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MEASURING COMPACT DEVELOPMENT POTENTIAL OF AN EMERGING URBAN AREA: A CASE OF SAVAR

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ABSTRACT

Compact development is an urban development policy aimed at promoting high density mixed used city to improve city's environmental condition. Savar is a fast-growing outer urban area of the capital Dhaka, which is growing through rapid urbanization in the recent decade. As enormous population growth causing the capital city to expand beyond city boundary, Rajdhani Unnayan Kartripakkha (RAJUK), the Capital Development Authority of the Government of Bangladesh has identified Savar as one of the five outer urban areas in the Regional Development Plan (RDP) known as Dhaka Structure Plan (2016-2035) for promoting compact development where various activities of the capital city will shift to minimize the congestion of the core city. For successful implementation of this strategy a careful investigation of the existing spatial structure of these areas is essential for guiding future urban development. Therefore, this study aims to evaluate the potential of these proposed urban areas to accommodate their future growth in a compact manner focusing on Savar, an established urban area of the Dhaka Metropolitan Region. For assessing the compact development potential of Savar, this paper analyzed six indicators of two major aspects of urban form, population and land use pattern using Geographical Information System (GIS). The results of this study revealed that the growth pattern of Savar is still not compact and efficient planning mechanism should be devised for its future growth in a sustainable manner. The findings of this study will help policymakers, planners, architects and development authorities in policymaking, planning and designing a more sustainable and efficient urban area through compact urban development at intra-urban level.

Keywords: *Compact development; Dhaka Metropolitan Region; Dhaka Structure Plan; Savar.*

1. INTRODUCTION

The growing urban population in developing nations has been a concern for urban planners and sustainability experts because more than half of the world's population now resides in urban areas (Kotharkar and Bahadure, 2020). Due to the rapid increase in the world's urban population, between 2000 and 2050, urban space will need to be doubled in developed countries and expanded by 326 percent in developing countries (Rahman *et al.*, 2021). Managing urban growth is particularly challenging for the developing countries, as they are often characterized by the unregulated intensification process that is aggravated by population increase and development pressure, which is making the cities more crowded, unplanned, and ecologically unfriendly (Zaman and Lau, 2000). Moreover, unplanned urban growth creates urban sprawl which is posing adverse effects on urban sustainability through higher carbon emission, agricultural land reduction, increased expenditures on infrastructural facilities provision, negative impact on public health and creation of social problems (Rahman *et al*., 2021). Hence, there is growing concern among various researchers, urban professionals and authorities for compact urban development as means of sustainable urban development (Adnan *et al*., 2009; Imon, 2001; Zaman and Lau, 2000; RAJUK, 2015; Rahman *et al*., 2021).

Compact urban development indicates an urban development pattern with spatial contiguity, strong centres, mixed land uses, medium to high densities, good accessibility, and permanent open spaces (Ewing and Hamidi, 2015). Compact urban development has long been the subject of discussion on sustainable urban form, which is considered to be a significant step in the direction of resolving many issues faced by the contemporary cities. Proponents of compact urban development claim that, "higher densities reduce energy consumption, and thus also pollution" - stemming from the idea of reducing transport demands and improving quality of life to ensure a more sustainable city form (Imon, 2001).

Interest in compact development has been concentrated in developed countries such as USA, Japan, and Australia (Jenks and Burgess, 2000), although European cities have been forcing densification for many decades because of limited available land (Koziatek and Dragicevic, 2019). Due to exceptionally high population growth demands coupled with the depletion of available land, Shanghai and Hong Kong are amongst many Asian cities

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that are examples of compact cities with high volumes of high-rise buildings (Jenks and Burgess, 2000). In the context of Dhaka, recently RAJUK have undertaken compact development policies to make Dhaka city liveable through accommodating the growth in a compact manner. In this regard, Dhaka Metropolitan Region (DMR) is conceptualized as a polycentric urbanized area encompassing a number of physically contiguous cities and growth centres (RAJUK, 2015; Hassan and Southworth, 2018). In general, compact development is key element in regional polycentric structure anchored by dense, diverse and accessible compact centres (Park *et al*., 2020). Therefore, for the successful polycentric metropolitan growth of DMR, it is imperative to ensure compact development of the proposed cities and growth centres. But implementation of similar development strategy on each of these outlined urban areas is a challenge. In fact, each of these urban areas have different socio-economic, demographic, spatial and political aspects albeit put under the umbrella term, polycentric metropolitan region in the Structure Plan. Some of them are densely populated i.e., Narayanganj, Gazipur; some of them are over-crowded, i.e., Dhaka city; some of them are rapidly urbanizing i.e., Savar; and even some of them are still undeveloped, i.e., Purbachal, Jhilmeel (RAJUK, 2015). Therefore, critical question arises, "do all of these areas need similar compact development strategy or even do all these urban areas have the potential for compact development for successful metropolitan growth?"

Recently much attention has been given on the relationship between urban form and sustainability (Abdullahi *et al*., 2017). Various studies have attempted to demonstrate how a city's shape, size, density, and distribution of land use may affect its sustainability (Kotharkar *et al*., 2014). So, such investigation can have useful implication in assessing and formulating efficient planning mechanism for the regional development of Dhaka. Previously, several studies have investigated the spatial structure of the core city of DMR, Dhaka city for sustainable as well as compact development (Adnan *et al*., 2009; Rahman *et al*., 2021). But such study on the form and structure of outer urban areas of DMR is still limited. As Dhaka city is already overburdened with rapid population growth and loss of ecologically critical areas, the current planning regime has already shifted focus on these outer urban areas for sustainable regional growth. A critical investigation of the form and structure of these outer urban areas will not only facilitate the regional compact development strategy but also bridge the current gap in the research on relatively small and developing urban areas.

Therefore, the aim of this study to evaluate the compact development potential of these outer urban areas focusing on the Western zone[1] (Savar) to facilitate compact development strategy adopted by the Structure Plan (2016-2035). The Western zone has been chosen as a case as it is a rapidly urbanizing area among the all proposed outer zones. Since becoming the municipality, the urban growth rate of Savar has been significantly accelerating. Furthermore, the establishment of planned industrial areas, led to a sharp rise in the rate of population growth with additional employment opportunities (Dewan and Corner, 2014; Hassan and Southworth, 2018). A comparison among the growth scenario of different urban areas in DMR shows that, the Western zone (Savar) has very high growth rates during 2001-2011 with 9.26% (Table 1). Also, the growth rate in this zone has increased significantly with 5.38% between periods (2001-2011) and (1991-2001), whereas it is very low about 0.58% in Southern and declined by -1.05% in the Central zone. Also, the Western zone has the highest rate of increase in population density with 8.33% between periods (2001-2011) and (1991-2001). Therefore, such emerging urban area, which is growing above average growth rate of the entire metropolitan region should be of prime concern for future planning.

Table 1: Growth scenario of the six zones of DMR (Source: RAJUK, 2015)

Zone	Annual population growth rate (%)		Increase in population density per year (ppa) (%)		Percentage change in population growth rate	[2]Percentage change in the rate of increase of population density
	1991-2001	2001-2011	1991- 2001	2001-2011		
Central	4.20	3.15	5.08	3.60	-1.05	-1.48
Northern	4.09	7.43	5	10	3.34	5
Eastern	1.99	2.72	1.42	2.5	0.73	1.08
Southern	3.04	3.63	3.33	4.5	0.58	1.17
South Western	1.3	2.79	1.53	2.66	1.50	1.13
Western (Savar)	3.88	9.26	5	13.33	5.38	8.33
Total	3.71	3.96	4.44	4.61	0.25	0.17

[1] Originally in the Structure Plan (2016-2035) these functional areas are termed as 'regions'. To avoid misinterpretation regarding 'regions within region' these six areas have been termed as 'zones' in this study.

