter neighbourhoods, are within an acceptable distance from basic transport and social facilities and contain appropriate economic and social activity around urban centres and local hubs (Urban Task Force, 1999). Recent research has shown the following characteristics of a compact city which improve the environmental, social, and economic performance of cities (Giddings and Rogerson, 2021):

- Dense and adjacent developments and activities;
- Public spaces, including squares, parks, and streets;
- Effective public transport systems;
- Walking distances within the city centre; and
- Accessibility to work, services, and provisions.

For polycentric cities, Transit-oriented development (TOD) is a suitable compact city model, which is based on intensification (or densification) around transport interchanges or along transport corridors (Burgess, 2000; Jenks, 2019). TOD originally began in 1993 with the publication of Peter Calthorpe's (1993) book *The Next American Metropolis*. Calthorpe and his colleagues based their theory on the ideals of the Garden City movement (Vernet and Coste, 2017). TOD is a mixed-use development with a fine grain of different land uses that lessens dependency on private vehicles by offering more flexible and comfortable accessibility within an area of approximately 5-10 minutes' walk (Azmi *et al*., 2021). TOD places public transport nodes conveniently to accommodate people, activities, buildings, and public spaces within easy walking and cycling distances, connecting neighbourhoods to other parts of the city or urban centres (Iannillo and Fasolino, 2021).

Theoretical background on nodes and centres

Earlier cities were mostly dependent on one central area that functioned as the centre of finance, the economy, and administration. As cities grew with an increased demand for urban space, the single hubs of monocentric cities lost their importance, and various activity centres emerged to accommodate the diversified functions (Afrose *et al*., 2019). The internal structure of polycentric cities was probably first explained by the multiple nuclei model, which suggested that many cities have several growth points, with those that have reached a significant size, acting as satellite nodes, or nuclei of activity around which land use patterns formed (Harris and Ullman, 1945). This model recognised the multi-nodal nature of urban growth and was relatively more convincing than earlier models in explaining how land-use patterns vary depending on local contexts (Pacione, 2009). However, each city is a unique, dynamic entity with complex social, economic, political, and cultural interactions that often prove inadequate for a single model to explain its changing pattern or growth (Afrose *et al*., 2019). The heterogeneity of urban activities is partly shaped by the transport system, where central areas have emerged because of economic, political, institutional, or cultural factors (Rodrigue, 2020).

Nodes, usually squares, plazas, and crossroads, are concentrated areas of urban centres with a high density of various urban activities connected by many streets (Mitkovic and Dinic, 2004). A city consists of several nodes of various core activities, with a significant concentration of commerce, politics, culture, and power. Their importance, number, and pattern of distribution also vary in different contexts and can be observed from the factors associated with the city's growth pattern. Core activities generally consist of central urban functions corresponding to most urban needs, except dwelling and production (Mitkovic and Dinic, 2004).

In the relevant literature, various core activities of cities have been identified and categorized. Nooraddin (2016) cataegorized three core activities as: the power core encompassing administrative functions, the economic core constituting commercial buildings, and the social core facilitating major social activities. Hall (1999) distinguished

four key city centre activities: finance and business services, power and influence, creative and cultural industries, and tourism. From an urban geography perspective, Rodrigue (2020) classified urban activities into core, central, and peripheral activities based on their distribution in central areas and the periphery. A central area is a cluster of core and/or central activities, where core activities are the highest-order activities (i.e., tertiary and quaternary activities) involved in management and consumption, and the central activities include the functions of production and distribution. Peripheral activities are primarily residential or local services.

The relationship of core activities having specific land uses can be expressed in terms of the mobility of passengers and freight (Rodrigue, 2020). The most significant relationships in land use include: commuting (movements between residential areas and workplaces); professional movements (work-based movements within central areas); personal movements (activities involving shopping and social interactions); and distribution (freight movements involving goods).

Nodal activities in Dhaka

Despite originating as a politico-administrative city, different economic and commercial activity concentrations have contributed to Dhaka's prominence over time (RAJUK, 2015). Historians say Dhaka could be defined as a combination of political and multi-functional capital (Kolbe, 2011). Dhaka is the nation's largest provider of non-farm employment, consumer and capital goods, and services (RAJUK, 2015). In addition, some nodal activities could also be identified from the city's historical population growth and associated factors. For instance, after becoming the provincial capital in 1947, Dhaka experienced growth mainly to accommodate Muslim migrants and people involved in the new administration and business establishments (Ahmed *et al*., 2014b). After becoming the capital of Bangladesh in 1971, population growth took place unprecedentedly to accommodate marginalized groups and many rural unemployed people (Ahmed *et al*., 2014b). Since Bangladesh's gaining independence, these large rural-urban population flows have been the key driver of the urbanization process of Dhaka (RAJUK, 2015). Recent studies have shown, approximately 63% of the total growth of Dhaka's population is due to in-migration (Ahmed and Meenar, 2018). Pull factors affecting this rural-urban migration are mainly commercial, industrial, and institutional activities (RAJUK, 2015). Another important population pull of Dhaka is attributed to the high concentration of technical schools, research centres, and universities that attract many students nationwide each year (Gapihan, 2020; Al Amin *et al*., 2017). Therefore, in Dhaka's context, the nodal activities can be conceptualized as administrative, institutional, educational, and commercial activities that have contributed to Dhaka's primacy and enormous population growth.

METHODOLOGY

Study area

The study area encompasses Dhaka, the core city of the Dhaka Metropolitan Region, which includes the DCC (Dhaka City Corporation) area and its fringe (RAJUK, 2015) (Figure 1). It constitutes Bangladesh's political, administrative, cultural, and commercial capital. Compact city planning in developing countries requires appropriate land use planning in core areas, with more sensitivity to the existing urban fabric, acknowledging their social value and economic diversity (Jones, 2000). Therefore, the regional policy for compact development can be achieved if the related problems with the core city's excessive congestion can be identified and evaluated from a compact city perspective.