[2] Percentage change in rate of increase of population density is calculated from the difference of increase in population density per year between (2001-11) and (1991-2001)

The specific objective of this study is to analyze the spatial structure of Savar area in terms of compact development indicators. Among various attributes of urban form, the scope of this study has been limited to the population and land use pattern of the case area. These two attributes are fundamentally related to urban compactness indicators (i.e., density, land use mix etc.) and are important parameters for assessing city's spatial structure (Nadeem *et al*. 2021; Burton 2000, 2002; Bertaud 2001, Kotharkar and Bahadure, 2020; Kotharkar *et al*., 2014). Additionally, this study specifically focused on the proposed urban area, sub-regions and urban centres of Savar as outlined in the Structure Plan (2016-2035) so that the findings can be applicable for future strategic planning in line with RAJUK's compact development strategy. In fact, these sub-regions and urban centres have been proposed in the Structure Plan based on the population data of the year 2011 which is very old (RAJUK, 2015). In this regard, an updated data intensive research will provide useful insights on future planning and development of Savar in an efficient manner. Therefore, next section has provided a brief overview on the historical growth of Savar and various policies and strategies undertaken by the Structure Plan to interpret the growth pattern of Savar and RAJUK's current development strategy.

2. REVIEW OF STRUCTURE PLAN (2016-2035) AND OVERVIEW OF SAVAR

The Structure Plan (2016-2035) covers an area of approximately 1528 sq. km including the previous DMDP (Dhaka Metropolitan Development Plan) area with some extension in the North and North-eastern parts (RAJUK, 2015) (Figure 1A). This planning area includes two City Corporation areas of Dhaka city, some portion of Gazipur City Corporation and Narayanganj City Corporation area, Keraniganj Upazilla and part of Savar Upazilla and designated as Dhaka Metropolitan Region (DMR). The Structure Plan (2016-2035) identified some strategic areas for active future developments and some areas for passively preserving purposes (Figure 1B).

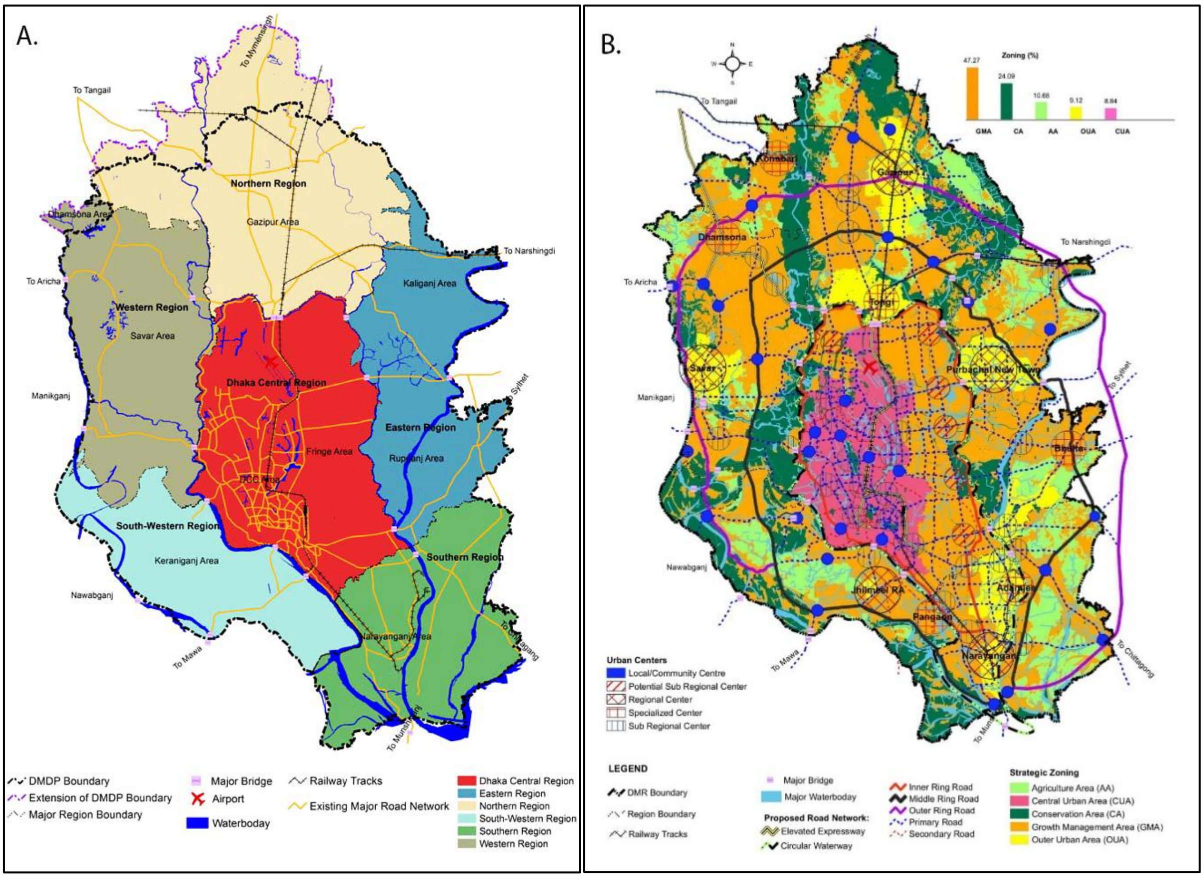

Figure 1: A. Proposed zones in Dhaka Metropolitan Region (DMR); B. Strategic Land Use Zoning of Structure Plan (2016-2035). (RAJUK, 2015; 2018)

Based on the above framework, a two-tier zoning regulation is proposed in the Structure Plan. For the first tier, whole DMR is divided into two strategic zones namely Urban Promotion Area (UPA) and Urban Control Area (UCA) based on the possibility of future urbanization and preservation respectively (RAJUK, 2015). UPA includes three strategic management areas: Central Urban Area (CUA), Outer Urban Area (OUA) and Growth

Management Area (GMA). CUA and OUA are both established urban areas defined by Local Government (LG) administrative unit boundaries in which the CUA encompasses only the core city (Dhaka city). GMA are mainly developing areas where land is being transformed from rural uses i.e., agriculture to urban uses e.g. residence, commerce, industry etc. (RAJUK, 2015). UCA included two strategic management areas namely Agriculture Area (AA) and Conservation Area (CA), where the former consists of prime agricultural lands and the latter includes environmentally sensitive areas. In the second tier, local or detail land use plans under the Detailed Area Plan (DAP) would specify the designation of detailed land use zones and permitted or prohibited activities for each zone. In this way, zoning at the Structure Plan level broadly delineates strategic management areas that should be followed in the Detailed Area Plan (DAP) or other action area plan at the local level (Figure 1B).

To promote compact urban development, two key spatial strategies have been undertaken in the Dhaka Structure Plan (2016-35). The first one is to divide the whole planning area into six functional zones as self-sufficient areas that can provide both accommodation and work opportunities for their residents along with other basic urban services namely Central zone (Dhaka City and fringe), Eastern zone (Tarabo, Bhulta, Purbachal and Kaliganj), Northern zone (Tongi, Gazipur and vicinity), Southern zone (Narayanganj), Western zone (Savar, Dhamsona and surrounding) and South-Western zone (Keraniganj) (RAJUK, 2015) (Figure 1A). These zones are defined as functional areas within the region almost like a city by themselves with a central focal point of urban agglomeration. These zones are considered as the basic units of the functional decentralization for redistribution of activities to create more balanced urban development (RAJUK, 2015). The second one is the creation of major focal points in urban settlement called 'centres' which would be intensely built and provide major public functions and could be in established, developing or potential urban areas (RAJUK, 2015) (Figure 1B). In a nutshell, this strategy involves focusing activities in centres, as the majority of the growth in the current trend has been occurring outside of the core city anyway, it can be accommodated in certain points in a compact manner to make maximum utilization of the existing infrastructure (RAJUK, 2015).

Originally Savar was a small township where initial urban development took place on the north-east bank of the Dhaleswari River and the northern, eastern, and southern part of the area was largely agricultural or marshy land (Hassan and Southworth, 2018). The population of Savar was 131,429 in the year 1974 (BBS, 1974). Although, approximately 14,580 hectares or 58% was agricultural and 6954 hectares or 27% of the total land in Savar was low-land in 1972, the built-up area had increased by approximately 211% between 1972 and 1980 (Hassan and Southworth, 2018). During the same period the population growth was around 92% (BBS, 1974; BBS, 1983).

The original township with 13 local administrative units (union councils) were turned into Savar Upazilla in 1983. In 1991 Savar municipality was established (Savar Pourashava, 2016). The urban growth in Savar persisted in the years that followed, but at a significantly faster rate than before (Hassan and Southworth, 2018). During 1990-1995 the total urban growth in Savar was approximately 325% with annual increase rate of 34%. During 1995-2000, the developed land became approximately doubled (from 628 hectares to 1274 hectares) with a net increase rate of 103%. In the period between 2005-2010 the net growth rate further increased (approximately 150%), where the developed land reached 4660 hectares in 2010. Between 2001-2011 census periods, population growth was also highest at around 130% (BBS, 2014; BBS, 2008).

The formation of several planned large-scale industrial zones, such as the Dhaka Export Processing Zone in Dhamsona in the early 1990s and heavy industrial plants in Nayarhat in the middle of the 1970s created pressure for urban expansion in Savar (Dewan and Corner, 2014; Hassan and Southworth, 2018). As a result, the population increased, due to a significant influx of rural migrants seeking employment in Savar's expanding industrial sectors. Population densification in this zone is also strongly influenced by the proximity to regional highways (Dewan and Corner, 2014). However, despite its lack of urban amenities, two bridges over the Buriganga River and a 32-km multipurpose flood control embankment are accelerating the zone's fast urbanization (Chowdhury, 2003). In addition, a number of establishments with growing tourism importance such as Jahanginrangar University, the Savar Cantonment, the Atomic Energy Center, and the National Memorial, have further reinforced development of Savar (Hassan and Southworth, 2018). At present a large number of offices, business centres as well as schools and other commercial activities are concentrated in the municipality area of Savar (Akter *et al*., 2021). Table 2 show the population of Savar zone in different years.

Table 2: Population in Savar zone in different years (Source: RAJUK, 2017; WorldPop, 2020)

Zone name	Population			
	1991	2001	2011	2020
Western (Savar)	362,636	530,501	1,285,836	1,735,920

In Detailed Area Plan (2022-2035), Savar municipality and surrounding union councils/ townships are designated under the Western zone (RAJUK, 2022). A significant portion of this area are mainly developing areas where land is being transformed from rural uses like agriculture to urban uses e.g. residence, commerce, industry etc. This Western zone has been again divided into nine smaller sub-regions for future development plan. Sub-regions are the smallest administrative unit in the Structure Plan. Each of the six zones in DMR is subdivided into seventy-five sub-regions to facilitate area-wise detailed planning under the Detailed Area Plan (DAP) 2022-2035 (RAJUK, 2022). Sub-regions were redistributed based on the physical structure, development pattern, population density, land use pattern, existing road network density and structure, socio-economic status of the inhabitants and special characteristics, i.e., topography, forests, water bodies, environmentally sensitive areas or disaster risk (RAJUK, 2022).

3. METHOD OF THE STUDY

3.1 Study Area

The study encompasses the proposed 253 sq. km Western zone of Dhaka Metropolitan Region (DMR) including Savar municipality and surrounding townships which is slightly smaller than the current Savar Upazilla area (RAJUK, 2022). For the purpose of the study this area has been termed as Savar zone in this paper. Currently this area is growing above average population growth of the entire Dhaka Metropolitan Region (DMR). Also, the population density is of this area is moderate and can be used effectively through better land use management. Figure 2A shows the study area with respect to DMR and Figure 2B shows its different sub-regional boundaries.

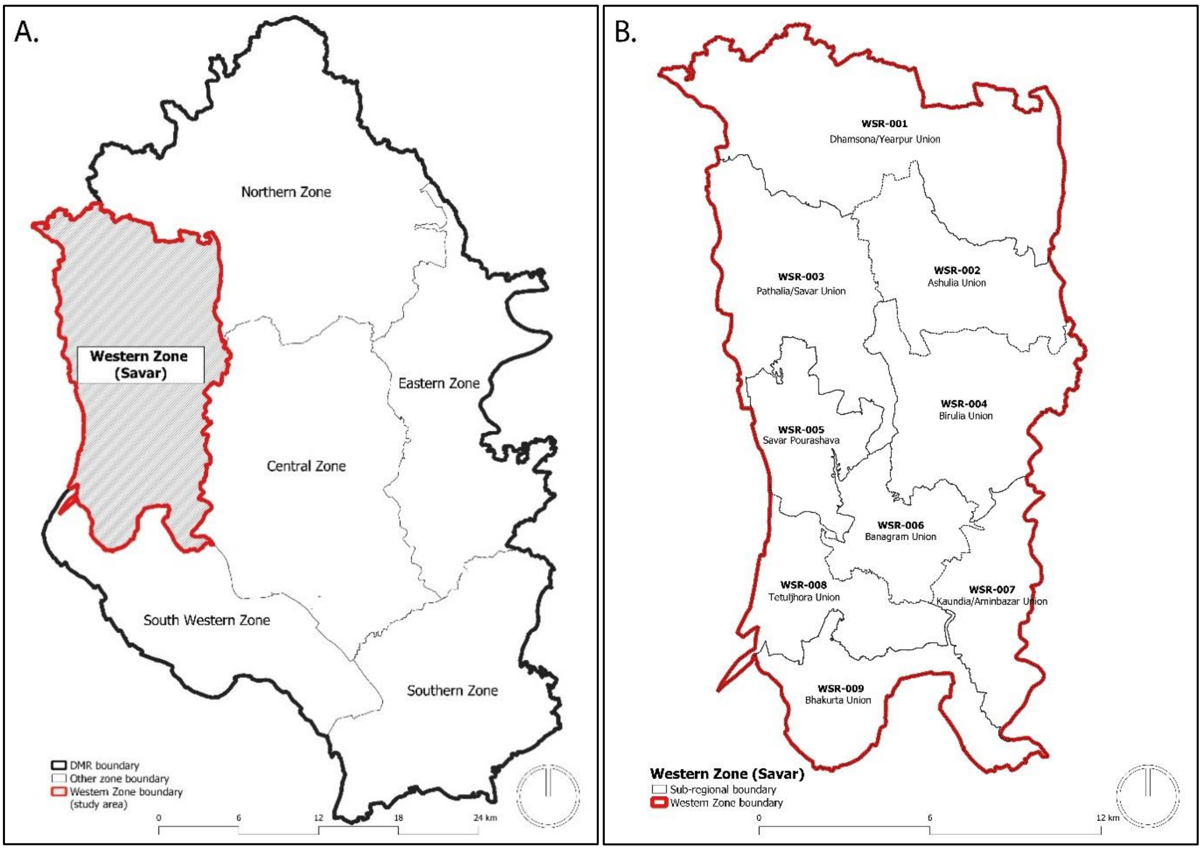

Figure 2: A. Location of study area in DMR; **B.** Sub-regions of Savar zone according to the Structure Plan (2016-2035)

Existing research suggests that the notion of compact development encompasses a variety of scale regarding measures, policies and strategies. For example, Burton (2000) evaluated compactness with social equity at city-level for 25 towns and cities of UK. Imon (2001) evaluated compact development potential of Dhaka from metropolitan level policy perspective considering the centrally concentrated form of Dhaka and the problems associated it. Adnan *et al*. (2009) evaluated the option of compact development as sustainable urban form for Dhaka at city-level. Kotharkar *et al*. (2014) scaled the compact urban form of Nagpur city, India at city-level. At the neighborhood level, Rahman *et al*. (2021) measured compactness of eight wards of Dhaka city to study and evaluate city's compactness as a whole. The Western zone (Savar), along with the other five zones, are conceived under RAJUK (2015)'s compact development strategy as self-sufficient entities, much like a city by itself. Therefore, this research conceptualizes the study area at a scale of city and evaluate its compact development potential at intra-urban level.

3.2 Data

This study has been carried out using secondary data. GIS database of population and land use distribution is the principal resource for conducting this research. GIS database of land use distribution and administrative boundaries of the study area have been collected from RAJUK (RAJUK, 2017). As the census population data was of much earlier time (during 2011), updated population GIS raster data of WorldPop (2020) have been used from online resources. Besides, various calculations on land use distribution have been conducted on parcel level data following some existing literature, due to unavailability of plot and building level data (Mavoa, 2018; Brown *et al.*, 2009). Other secondary data includes various maps, books, research works, journals and works of undergraduate and post-graduate students i.e. theses, projects etc. These are collected from the online resources, various institutions and organizations.