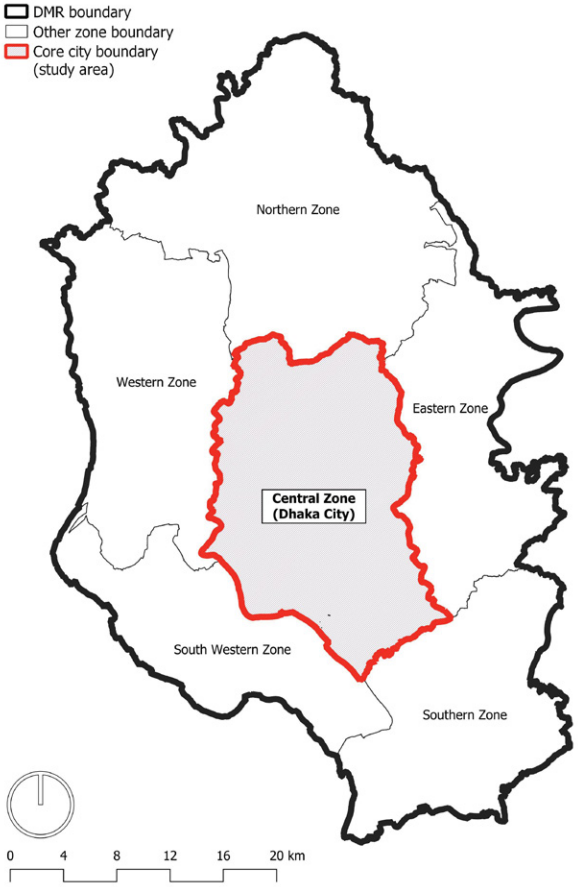

Figure 1. The boundary of Dhaka as demarcated in the Draft Dhaka Structure Plan (2016-2035)
(Source: Authors using the GIS database from the city development authority, RAJUK)

Data

For this study, GIS-based land use parcel data was collected from RAJUK (RAJUK, 2017). This database was developed through field surveys conducted during 2016-2017 to prepare the Detailed Area Plan (2016-2035). Besides this, some secondary data sources i.e., Govt. and Non-Govt. Transportation Plans, Regional Development plans, Reports, Research Papers, Books, etc., have been studied for this research. Alongside the GIS database, existing open-source databases, i.e., Google Maps and OpenStreetMap, have also been used to take necessary references for mapping.

Method

This study broadly involved two steps. First, the study tried to identify the activity nodes of Dhaka from the cluster of core activities. Second, it performed some area-based calculations in GIS to assess the land distribution around

each node. These two steps are briefly explained below.

First, to identify the activity nodes, the distribution pattern of the core urban activities, i.e., the administrative, institutional, education and research, and commercial land parcels, was observed in the land use map of Dhaka. In this process, the locations of existing inter-city bus terminals were also considered for their significant role in generating urban activities (Rodrigue, 2020). Then, the activity nodes were identified from the concentration of these core activities, considering the intersection of the primary roads, public transport access points, available commercial land parcels, and some proposed nodes in the Draft Structure Plan. Ideally, a centre's node is the place of maximum intensity, frequently being the point of the highest pedestrian concentration and traffic congestion (Murphy and Vance, 1954). Therefore, to identify activity nodes within core activity clusters, the distribution pattern of commercial activities was particularly emphasized, since they are usually pedestrian-related (Bobkova *et al*., 2019).

Among the various compact city indicators, this study focused on the land use mix of the activity nodes. Land-use mix is one of the fundamental aspects of a compact city and an important part of TOD (Iannillo and Fasolino, 2021). Land use mix measurements yield significant results when measuring buffer zones created around points of interest (Bordoloi *et al*., 2013). The transit industry widely applies 400-metre and 800-metre buffer radii for estimating service areas around public transportation nodes (El-Geneidy *et al*., 2014). Again, compact centres are often defined as areas within 800 metres of a central point and that exhibit a potent mix of uses, public transit availability, density, and walkability (USGBC, 2022). Therefore, a catchment radius of 800 metres was taken around each node for land use analysis in this study.

For land use analysis, this research adopted the land use classification provided by RAJUK (2017), which includes 15 categories of functional typology, namely administrative, agriculture, commercial, community facilities, education and research, health facilities, industrial, institutional, mixed-use, open space, residential, restricted, transportation and communication, vacant land and water body. Land use mix was calculated through Balance Index (Iannillo and Isidoro, 2021). Balance Index can be used to assess the relationship between residential and non-residential areas (N = 2). It is defined as:

$$BAL=1-\frac{|X-aY|}{(X+aY)}$$

where,

X is the land area for residential use;

Y is the land area for non-residential use;

a = X*/Y* is an adjustment factor representing the relative balance of land use. An adjustment factor may not be necessary if an approximately equal level of X and Y is expected. The Balance Index was calculated in this study for each node with consideration for the residential and non-residential land parcel areas within adopted buffer areas. Residential and non-residential land use refers to the built-up areas dedicated to a city's residential and non-residential uses, respectively. The built-up area wasestimated in this study according to the definition of the net urban land area provided in the Draft Structure Plan (RAJUK, 2015).

CORE ACITIVITIES IN DHAKA

Administrative activities

In the land use database of RAJUK (2017), the 'administrative' land use category includes Bangladesh's executive, legislative, and judicial headquarters. These activities are primarily concentrated in the Motijheel, Ramna, Tejgaon, and Sher-e-Bangla Nagar areas. These areas have been demarcated under three zones, i.e., A-1, A-2, and A-3 (Figure 2).

Zone A-1 covers Motijheel and Ramna areas, where two distinct clusters can be identified: one near the Press Club bus stop and another near Shapla Square. The Press Club bus stop is an important public transport node around the Executive Division of the Bangladesh Government (the Secretariat) and the Judicial Division (Supreme Court). However, areas surrounding this node lack public spaces and commercial activities, making it less vital. Shapla Square has a higher concentration of commercial activities, but it is located at the edge, far away from the cluster of the Press Club node. The Dainik Bangla node is located in between these two nodes with significant commercial activities. This node lies at the crossroads of two primary roads, making it accessible from all directions. The 800-metre buffer radius around this point covers significant administrative and commercial activities in this zone.

Zone A-2 covers the Tejgaon area, where administrative activities are significantly concentrated near the Saat Rastar Mor (Seven Roads Intersection) and extended radially from the node. Although commercial activities are not concentrated close to the node, most administrative and commercial activities are located within the buffer area.