3.3 Indicators of Compact Development

This study focused on population and land use pattern of Savar area to evaluate the potential of compact development. These two attributes have been widely considered in contemporary urban research for measuring compact urban form (Burton, 2002; Kotharkar *et al*., 2014; Rahman *et al.*, 2021), measuring urban sustainability (Liaqat *et al*., 2017; Adnan *et al*., 2009), analyzing urban spatial structure (Bertaud, 2001; Adnan *et al*., 2009) and scaling the potential of compact city development (Nadeem *et al*., 2021; Kotharkar and Bahadure, 2020).

Higher density is one of the key components of compact urban form (Kotharkar and Bahadure, 2020; Nadeem *et al*., 2021). Urban density can be measured through a variety of aspects, such as population, building, residential, road network etc. (Abdullahi *et al*., 2017). Density of population (or employment or other urban activity) on urban land at neighborhoods, municipalities or metropolitan levels can speculate the efficiency of urban land use (OECD, 2012). High densities provide more land for agricultural and open spaces, provide better public transportation service with a lesser reliance on automobiles, reduce urban environmental footprint and slow the consumption of non-renewable resources (Liaqat *et al*., 2017). Compact urban forms contribute to sustainability by consuming less land and reducing travel distances in which higher densities promote diverse services and local businesses (Kotharkar and Bahadure, 2020).

Land use distribution (i.e. proportion of existing land uses, road network, open spaces, civic facilities etc.), land use mix, ratio of residential to non-residential uses and ratio of built-up to open area are essential elements for assessment of urban forms in terms of compactness and sustainability (Nadeem *et al*., 2021; Liaqat *et al*., 2017; OECD, 2012; Burton, 2002). As dense urban environments tend to be mixed-use environments, the positive impacts attributed to density in the literature may result as much from mixed uses (Ewing, 2008). Built-up areas with a high mixture land uses are regarded as compact and sustainable, whereas a high percentage of residential land use in an urban area means that it is homogenous and non-mixed, thus sprawling (Frenkel and Ashkenazi, 2008). Mixing complementary land uses reduces trip lengths and encourages alternatives to the automobile and the highest rates of walking/bicycling are prevalent in cities with a balance of jobs and residents (Ewing, 2008).

There are various indicators to measure population and land use attributes of urban form. Due to limited availability of spatial data, some specific indicators were analyzed for conducting this research. Overall, four indicators (built-up area density, density profile, average distance per person to CBD and dispersion index) from population and two indicators (land use distribution and balance index) from land use pattern been derived from various published literature to measure compact development potential of Savar area (Table 3).

Table 3: Derived indicators of compact development adopted in this research with elaboration and literature sources

Attributes	Indicators	Elaboration	Source
Population	Built-up area density	Population/Built-up area	Nadeem *et al*. 2021; Burton 2000, 2002; Bertaud 2001, Kotharkar and Bahadure, 2020; Kotharkar *et al*., 2014
	Density profile	Density profile shows the population density	Nadeem *et al.*

Attributes	Indicators		Elaboration	Source
			distribution from the distance from the city centre (CBD) at 500m, 1 km or 2 km interval up to certain km or up to administrative boundary.	2021; Adnan *et al.*, 2009, Bertaud, 2001; Kotharkar *et al.*, 2014
	Average distance per person to the CBD		Sum of the product of the administrative sub-division unit population and distances of individual unit to the CBD or CBDS/ Total population of the area. It can be calculated by using the following equation: Average distance per capita to CBD = $\frac{\sum_{i=1}^{i} Di\, P_i}{\sum P_i}$ Where, D_i = distance of i^{th} administrative sub-division to CBD; P_i = total population of i^{th} sub-division; i = 1, 2, 3, 4………………. up to n, where n is the number of the sub-division units	Adnan *et al.*, 2009; Bertaud, 2001
	Dispersion Index		Average distance per person to the CBD/ Average distance per person to center circle of area equal to built-up area. It can be calculated by using the following equation: $\rho = \frac{\sum_i d_i w_i}{\frac{2}{3}\sqrt{\frac{A}{\pi}}}$ Where, ρ = the Dispersion Index; d_i = the distance of the ith tract (for Savar, each sub-region has been considered as a single tract) from the CBD; w_i = tract's share of the city population; and A = the built-up area of the city.	Nadeem *et al.*, 2021; Kotharkar and Bahadure, 2020; Adnan *et al.* 2009; Kotharkar *et al.*, 2014
Land Use Pattern	Land use Distribution	Percentage of built-up area	Built-up area/Total area	Nadeem *et al.*, 2021; Liaqat *et al.*, 2017;
		Percentage of road network	Area of road network/ Total area	Nadeem *et al.*, 2021; Liaqat *et al.*, 2017;
		Percentage of open space	Area of open space / Total area	Nadeem *et al.*, 2021; Liaqat *et al.*, 2017;
		Number of civic facilities	Existing number of civic facilities/ Required number of civic facilities for existing population	Burton, 2002
	Balance Index		The balance index can be used to assess the relationship between residential and non-residential areas (N = 2). It is defined as: $BAL = 1 - \frac{\lvert X-aY \rvert}{\lvert X+aY \rvert}$ Where, X is the amount of land intended for residential use; Y is the quantity of land intended for non-residential use; a = X*/Y* is an adjustment factor that represents the relative balance of land uses, which is used as a benchmark for a reasonable level of balance. If there are theoretical reasons to expect approximately the same level of X and Y (i.e. workers and jobs), an adjustment factor may not be necessary.	Song *et al.*, 2013; Iannillo and Isidoro, 2021; Grekousis *et al.*, 2021

Built-up area density or number of people occupying urban built-up area indicate whether the development pattern is sprawling or compact (Kotharkar and Bahadure, 2020). This indicator is also used to assess the feasibility of public transport and viability of local facilities, and services (Burton, 2002). Therefore, this indicator can provide useful insights about the actual consumption of land for urban use, infrastructure requirements and existing development pattern in the study area. Built-up density has been calculated in this study to comprehend the development pattern and land and energy use efficiency in Savar area.

Density profile represents the dispersion across metropolitan area and agglomeration of people around CBDs or centres (Kotharkar *et al*., 2014). The higher density at nodal point with steeper gradient of profile, the higher is the accessibility of the centres indicating compact development pattern (Bertaud, 2001). Besides, density peaks far from the centres indicates the process of developing new nodes (Kotharkar and Bahadure, 2020). Therefore, this indicator has been used in this study to depict spatial distribution of population densities of the urban centres proposed in the Structure Plan for assessing their compactness.

The average distance per person to the CBD is fundamentally related to the urban spatial structure (Bertaud, 2001). Less average distances to CBD results in shorter trips to reach desired locations. This ensures accessibility which is again closely associated with a compact urban form (Kotharkar and Bahadure, 2020). A related variable is Dispersion Index (D.I.) which a good indicator of dispersion for a given city and widely used to compare the shape performance of various cities (Adnan *et al*., 2009). Therefore, both of these indicators have been calculated in this study to assess the shape performance of Savar area in reducing trip length considering the location and distribution population in the proposed urban centres.

Land use composition of Savar has been investigated to assess the proportion of various land parcels in the study area. Some land use categories are critical for city's sustainable urban growth i.e., open spaces, built-up area, road network etc. (Liaqat *et al*., 2017; Kotharkar *et al*., 2014; Nadeem *et al*., 202; UN Habitat, 2014). Accessibility of local services is also an important aspect of compact urban form and existing research assessed urban compactness through evaluating the provision of civic facilities (OECD, 2012; Burton, 2002). In this regard existing and required civic facilities of Savar area have also been identified from the Detailed Area Plan (2022-2035) and OpenStreetMap to determine their deficiency, if there exists any.