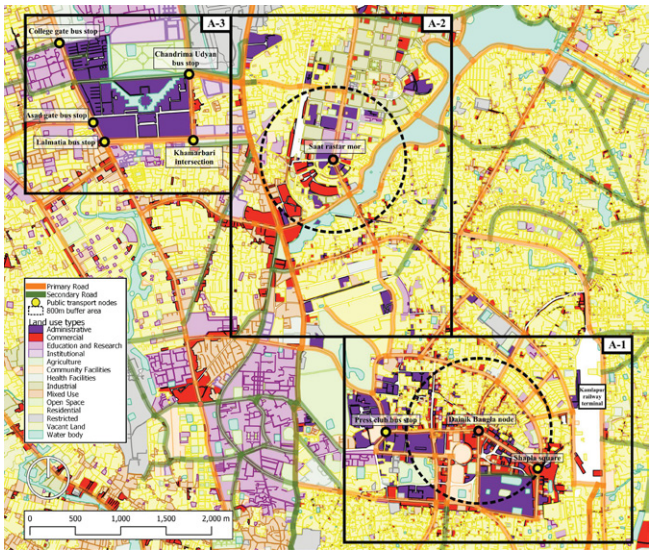

Figure 2. Land use distribution around the major nodes in the Administrative areas of Dhaka: A-1. Motijheel and Ramna; A-2. Tejgaon and A-3. Sher-e-Bangla Nagar
(Source: Authors using the GIS database from the city development authority)

Zone A-3 covers the Sher-e-Bangla Nagar area where the administrative land parcels (National Assembly premise) are surrounded by the College Gate bus stop, Asad Gate bus stop, Lalmatia bus stop, Khamarbari intersection and Chandrima Udyan bus stop. However, activity nodes supporting public activities and interaction are inadequate in this area. A single land use category occupies significant land around these nodes and has very low commercial activities.

Institutional activities

The 'institutional' land use category mostly includes different Govt. and Non-Govt. institutes, and various training, cultural, and convention centres (RAJUK, 2017). They are mostly concentrated in the areas of Agargaon, Farmgate, Mirpur, and Darus Salam. These areas have been demarcated under three zones, i.e., I-1, I-2, and I-3 (Figure 3).

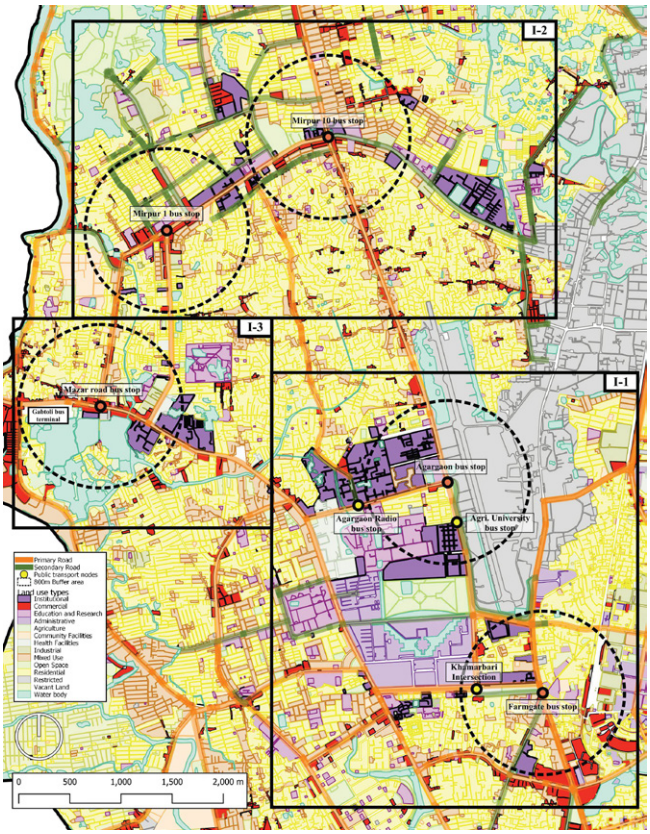

Figure 3. Land use distribution around the major nodes in the Institutional areas of Dhaka: I-1. Agargaon and Farmgate; I-2. Mirpur; and I-3. Darus Salam (Source: Authors using the GIS database from the city development authority)

Zone I-1 covers the Agargaon and Farmgate areas. In Agargaon (northern I-1), institutional activities are concentrated around the Agargaon bus stop, Agargaon Radio bus stop, and Agricultural University bus stop. Commercial activities are located at the Agargaon bus stop near the junction of the two primary roads. In Farmgate (southern I-1), the Khamarbari Intersection and the Farmgate bus stop are two important institutional nodes. Among them, commercial activities are mostly concentrated at the Farmgate bus stop, along with significant institutional activities. Both the Agargaon and the Farmgate bus stops are located at the major hub of the city's public transport network, and therefore constitute the major activity nodes for zone I-1.

Zone I-2 covers Mirpur, where institutional activities are concentrated linearly along the primary road in the east-west direction. From the distribution of commercial activities two important nodes, i.e., the Mirpur 1 bus stop and Mirpur 10 bus stop, can be identified in this area. They are the major activity nodes of this area owing to their location at the 3-way intersection of the primary roads and they have significant commercial activities.

Zone I-3 covers Darus Salam, where the Mazar Road bus stop is the major activity hub. Alongside significant commercial activities, the importance of this node lies in its location close to the Gabtoli bus terminal and its position at the junction of two primary roads. The Draft Structure Plan proposes a local centre at this node (RAJUK, 2015).

Education and research activities

Land use in the education and research category mostly includes schools, colleges, universities, and research institutes (RAJUK, 2017). These activities are mostly concentrated in the Shahbag, New Market, and Mohammadpur areas. These areas have been demarcated under two zones, i.e., E-1 and E-2 (Figure 4).

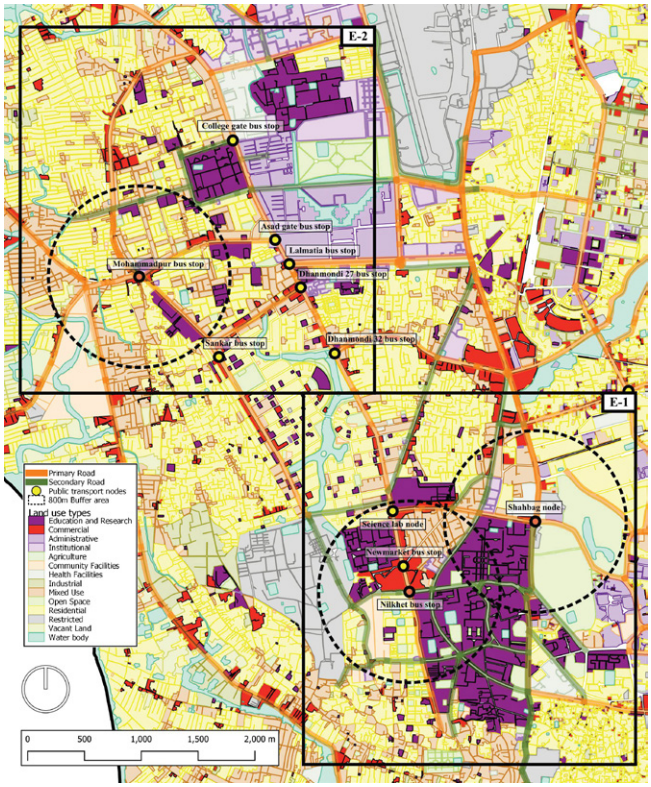

Figure 4. Land use distribution around the major nodes in the Educational areas of Dhaka: E-1. Shahbag and Newmarket and E-2. Mohammadpur
(Source: Authors using the GIS database from the city development authority)

Zone E-1 covers the Shahbag and Newmarket areas. The Shahbag node and Nilkhet bus stop are the two major activity nodes of these areas. In Shahbag, significant educational parcels and commercial activities are concentrated around the Shahbag node. Two major public universities in the country and a medical college are located in this zone. Education and research category land parcels in Newmarket

are concentrated along the primary roads. Among the three important nodes in the area (i.e., the Nilkhet bus stop, Newmarket bus stop, and Science Lab node), commercial activities are significantly concentrated around the Nilkhet bus stop.

Zone E-2 covers Mohammadpur, where educational institutions are distributed in various locations. Notable nodes in this area are the College Gate bus stop, Asad Gate bus stop, Lalmatia bus stop, Dhanmondi 27 bus stop, Dhanmondi 32 bus stop, Sankar bus stop, and Mohammadpur bus stop. The Mohammadpur bus stop is an important transportation node in the city and constitutes the major activity hub in zone E-2 for its vital connectivity with the primary network and concentration of commercial activities. The Draft Structure Plan proposes a sub-regional centre at this node (RAJUK, 2015).

Commercial activities

Commercial activities in Dhaka are not characterized by single hubs but rather by a ribbon development pattern, following some principal arterials in a dispersed manner. Due to their linearity and sparsity, it is difficult to identify the commercial clusters in the existing land use map. Therefore, to identify the city's key commercial areas, this study has taken references from previous studies. Earlier studies have identified and mentioned seven commercial centres so far, namely Motijheel (Afrose *et al*., 2019; Ahsan, 1991; Islam and Adnan, 2011), Karwanbazar (Afrose *et al*., 2019; Eisenberger and Keck, 2015; Islam and Adnan, 2011), Mirpur (Afrose *et al*., 2019; Islam and Adnan, 2011), Gulshan (Afrose *et al*., 2019), Banani (Afrose *et al*., 2019), Mohakhali (Afrose *et al*., 2019), and Old Dhaka (Afrose *et al*., 2019). Some activity nodes have already been identified in the Motijheel and Mirpur areas (Figures 2 and 3). The remaining four areas, Karwanbazar, Gulshan, Banani, Mohakhali, and Old Dhaka have been demarcated under three zones i.e., C-1, C-2, and C-3 (Figure 5).

Zone C-1 covers the Karwanbazar area, where the SAARC Fountain is the major commercial node. The SAARC Fountain is also one of the major activity hubs in the city where the city's important primary roads intersect. Various commercial activities are concentrated around this node and distributed radially from the SAARC Fountain in all directions. The original Karwanbazar wholesale market is located at the northeast corner of the node, surrounded by high-rise residential buildings, government agency buildings, autonomous bodies, and various companies (Afrose *et al*., 2019). This node is also home to some significant landmarks, i.e., the Pan Pacific Hotel Sonargaon (a five-star hotel), and Bashundhara City (a premier shopping mall), with some business and trade centres. At the southwestern corner of this node, there are corporate offices, business centres, hotels, convention halls, and furniture markets. All these commercial developments are located within the 800-metre buffer area around the SAARC Fountain.

Zone C-2 covers the Gulshan, Banani, and Mohakhali areas. The major commercial axis of Gulshan runs between the Gulshan 1 and Gulshan 2 Circles in the north-south direction. The Gulshan 1 Circle, located at the intersection of two primary roads, is this area's major activity node. It is characterized by significant commercial activities, including five-star hotels, shopping malls, supermarkets, furniture stores, clothing stores, restaurants, banks, corporate offices, etc. The major transportation node in Banani is the Kakoli bus stop. On the southwestern portion of this node, there are narrow commercial strip developments that include various retail and wholesale shops of specialized products, i.e., steel furniture, building materials, glass materials, hardware, electronics, etc. Some secondary commercial axes in Banani accommodate five-star hotels, shopping malls, restaurants, hotels, business centres, corporate offices, and banks. In Mohakhali, the Mohakhali bus stop is the major activity node located at the prime junction of the city's three primary arterials. The Mohakhali bus terminal is located at the southwestern part of this node, and it provides inter-city transportation services from Dhaka to the northern cities. Besides this, a city corporation supermarket and a green market are located at the eastern corner of the node.

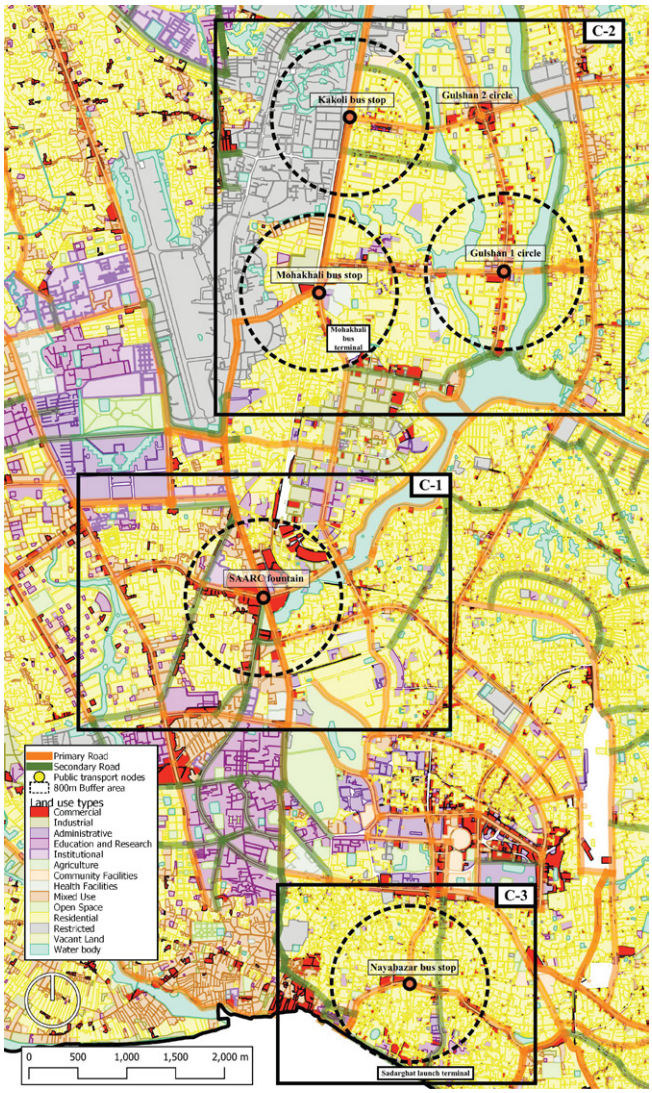

Figure 5. Land use distribution around the major nodes in the Commercial areas of Dhaka: C-1. Karwanbazar; C-2. Gulshan, Banani and Mohakhali; and C-3. Old Dhaka
(Source: Authors using the GIS database from the city development authority)