Lastly Balance Index has been calculated to assess the land use mix of the study area. Land use mix indicates the diversity of land uses of an urban area and a key component of compact development (Bordoloi *et al*., 2013; OECD, 2012). Increased land use mix tends to reduce travel distances and encourage walking and cycling environments (Adnan *et al*., 2009). Such indicator can be also useful in depicting availability of services within close proximity in Savar area (Kotharkar and Bahadure, 2020).

4. RESULTS AND DISCUSSION

4.1 Population

Population density of the number of people within a standard spatial unit has been associated most strongly with sustainable travel behavior (Burton, 2002). Generally, a population density lower than 2500 persons per sq. km is assumed low, such as most of the North American and Australian cities. Meanwhile, most of the European cities with 5000 persons per sq. km and Asian cities often with more than 10,000 persons per sq. km are assumed as high-density urban developments (OECD, 2012).

In Bangladesh the concept of density was used to delineate urban areas from rural areas. According to "Paurashava Ordinance 1977" areas having population density not less than 2000 per sq. mile (approximately 770 per sq. km) were to be considered as urban areas (Khan *et al*., 2017). In 2009, this ordinance was amended as "Local Government (Paurashava) Act 2009" and according to the act, density of at least 1500 per sq. km is required for an area to be considered as an urban area (Khan *et al*., 2017).

Gross population density of the Savar zone according to 2020 population is about 6862 persons/sq. km. In addition to average density in a metropolitan area, the spatial distribution of density (i.e., where the denser areas are located in a metropolitan area) is also important (OECD, 2012). Figure 3 shows the gross population density of the sub-regions of the Savar area. From the Figure 3 it can be seen that, among the nine sub-regions, Savar Pourashava has the highest gross density about 15,677 people per sq. km according to the population data of 2020 (Worldpop, 2020). Lowest densities are observed in Birulia union (about 3429 people per sq. km) followed by Banagram union (about 4007 people per sq. km).

Table 4 shows the gross population density of the nine sub-regions in Savar in the years 2001, 2011 and 2020. It is observed that except Savar Pourashava, the remaining eight sub-regions have increase in population density between the years 2011 and 2020. If we compare the density changes between the periods (2001-2011) and

(2011-2020), we can see that in Birulia union, Banagram union, Kaundia/Aminbazar union and Bhakurta union the gross density increased significantly between (2011-2020) compared to that between (2001-2022). In Dhamsona/Yearpur union the gross density did not increase at the same rate between (2011-2020) with that between (2001-2011). On the other hand, in Ashulia union, Pathalia/ Savar union and Tetuljhora union the gross density increased following relatively similar trend between (2011-2020) with that between (2001-2011). However, in Savar Pourashava, it has been observed that the gross density falls between the period 2011-2020.

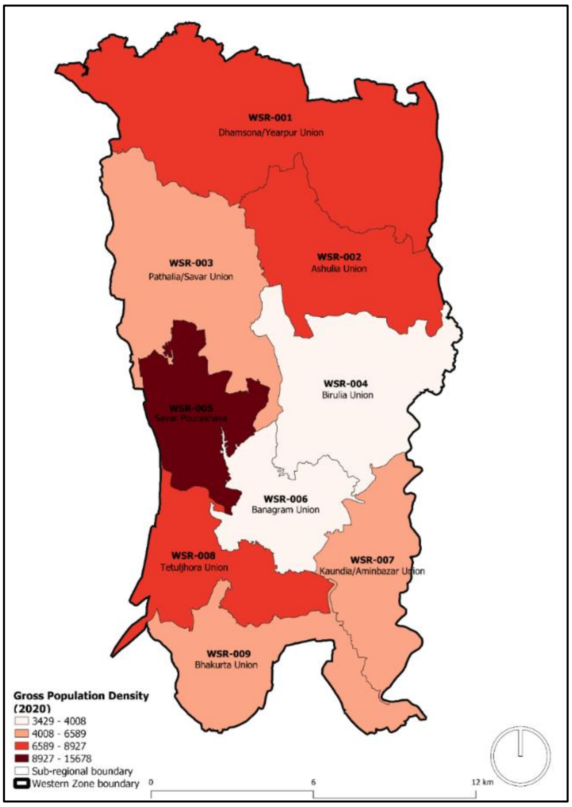

Figure 3: Gross population density distribution across individual sub-regions of Savar zone.

Table 4: Population and Density of the individual sub-regions of Savar zone in the years 2001, 2011 and 2020

Sub-region ID	Zone Name	Area (sq. km)	Population			Gross Density (per sq. km)		
			2001	2011	2020	2001	2011	2020
WSR-001	Dhamsona/Yearpur Union	60.18158399	102514	425966	461432	1703.411463	7078.012438	7667.328931
WSR-002	Ashulia Union	26.25925955	41944	143952	234412	1597.303226	5481.951984	8926.832058
WSR-003	Pathalia/Savar Union	36.82858412	81657	139037	184375	2217.21801	3775.246954	5006.301611
WSR-004	Birulia Union	32.38669706	23760	41188	111061	733.6345524	1271.756732	3429.216626
WSR-005	Savar Pourashava	17.67130825	127542	286000	277049	7217.46224	16184.4271	15677.8998
WSR-006	Banagram Union	16.87056665	24742	33627	67615	1466.577888	1993.234768	4007.86775
WSR-007	Kaundia/Aminbazar Union	19.70956475	50056	65296	129874	2539.68064	3312.909282	6589.389551
WSR-008	Tetuljhora Union	20.9275555	41978	106929	169043	2005.872114	5109.483522	8077.532036
WSR-009	Bhakurta Union	22.58240428	36308	44947	101062	1607.80046	1990.354944	4475.254218

Source: RAJUK, 2017; WorldPop, 2020

4.1.1 Built-up Area Density

Gross density measures reveal little about the density of the built-up parts of a city. A city with dense development within large areas of open space may appear to be low density on the basis of gross measures (Burton, 2002). Therefore, built-up area density (i.e., population density within urban land) is more relevant for measuring the efficiency of urban land use (OECD, 2012). It is recommended that the population density within a sustainable neighborhood should be at least 15,000 persons per sq. km (Nadeem et. al. 2021). The built-up area of the Western zone is about 121 sq. km. So built-up area density according to 2020 population is about 14,308 persons/sq. km which is very close to the recommended density.

4.1.2 Density Profile

In the Structure Plan (2016-2035) some urban centres have been identified for the Savar zone at different intersections, transport hubs and critical points around which different public functions and urban services gathered and are growing (RAJUK 2015, 2018). Six urban centres have been designated at different public transport nodes. These urban centres will be commonly equipped with residences, government and administrative services, health and educational services, employment, retail, transportation facilities, recreation and public spaces (RAJUK, 2015). Some of these centres are established while some of them are planned. For the density profile all of these proposed centre have been analyzed with the population raster data of 2020 at 500 m interval from the central point. Table 5 shows the name of these proposed urban centres and their nodal points provided in the Structure Plan (2016-2035).

Table 5: Proposed urban centres and nodal points in Structure Plan (2016-2035) for Savar zone.

Name of the Centre	Nature	Central Point	Admin Unit
Savar	Established	Savar Bazar Bus Stop	Savar (Pouroshava)
Aminbazar	Planned	Aminbazar Bus Stop	Tetuljhara Union
Hemayetpur	Planned	Hemayetpur Bus Stop	Tetuljhara Union
Ashulia	Planned	Ashulia Bazar Bus Stop	Ashulia Union
Jirabo	Planned	Jirabo Bus Stop	Yearpur Union
Baipail	Planned	Baipail Bus Stop	Dhamsona Union

Source: RAJUK, 2015

Density profile shows how the population of city is spatially distributed throughout the whole area. From the density profile it is easily understood how the population density changes at various distance from the centre of Central Business District (CBD) (Adnan *et al*., 2009). Density profile also indicate how many people have easy access to the centres (Nadeem *et al*., 2021). The number of people which can have easy access to the centre is very much related to the density profile where the steeper the gradient of the profile, the higher is the accessibility of the centre (Bertaud, 2001). Density profile is measured by the distribution of population densities of built up areas by distance from the centre of the CBD (Bertaud, 2001). Density profile shows the population density distribution from the distance from the CBD at 500 m, 1 km or 2 km interval from 0 to 45 km or up to administrative boundary (Bertaud, 2001; Kotharkar *et al*., 2014; Adnan *et al*., 2009). Density profile is established by calculating the number of people within each consecutive ring centred on the CBD, calculating the built-up area within the same rings, then for each ring dividing the population by the built-up area (Bertaud, 2001). Adnan *et al*. (2009) had calculated density profile at 500m interval (500-3000 m) for 3 centres of Dhaka city. They measured this profile for each centres of Dhaka city at 500 m interval considering the total area of each consecutive rings. Following the work of Adnan *et al*. (2009), the total area of each rings has been considered in this study instead of built-up area for calculating densities, as the data on built-up area of the outer rings (beyond 1500 m) was not available for each centres in Savar. Figure 4 shows the location of the centres and adopted buffer areas for this research.