Zone C-3 covers the Old Dhaka area, where commercial activities are distributed sporadically toward inaccessible locations. The major activity node in this area is the Nayabazar bus stop which lies at the intersection of two primary roads. Commercial activities near this node include markets (kitchen, paper, and steel), building material stores, banks, etc. Commercial areas developed along the riverside (near the Sadarghat launch terminal) are poorly connected with the main arterials, and are, therefore, inaccessible from the city.

Public transport infrastructure

There are three inter-city bus terminals in Dhaka, namely Gabtoli, Mohakhali, and Saidabad (JICA, 2015). Some activity nodes have already been identified near the Gabtoli bus terminal and Mohakhali bus terminal earlier in this study (Figures 3 and 5). The remaining area around the Saidabad bus terminal (Jatrabari) has been demarcated under the T-1 zone (Figure 6).

Figure 6. Land use distribution around the major node in the selected bus terminal area of Dhaka: T-1. Jatrabari
(Source: Authors using the Strategic Transport Plan Report and GIS database from the city development authority)

In zone T-1, the Saidabad terminal is mostly surrounded by residential areas with fewer commercial activities. Near the terminal, significant commercial activities can be observed around the Jatrabri bus stop. This node is a major transportation hub in the southeastern part of the city where three inter-city highways intersect. A sub-regional centre is proposed at this node in the Draft Structure Plan (RAJUK, 2015).

Activity nodes in Dhaka

Based on the clusters of administrative, institutional, education and research, commercial activity, and the location of inter-city bus terminals, the following sixteen activity nodes of Dhaka can be identified (Figure 7). They are the Dainik Bangla node (Motijheel), Nayabazar bus stop (Old Dhaka), Nilkhet bus stop (Newmarket), SAARC Fountain (Karwan bazar), Mohakhali bus stop (Mohakhali), Gulshan 1 Circle (Gulshan), Kakoli bus stop (Banani), Mirpur 1 and Mirpur 10 bus stops (Mirpur), Agargaon bus stop (Agargaon), Shahbag node (Ramna), Farmgate bus stop (Farmgate), Saat Rastar Mor (Tejgaon), Mohammadpur bus stop (Mohammadpur), Mazar road bus stop (Gabtoli), and Jatrabari bus stop (Jatrabari).

Among them, two activity nodes are located in the older part of the city, Old Dhaka and Jatrabari. The indigenous, informal settlements in the older part have a high-density mixed land use pattern, with commercial uses on the outer layer and residential and manufacturing uses in the inner part (Rahman *et al*., 2021). The distinct pattern is characterized by the narrow, winding, and intricate street network, which continuously twists in and out, and is extremely crooked in some places (Nilufar, 2011).

The remaining fourteen nodes are located in the newer part where planned and informal settlements coexist. Among them, the activity nodes in Agargaon, Banani, Gulshan, Mirpur 1, Mirpur 10, Mohammadpur, Motijheel, Newmarket, Shahbag, and Tejgaon are characterized by planned, regular layouts accommodating mostly residential, administrative, institutional, commercial, and industrial land use. Their street layout follows a rigid grid iron pattern with some semicircular arcs. They appear to be partly imposed upon their surroundings since the land formation had little impact on the new developments (Nilufar, 2011). The activity nodes in Farmgate, Gabtoli, Karwanbazar, and Mohakhali of the newer part show significant unplanned, informal development patterns. Developed by private landowners, informal settlements are characterized by spontaneous commercial, residential, and mixed-use developments. These layouts consist of narrow, winding streets, and irregular, dispersed, and asymmetric plot configurations (Rahman *et al*., 2021). The main thoroughfares turn into major shopping strips and most buildings tend to have ground-level shops (Nilufar, 2011). The inner roads exhibit spontaneous growth as they generate with the growing plot division.

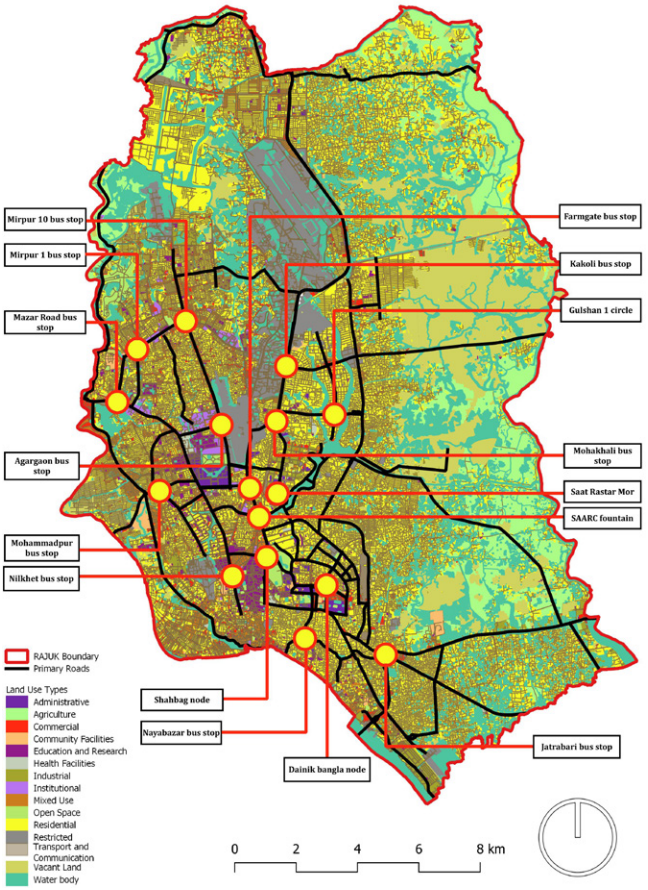

Figure 7. Activity nodes in Dhaka
(Source: Authors)