Figure 5 shows the density profile of the proposed urban centres of Savar area. Ideally for compact pattern the density gradient should follow a negatively sloped exponential curve where density should be highest near the nodal point (Bertaud, 2001). From Figure 5 it has been observed that, except Baipail, all of the centres of Savar zone has highest density within 500 m radius from the central point. However, the density gradient does not follow a negative slope for all centres. In Aminbazar, the density gradually decreases from the central point up to 1500 m, then starts to increase. In Ashulia, the density is considerably higher within 500 m distance from the node but falls rapidly between 500 to 1000 m. There is a slight increase near 1500 m but after that the density falls. In Baipail, the density profile follows a relatively positive gradient up to 2000 m, beyond which the density abruptly falls below 500 people/sq. km. In Hemayetpur, the density profile shows a negative gradient which is ideal for compact pattern, but between 1500-200m there is a moderate rise in the density. In Jirabo, highest density has been observed within 500 m radius of the nodal point. After that the density has been dropped between 500-1000m. Then from 1000m-2000m the density profile has followed a positive gradient and beyond 2000m the density decreased. In Savar municipality, the peak density is exceptionally higher near the nodal area (within 500m). But the densities significantly dropped in the successive radii with moderate increase between 1000-1500m and between 2000-2500m.

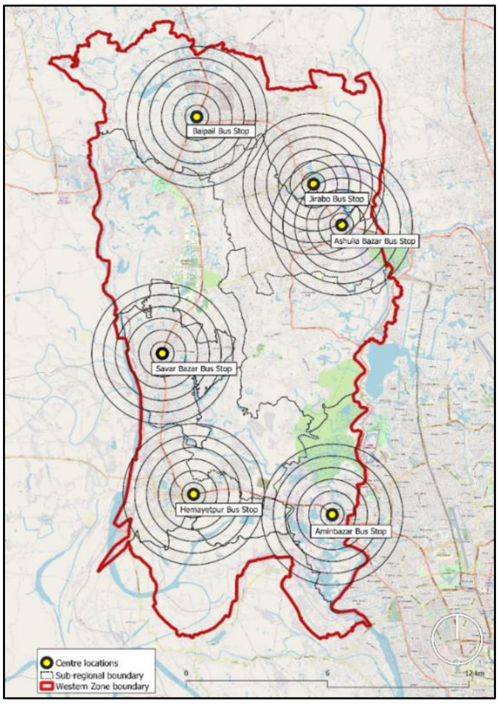

Figure 4: Location of the proposed centres of Savar zone in the Structure Plan (2016-2035) and individual six buffer rings at 500 metre intervals.

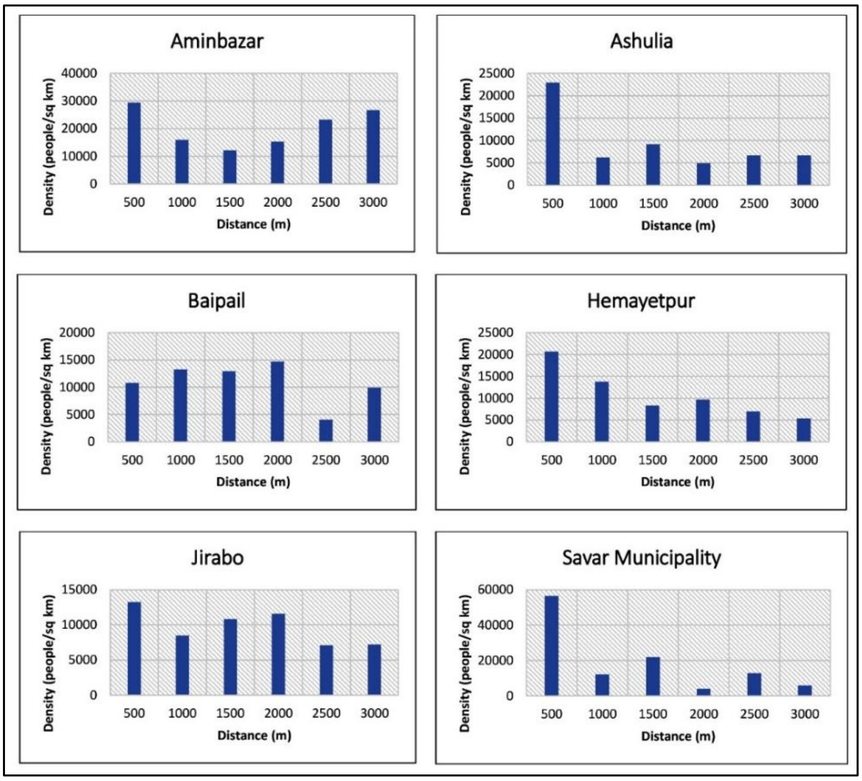

Figure 5: Density profile of the six urban centres in Savar.

4.1.3 Average Distance per Capita to the CBD

Average distance per capita to the CBD is simply the weighted average distance a person must travel to get to the CBD regardless of where they live and serves as a useful indicator of a city's size, compactness, and efficiency. With lower average distance per capita to the CBD, the trip length to reach CBD is reduced. It is desirable to have as many people as close as possible to the city centre, to improve the performance and functionality of the city with the least amount of transportation expense, time, fatigue, and inconvenience (Bertaud, 2001; Adnan *et al*., 2009). In case of multiple centres, first average distance per capita to each CBD is calculated, then average distance per capita to CBD for whole city can be calculated by taking the average value for all CBDs (Adnan *et al*., 2009). Table 6 shows the average distance per capita to CBD considering the proposed six centres of Savar zone in the Strcuture Plan. The average distances have been calculated from the distances of each of the six centres from their nodal points to the centroids of the nine administrative units (i.e., sub-regions). Population data of 2020 have been used for estimating the population in each of these sub-regions following the equation provided in Table 3 (WorldPop, 2020).

Table 6: Average distance per capita to the proposed centres in Savar zone.

No.	Name of the Centre	Average Distance Per Capita (km)
1.	Aminbazar	11.28
2.	Ashulia	8.32
3.	Baipail	8.47
4.	Hemayetpur	9.58
5.	Jirabo	8.21
6.	Savar	6.91
	Whole Savar Zone	8.8

Table 6 shows that among the six centres the average distance per capita to the CBD is the highest in Aminbazar (11.28 km), and lowest in Savar (6.91 km). This indicates the centre, Savar (Savar Bazar Bus Stop) is located close to a significant amount of population in the whole zone and therefore comparatively less distance is required to reach Savar by majority of the inhabitants. However, when average value has been calculated for the whole Western zone, it has been found that Savar zone has a relatively higher average distance per capita to CBD as a whole (8.8 km) (Table 6). This can be assessed from the trend line on the graph in Figure 6 which shows the relationship between the size of the built-up area and the average distance per person for a fictitious city whose shape would be a circle and that would have a uniform density. The trendline in Figure 6 have been conceived through calculating built-up areas of circular cities with 5 km, 10 km, 15 km and 20 km radii in which the expected values of average distance have been calculated from the equation $y = 0.375x^{0.5}$. The points for cities that are below the line perform better in terms of shape, while those that are above the line perform worse (Bertaud, 2001; Adnan *et al*., 2009). The red point indicates the average distance per capita of Savar zone.