Land use pattern of the activity nodes

In most of the activity nodes, residential land parcels occupy most of the land area within the 800-metre buffer, where Old Dhaka, Jatrabari, and Mirpur 1 have the highest residential share, with 60.01%, 53.73%, and 52.59%, respectively (Figure 8). In Agargaon and Banani, a significant share of the buffer area is occupied by the restricted land use category; however, apart from that, they are primarily occupied by institutional (20.07%) and residential (29.55%) land use, respectively. The nodes in Newmarket and Shahbag are predominantly occupied by the education and research land use categories, with 33.92% and 18.94%, respectively. Relatively higher percentages of commercial areas can be seen in the nodes of Tejgaon, Motijheel, and Karwanbazar (17.52%, 16.80%, and 12.07%, respectively). In contrast, the commercial shares of Agargaon, Shahbag, Mohammadpur, Mohakhali, and Banani are comparatively lower, with 0.53%, 1.91%, 2.01%, 3.45%, and 3.47%, respectively. However, there is a significant percentage of mixed-use category land use observed in the Mohammadpur and Mirpur 10 nodes, with 25.82% and 23.61%, respectively.

In some cases, they are significantly concentrated near the nodes, i.e., in Mohakhali and Karwanbazar. But in Farmgate, Gabtoli, and Tejgaon, they extend deep into the secondary and local roads in a dispersed pattern. In Old Dhaka and Jatrabari, the non-residential parcels are sparsely developed within a predominantly residential grid. In Agargaon, Banani, Motijheel, Newmarket, and Shahbag, the non-residential parcels cover a significant buffer area where pockets of fewer residential developments are visible.

Table 1 depicts the calculated Balance Index values of the activity nodes. It shows that the nodes in Agargaon, Newmarket, Shahbag, Motijheel, Tejgaon, and Banani are dominated by non-residential land parcels, with 90.27%, 84.50%, 73.30%, 67.26%, 63.09% and 61.97% shares, respectively. On the other hand, the nodes in Gulshan, Old Dhaka, Jatrabari, and Mirpur 1 are dominated by residential land parcels with 74.30%, 70.96%, 67.02%, and 64.53% shares, respectively. The Balance Indices of these nodes range from 0.19 to 0.31 (poor) in Agargaon and Newmarket; 0.51 to 0.76 (moderate) in Gulshan, Shahbag, Old Dhaka, Motijheel, Jatrabari, Mirpur 1, Tejgaon, and Banani; and

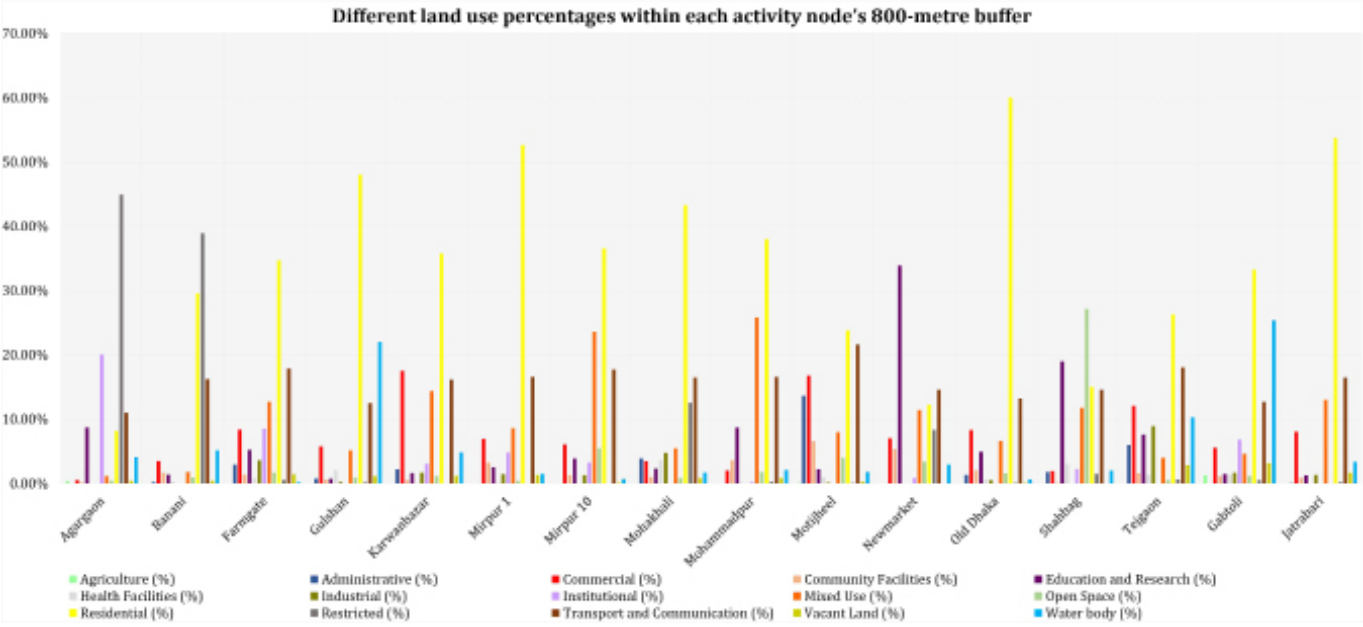

Figure 8. Percentage of different land uses for each activity node
(Source: Authors using the GIS database from the city development authority)

The share of residential land use is also very low in some nodes, namely Agargaon, Newmarket, and Shahbag, where Agargaon has the lowest (8.19%), followed by Newmarket (12.26%), and Shahbag (15.04%). Besides these, most activity nodes have a very low percentage of open space within the buffer area, except Shahbag, where it is about 27.15%. For sustainable neighbourhoods, at least 15% of the land should be allocated for open public space (UN-Habitat, 2014). In Agargaon, Banani, Gulshan, Mirpur 1, Mohakhali, and Tejgaon the percentage of open public space is less than 1%. In Jatrabari this percentage is 0%.

Overall, the non-residential land parcels around each activity node are mostly distributed along primary routes and concentrated in nodal areas (Figure 9). In Gulshan, Mirpur 1, Mirpur 10, and Mohammadpur, the non-residential land parcels are compactly distributed along the primary roads.

0.87 to 0.96 (good) in Farmgate, Karwanbazar, Mirpur 10, Mohakhali, Mohammadpur, and Gabtoli.

DISCUSSION

6.1 Summary of the findings

The core activities of Dhaka are distributed over multiple locations. Although administrative, institutional, and education/research activities are distinctly concentrated at specific locations, commercial activities are linearly distributed along the major arterials in a dispersed manner. Relatively higher percentages of commercial land parcels can be observed in Karwanbazar, Motijheel, and Tejgaon (>10%). However, Agargaon, Shahbag, Mohammadpur, Mohakhali, and Banani exhibit a relatively lower share of commercial land parcels (<4%). Again, particular land

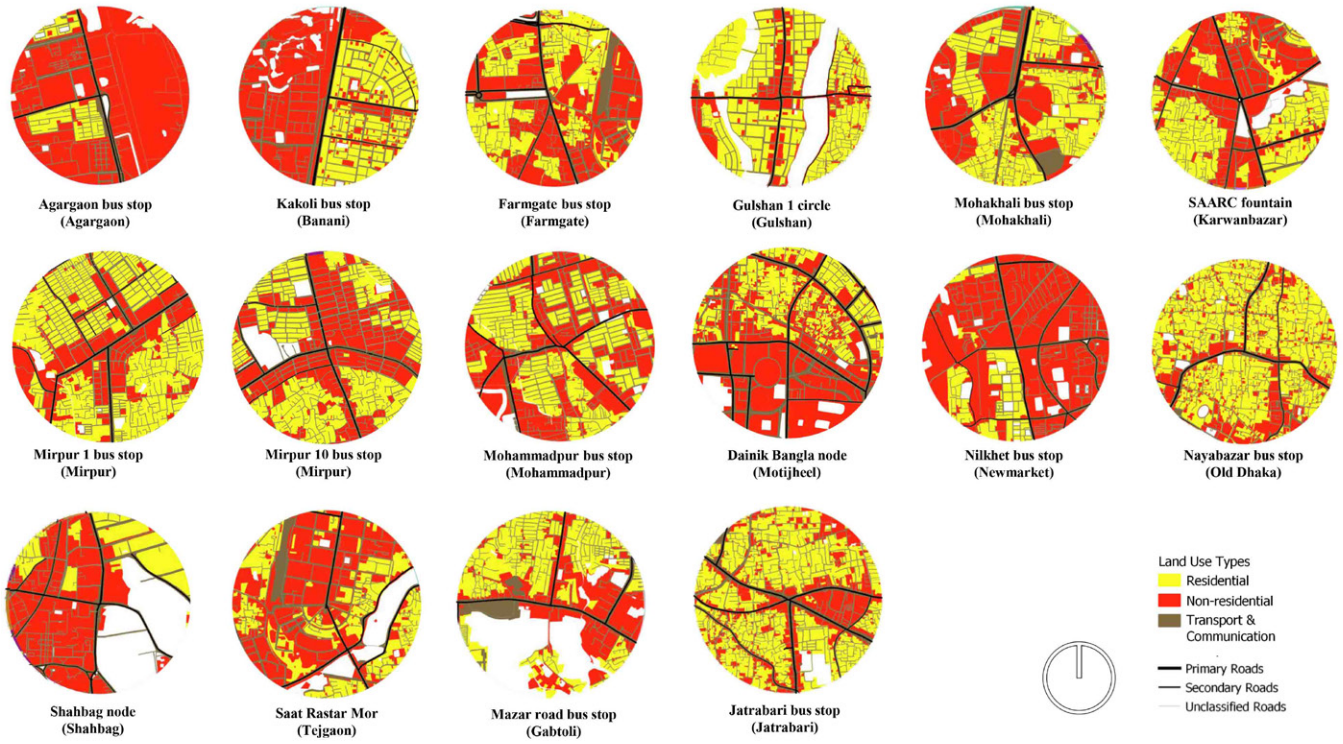

Figure 9. Residential and non-residential land distribution of the activity nodes (Source: Authors using the GIS database from the city development authority)

Table 1. Percentage of residential and non-residential urban land areas and the Balance Indices of the activity nodes

Node name	Residential urban land area (km^2)	Non-residential urban land area (km^2)	Share of Residential urban land area (%)	Share of Non-residential urban land area (%)	Balance Index	Remarks
Agargaon	0.16433	1.52377	9.73%	90.27%	0.19	Poor
Banani	0.59528	0.96991	38.03%	61.97%	0.76	Moderate
Farmgate	0.69968	0.91547	43.32%	56.68%	0.87	Good
Gulshan	0.96474	0.33364	74.30%	25.70%	0.51	Moderate
Karwanbazar	0.72005	0.84887	45.89%	54.11%	0.92	Good
Mirpur 01	1.05505	0.57997	64.53%	35.47%	0.71	Moderate
Mirpur 10	0.73341	0.7947	47.99%	52.01%	0.96	Good
Mohakhali	0.87269	0.76048	53.44%	46.56%	0.93	Good
Mohammadpur	0.76299	0.83457	47.76%	52.24%	0.96	Good
Motijheel	0.47803	0.98192	32.74%	67.26%	0.65	Moderate

parcels are dominant in some nodes, i.e., the education/ research (Shahbag and Newmarket) and institutional (Agargaon) categories. Besides these, most of the activity nodes of Dhaka have a very low percentage of open space. The land use mix analysis revealed that the activity nodes in Agargaon, Newmarket, Shahbag, Motijheel, Tejgaon, and Banani are dominated by non-residential land parcels, and those in Gulshan, Old Dhaka, Jatrabari and Mirpur 1 are dominated by residential land parcels. A good balance between residential and non-residential land parcels can be found in the Farmgate, Karwanbazar, Mirpur 10, Mohakhali, Mohammadpur, and Gabtoli activity nodes.

Overall, a significant portion of the city's area exhibits an unplanned layout, with residential areas intensified through high-density development and successive plot subdivisions. Furthermore, weakness in planning and zoning regulations, along with the expanding civic needs has resulted in the frequent intrusion of non-residential functions into the planned residential areas. The transportation network also lacks clarity between the major and minor segments. Piecemeal development of existing roads has caused poor linkages among transportation systems, resulting in irregular movement patterns (RAJUK, 2015). All these factors have led to the sporadic development of activity nodes, which lack defined boundaries and urban design regulations.