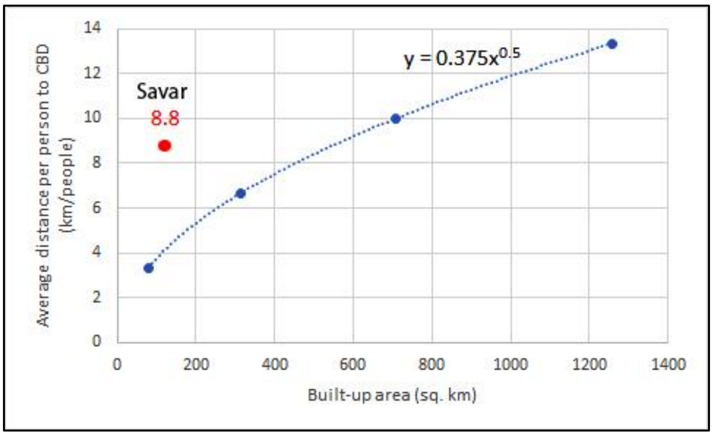

Figure 6: Relationship between average distance per person to the CBD and built-up areas of circular cities with different radii and the average distance per person to CBD of Savar.

From the Figure 6 it is clear that Savar is not in a good position in terms of average distance per person to CBD because of the higher existing average distance compared to the expected value. According to built-up area of Savar (121 sq. km) it is desired the average distance to be equal to about 4.13 km (following the equation $y = 0.375x^{0.5}$). But from analysis, it has been found that the real value is 8.8 km which is more than expected value; implying Savar is not in good position in terms of its performance. Higher value of average distance indicates that the residential area is located slightly far from the urban centres (Adnan *et al*., 2009).

4.1.4 Dispersion Index

Dispersion Index is used to measure the shape performance of a city with respect to the spatial distribution of people over the entire city (Kotharkar and Bahadure, 2020). This index is calculated as the ratio of the average distance per person to the centre of a city to the average distance per person to the centre of a circular city with an area equal to the built-up area of the city studied with a uniform density (Nadeem *et al*., 2021). This ratio helps in comparing different cities with different sizes or the same city across time with changing size (Kotharkar and Bahadure, 2020). The Dispersion Index value of 1.0 is used as a threshold between compactness and dispersion, where if the index value exceeds 1.0, the city is considered dispersed, and if it falls below 1.0, the city is considered compact. (Nadeem *et al*., 2021; Kotharkar and Bahadure, 2020). Ideally, a city with uniform density and a perfectly circular shape will have a shorter average trip distance than a city with the same density but an irregular shape. Similar to this, the average travel distance will be shorter if density is higher near the city centre (Kotharkar and Bahadure, 2020).

This study on Savar zone has found that there is a higher Dispersion Index of 2.12 which does not indicate good shape performance. Such index value indicates the dispersed and farthest settlement pattern from centres, which increases the cost, time, fatigue, and mental stress for individuals associated with travel to urban centres and to the workplaces.

4.2 Land Use Pattern

This research has focused on the land use distribution and land use mix to assess the land use pattern of Savar. For the analysis of land use pattern, this research adopted the functional typology of land use of Savar based on the classification provided by RAJUK (2017). This classification included 15 categories of functional typology at parcel level 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. The built-up area has been calculated from the existing land use database following the net urban land area[3] definition provided in the Structure Plan (2016-2035) for various analyses performed in this study (RAJUK, 2015). Except for agriculture, open space, road/railways and waterbodies, the remaining 11 categories of land use have been considered to calculate built-up area for the purpose of different analyses in this research. Since fine-grained data on building footprint, floor number and area, plot area, etc. are not readily accessible and their preparation is very time-consuming, accurately depicting actual land use in an urban area is often challenging. In such cases, many researches on land use measures considers land area for estimating land use distribution, land use mix and residential/non-residential uses due to lack of floor area information (Mavoa, 2018; Brown *et al*., 2009; Song and Knaap, 2004). Therefore, all analyses performed in this study i.e., built-up area, residential and non-residential uses etc. have been calculated on land parcel area available for each type of uses. Following the land use database of RAJUK (2017), non-residential uses (all land uses in the built-up area except residential use) have been considered for the following categories: administrative, commercial, community facilities, education and research, health facilities, industrial, institutional, mixed-use, restricted and vacant land.

4.2.1 Land Use Distribution

Land use distribution indicates the proportion of different land uses within an administrative boundary. A categorical analysis of the spatial use and urban sprawl is represented by this distribution (Liaqat *et al*., 2017). From the land use distribution, it has been observed that agricultural land constitutes the major share about 33% in Savar. Residential area comprises 26.52%. For a sustainable city, at least 30% of land and 15%–20% of the land should be allocated for roads and open public space respectively (UN Habitat, 2014). However, the amount of open space is only 0.25% in Savar which is very low. Besides, transport network is also inadequate (2.53%) as shown in the Table 7.

Table 7: Land use composition of Savar.

Land use types	Area (sq. km)	Percentage
Agriculture	84.14111543	33.24%
Commercial	3.806328283	1.50%
Community Facilities	0.420291445	0.17%
Education and Research	4.750707996	1.88%
Forest Land	2.844242541	1.12%
Health Facilities	0.024068331	0.01%
Industrial	8.262961938	3.26%
Institutional	5.793676154	2.29%

[3] Net urban land = whole area – (agricultural + water-bodies+ road/railways+ park/open space) (RAJUK, 2015)

Land use types	Area (sq. km)	Percentage
Mixed Use	3.4890188	1.38%
Open Space	0.641454231	0.25%
Residential	67.1492069	26.52%
Restricted	5.779652178	2.28%
Transport and Communication	6.410565549	2.53%
Vacant Land	21.85104078	8.63%
Water body	37.80531537	14.93%

Source: RAJUK, 2017

The ratio of built-up area to the open area is used for the trend relationship and the pattern of urban growth of a city (Nadeem *et al*., 2021). The standard ratio of built-up area to non-built up area is about 75% built up area or 3 times (Liaqat *et al*., 2017). In Savar, this ratio has been found to be only 0.92 which means a significant portion or the area is under non-urban use. In Savar, the amount of civic facilities is still not sufficient considering the existing demand of the residing population (RAJUK, 2022) (Table 8).

Table 8: Area and percentage of built-up and non-built up area of Savar.

Total Land Area	Built-up Area (sq. km)	Non built-up Area (sq. km)	Built-up Area (%)	Non built-up Area (%)	Ratio of built-up/non built-up area
253.1696459	121.3269528	131.8426931	47.92%	52.08%	0.920240249

Table 9 shows the existing and required civic facilities for the period between 2021-2025 in Savar zone. According to RAJUK (2022), the data on various civic facilities included schools and colleges, playgrounds, parks, community centres and hospitals for each of the sub-regions. As the data on exiting hospitals were not available in the documents of RAJUK, their numbers have been estimated from the OpenStreetMap. From the Table 9 it can be observed that, in each of the sub-regions the existing civic facilities are not sufficient and considerable amount of facilities are still required to fulfill the demand of the existing population.

Table 9: Existing and required civic facilities in the individual sub-regions of Savar.

Zone Name	Existing Civic Facilities					Required Civic Facilities (2021-2025)				
	Schools and Colleges (nos)	Play-ground (acres)	Park (acres)	Community Centres (nos)	Hospital (nos)	Schools and Colleges (nos)	Playground (acres)	Park (acres)	Community Centres (nos)	Hospital (nos)
Dhamsona/ Yearpur Union	24	21.28	20.82	2	2	94	178.31	89.16	3	3
Ashulia Union	11	10.84	28.11	0	0	29	56.21	28.11	1	1
Pathalia/Savar Union	8	24.81	0	1	0	24	45.21	22.61	2	2
Birulia Union	7	7.32	0	0	0	9	7.65	3.82	1	1
Savar Pourashava	12	17.45	6.74	2	10	28	80.93	40.47	9	9
Banagram Union	6	3.69	2.42	1	0	7	6.8	3.4	1	1
Kaundia/ Aminbazar Union	5	0.42	0	3	1	12	11.74	5.87	2	2
Tetuljhora Union	7	5.77	8.25	0	2	38	36.35	18.17	1	1
Bhakurta Union	3	5.04	0	0	0	9	7.78	3.89	1	1
Total in Savar Zone	83	96.62	66.34	9	15	250	430.98	215.5	21	21

Source: RAJUK, 2022 and OpenStreetMap

Table 10: Existing deficit in the civic facilities of Savar.

Civic facilities	Existing	Required (2021-2025)	Deficit	Deficit (percentage)
Schools and Colleges	83 nos	250 nos	167 nos	66.80%
Playground and Parks	0.66 sq. km	2.62 sq. km	1.96 sq. km	74.80%
Community Centres	9 nos	21 nos	12 nos	57.14%
Hospitals	15 nos	21 nos	6 nos	28.57%

Source: RAJUK, 2022 and OpenStreetMap

Table 10 shows the existing deficit of the civic facilities in the whole Savar zone. It has been calculated to estimate how many civic facilities are still required to meet the population demand and also the nature of the deficit for a particular facility in Savar. From the table it has been observed that for the period 2021-2025, still 167 schools and colleges, 1.96 sq. km of playground and parks, 12 community centres and 6 hospitals are required in Savar. Among the civic facilities, the deficit in the playgrounds and parks is the highest (about 74.80%), followed by schools and colleges (66.80%), community centres (57.14%) and hospitals (28.57%).

4.2.2 Land Use Mix

Compact city proponents envision a city with a balance between residential and non-residential land uses, one that is well-served by amenities (Burton, 2002). The proportion of residential to non-residential urban use indicate the mixed-use land consumption in a given area and is a crucial element for compact urban development. (Nadeem *et al*., 2021). The ratio of residential land use with non-residential land use should be around 50% residential land use or 1 time (Nadeem *et al*., 2021; Liaqat *et al*., 2017). Mixed-use areas also encourage interactions, thus boosting the local economy (Kotharkar and Bahadure, 2020). The share of residential land use in the whole Savar area constitutes about 55.35% of the built-up area, whereas the non-residential uses constitutes about 44.65% as shown in Table 11.

Table 11: Percentage of residential and non-residential urban land areas in Savar zone.

Residential urban land use (sq. km)	Non-residential urban land use (sq. km)	Net urban land area (sq. km)	Share of Residential urban land use (%)	Share of Non-residential urban land use (%)
67.1492069	54.17774591	121.3269528	55.35%	44.65%

Source: RAJUK, 2017

One of the useful land use mix measure is Balance Index (Song *et al*., 2013; Iannillo and Fasolino, 2021; Grekousis *et al*., 2021). Balance Index measures the degree to which two different types of land uses or activities (i.e. residential and non-residential parcels) exist in balance with each other within an area (Song *et al*., 2013; Iannillo and Fasolino, 2021). Cervero and Duncan (2003), for example, has employed this measure to investigate the balance between jobs and population within neighborhoods. This index allows to measure the degree of balance between two different types of land uses or activities within an area (Iannillo and Fasolino, 2021). The index ranges from 0 to 1 where values close to 1 are more balanced with greater land use mix. The lower the index value, the less balanced the two types of land use indicating one type dominates in terms of percentage coverage. Though the formula was developed to compare only two types of land use, it may be changed to incorporate a greater number (Song *et al*., 2013). Considering the proportion of residential and non-residential land area in Savar, the value of Balance Index was found to be 0.893086732 which indicates good land use mix in the urban area.

5. COMPACT DEVELOPMENT POTENTIAL OF SAVAR

The results of the study have been summarized and evaluated in Table 12 to demonstrate the compact development potential of Savar zone. Among various aspects of urban form this research focused on population and land use pattern and identified six indicators to assess urban form of Savar area. The calculated results from the derived indicators have been evaluated for compact development potential based on the standard values of these indicators from existing literature. Following some recent literature, the obtained values of different indicators have been ranked into good, moderate and poor for assessing the compact development potential of Savar.

Table 12: Evaluation of compact development potential of Savar.

Attributes	Indicators		Standards	Results	Remarks
	Built-up area Density		15,000 people/ sq. km	14,308 people/ sq. Km	Good
	Density Profile	Aminbazar	Should follow negative slope	Negative slope up to 1.5 km	Poor
		Ashulia		Negative slope up to 1 km	Poor
		Baipail		Positive slope up to 2 km	Poor
		Hemayetpur		Negative slope up to 3	Moderate

Attributes	Indicators			Standards	Results	Remarks
Population					km with slight peak at 2 km	
		Jirabo			Negative slope up to 1 km	Poor
		Savar			Negative slope up to 1 km	Poor
	Average Distance per Capita to the CBD			4.13 km	8.8 km	Poor
	Dispersion Index			1.0	2.12	Poor
Land Use Pattern	Land use Distribution	Built up Area		75%	47.92%	Poor
		Road Network		30%	2.53%	Poor
		Open Space		15%–20%	0.25%	Poor
		Civic Facilities	Schools and Colleges	250 nos	83 nos	Poor
			Playground and Parks	2.62 sq. km	0.66 sq. Km	Poor
			Community Centres	21 nos	9 nos	Poor
			Hospitals	21 nos	15 nos	Moderate
	Land use mix	Balance Index		1	0.89	Good

From Table 12 it has been observed that Savar has a good prospect in terms of built-up area density. However, the current urban form of Savar has some drawbacks in terms of other population-based indicators i.e., density profile, average distance per capita to the CBD and Dispersion Index. In this study, the density profile of six urban centres have been established based on the planning proposal of the Structure Plan (2016-2035). It has been observed that although the highest density was prevalent near the nodal areas in most of the centres, none of them exhibit a compact density profile. The average distance per capita to CBD is also higher in Savar considering its existing built-up area. Higher distance means higher rate of automobile dependence leading to severe traffic jam with increased air pollution (Adnan *et al*., 2009). From the land use pattern, it has been observed that the amount of built-up area, open space, transport network and number of civic facilities is still insufficient in Savar area. However, the area has a good land use mix overall in the existing built-up area.

Overall, six indicators of compact urban form have been used in this study derived from population and land use data. In terms of population, Savar has good performance only in built-up area density, but poor in other three indicators i.e., density profile, average distance per capita to CBD and Dispersion Index. On the other hand, from the two indicators derived from land use data, Savar urban area has overall good level of land use mix but poor distribution of existing land use i.e., built-up area, road network, open spaces and civic facilities. From this it can be concluded that Savar is still not exhibiting compact pattern of development. In this regard, necessary planning mechanism should be initiated for successful implementation of RAJUK's compact development strategy in order to guide this area's urban growth in a sustainable manner.

6. CONCLUSION

This study investigated the compact development potential of Savar, an emerging growth centre of Dhaka Metropolitan Region through analyzing some indicators of two important elements of urban form i.e., population and land use pattern. This study concluded that the urban form of Savar still does not exhibit a compact development pattern. Although, the proposed urban area has sufficient built-up density according to recent population data, density profile of the most of the proposed urban centres don't show negatively sloped gradient. Besides, the calculated shape performance based on the proposed urban centres has been found to be very poor requiring long journeys from home to work. On the other hand, analysis of existing land use data has revealed that, the amount of built-up area, open space, road network and civic facilities in Savar area is also insufficient according to compact development standards. But, the urban area has overall a good balance in terms of residential and non-residential parcel distribution. In such scenario, lack of proper planning and development initiative can lead to low-density and car-oriented sprawl development in Savar.

The findings of this study contribute to identifying the specific areas where more significant effort might be needed to facilitate compact development strategy in Savar. For example, the proposed urban centres can be re-evaluated considering the updated population data to identify suitable nodes for concentrating activities. Such nodes in turn can provide useful references in formulating provision of civic facilities in appropriate locations.

Also, the identified deficiencies in the percentage of open spaces and road network can be taken into considerations for future land use planning. In this regard, some areas in each of the proposed administrative units (sub-regions) can be identified and preserved for open public space along with an efficient road network to ensure intra-urban connectivity. Eventually, this will help the policymakers, planners and architects in formulating policies for compact development in the other proposed outer urban areas of the current Structure Plan. Also, this study can support future research related to urban spatial structure and can provide useful insights to evaluate the potential of compact development in other cities with similar geographical contexts, population, area, and structure.

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