Current development trends in relation to the compact city form

The findings of this study indicate that almost all activity nodes exhibit moderate to good land use diversity, which means that the nodes are, to some extent, self-supported. Inadequate infrastructure for services and transport has also caused residential units to remain close to workplaces, thereby reinforcing short travel distances. All these factors have contributed to the current multicentric compact city form, where the nodes are overcrowded and unsuitable for transit and walking. A large section of urban dwellers in Dhaka are pedestrians and daily commuters who suffer from a lack of convenience and orientation for urban movement. There remains also a major deficiency of parks and open spaces around the nodes. The plazas are neither marked nor designed for densely crowded nodal activity areas (RAJUK, 2015). Besides this, commercial buildings are spatially scattered around the city, not fully complying with the zoning policy. A recent study has revealed that about 67% of commercial and 51% of industrial buildings within Dhaka do not comply with land use zoning regulations (Rahman *et al*., 2021). It also reveals that approximately 10% of commercial buildings, 9% of industrial buildings, and 6% of residential buildings have encroached upon open spaces, flood-prone zones, water bodies, and future road-extension areas. Rigid planning practices are one of the reasons for land use zoning violations in Dhaka (Baumgart *et al*., 2011). For example, master plans often fail to accommodate informal housing and mixed land-use demands that characterize Dhaka's rapid urbanization. This discrepancy has resulted in widespread violations, as residents and developers prioritize functional needs over compliance with zoning laws. Therefore, zoning laws, originally intended to guide structured growth, have become ineffective due to inconsistent enforcement, inadequate monitoring, and lack of adaptability to new urban realities (Alam and Ahmad, 2010; Baumgart *et al*., 2011).

In the context of Dhaka, the current compact, mixed-use development pattern should be encouraged in order to reduce journey-to-work trips and traffic-related environmental problems. Alongside that, land use and transport planning need to focus on improving pedestrian networks and providing means for mass transit. Public transport should be incorporated with land use policies in order to ensure employment and balanced housing, thus motivating travel on foot or by bicycle, as well as public transport use (Roy *et al*., 2023). The promotion of compact and mixed-use urban forms requires a flexible and adaptive approach as opposed to the more rigid land use regulations that produce conventional low-density development patterns (Duany and Talen, 2002). However, for the nodal model to be effective, all tiers of urban planning must contribute to the achievement of dense, multifunctional, and transit- and walking-conducive nodes (Filion and Kramer, 2012). From this perspective, Dhaka's current trend of high density and unplanned nodal growth needs to be guided through a combination of policy measures, social considerations and physical design to achieve a compact city that ensures a transit-friendly, walkable urban environment.

Implications of the study

There are several implications of the findings from this study, which will allow policymakers to undertake specific nodal strategies considering the complex land use structure of the activity nodes.

First, the densest residential areas are located in the older part of the city (Old Dhaka and Jatrabari). Its organic character has resulted from a distinctive history, culture, and social composition. Nodal strategies in these areas should focus on the conservation of available open spaces and heritage sites in order to prevent the intrusion of incompatible land use, as well as infrastructure redevelopment (i.e., improving streets and pedestrian networks) to enhance the legibility of the urban space. Historically, Old Dhaka had a strategic urban design approach in creating Chawks (public squares), nodes, and streets. Walkable urban design strategies can be adopted in these nodes using strong social policies in order to revive the traditional pedestrian-oriented built environment.

Some activity nodes in the newer area are mostly characterized by planned development patterns (Agargaon, Motijheel, Mohammadpur, Gulshan, Banani, Newmarket, Shahbag, Tejgaon, Mirpur 1, and Mirpur 10). Our analysis has shown that they exhibit moderate to good levels of land use diversity, except for Agargaon and Newmarket. In Agargaon, a significant portion of the activity node (the eastern side of the Agargaon bus stop) falls within the Old Airport area, which is under military governance and not open to public use. The previous Structure Plan (1995-2015) had made strategic decisions to convert the area into a central park and sports complex; however, this could not be implemented due to opposition from the military administration (RAJUK, 2015). Integrated land use planning schemes can be undertaken in the Agargaon node, in order to designate public land for mixed-use zones that allow residential, commercial, and recreational functions, and that encourage multi-functional buildings. On the other hand, the Newmarket node is mostly surrounded by educational institutions and commercial buildings. A significant area surrounding the node is regulated by strict zoning. Therefore, commercial uses exert pressure on the node by encroaching on pedestrian sidewalks and parking spaces, resulting in traffic congestion. Additionally, some mixed-use buildings at the northeastern corner of the node are poorly connected to the main arterial and secondary streets. The distinct curved secondary road (previous inter-city railway line) asymmetrically cuts the nodal area without ensuring proper connectivity with the neighbourhood. Here adaptive strategies can be undertaken throughout the Newmarket node in order to enhance the intensity of public use along the major arterials. Furthermore, to ensure balanced movement, some local streets connecting secondary roads can be redeveloped as a pedestrian network where sidewalks can be redesigned to allocate designated vendor spaces and plazas in order to handle heavy pedestrian traffic. In all nodes, strategic adaptive measures can be undertaken to improve walking routes connecting neighbourhoods using MRT stations and bus stops.

Lastly, some activity nodes in the newer part have significant areas of unplanned development (Mohakhali, Gabtoli, Karwanbazar, and Farmgate). In these areas, non-residential use frequently invades residential areas, resulting in scattered non-residential parcels with weak accessibility to basic services and facilities. Perhaps these nodes can be considered for major urban interventions because of the transient nature of the built environment. Incentives can be provided for promoting high-density mixed uses near the nodes. Vertical expansions can be regulated on the most accessible urban blocks to ensure accessible public spaces near transit.

CONCLUSIONS

Overall, this study tried to identify the major activity nodes of Dhaka from the distribution pattern of core urban activities, as well as to assess their land use pattern from a compact city perspective. The study revealed that, although most activity nodes exhibit moderate to good land use diversity, they are mostly unplanned and lack urban design and planning regulations. Additionally, they represent distinct morphological patterns, with unique spatial layouts and heterogeneous land use distribution. Therefore, specific strategies are required for designing and planning these nodes, considering their intricate transportation network and complex land use dynamics. Given the vibrant functional land use surrounding the nodes, the planning goal should focus on creating a pedestrian-friendly built environment that is cohesive with the existing land use diversity.

The study was limited to land use parcel data for identifying the activity nodes, as plot, building, or floor level data were not available for analysis, and therefore could not be considered for a more accurate estimation of activity concentration. However, these findings can be utilized in future research to identify appropriate strategies for nodal development in Dhaka. These will provide useful directives for determining suitable urban interventions for specific nodes, including the demarcation of mixed-use zones, optimum Floor Area Ratio, accessibility analysis of transportation network, streetscape design, etc. The outcomes of this study will help improve knowledge and existing research on compact city development, and guide policymakers in future planning and design interventions for activity nodes in similar contexts.

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