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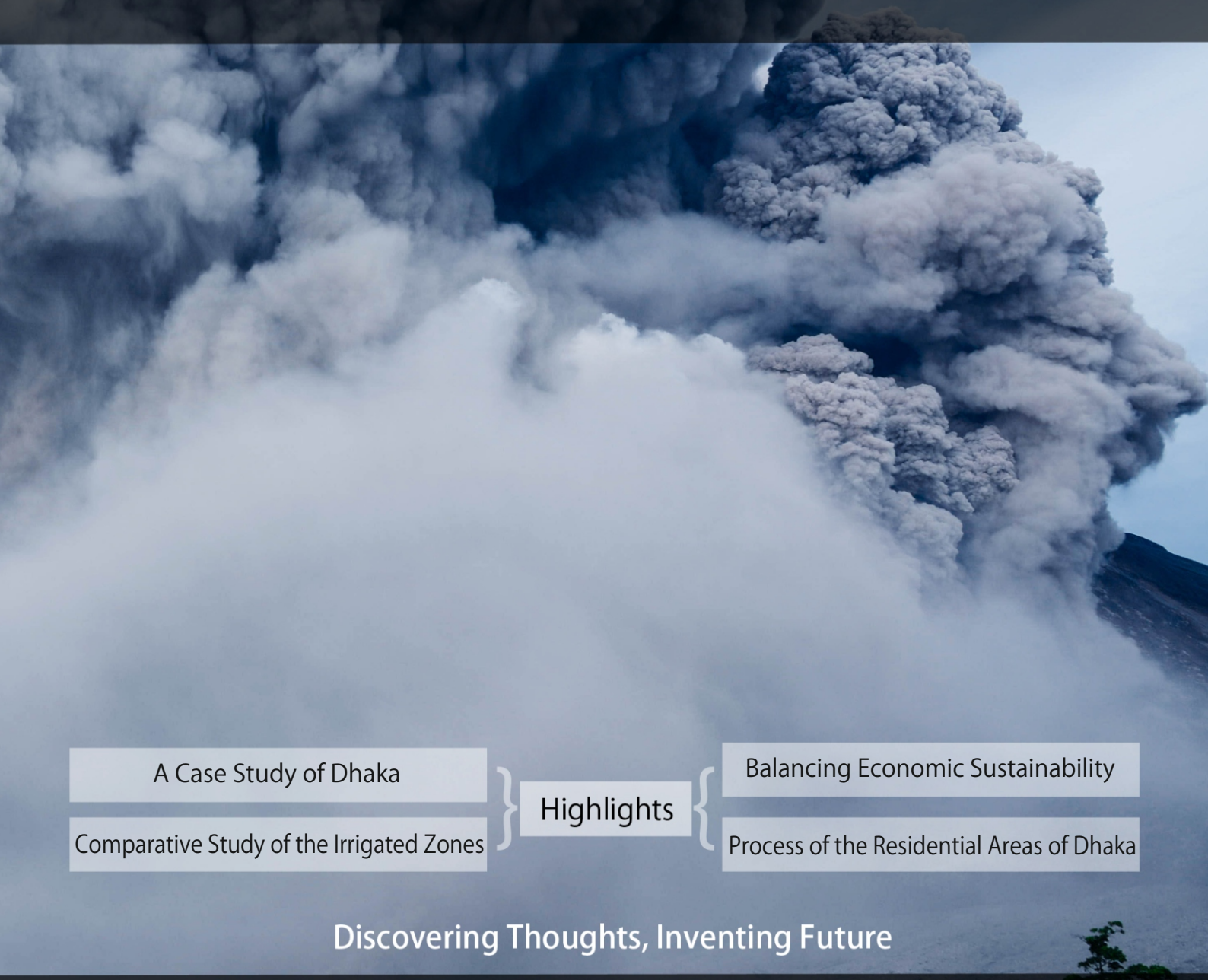

Highlights

- A Case Study of Dhaka
- Comparative Study of the Irrigated Zones
- Balancing Economic Sustainability
- Process of the Residential Areas of Dhaka

Discovering Thoughts, Inventing Future

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Balancing Economic Sustainability with Densification: A Case Study of Dhaka

By Syeda Jafrina Nancy & Roxana Hafiz

Abstract- Economically sustainable urban residential neighborhoods are characterized by adequate provision of physical infrastructure including transport facilities and utility services. The built urban fabric of residential areas of Dhaka has been undergoing densification operation over the past decades without considering the physical infrastructure capacity of these areas in terms of accessibility and provision of transportation and utility services. This intervention eventually exerted pressure on the existing infrastructure and caused negative externalities like traffic congestion, pollution, and water clogging. Thus, this paper aims to investigate the impact of densification on residential areas of Dhaka through the lens of economic sustainability. Seven residential areas from Old and New Dhaka that underwent various degrees of densification were selected as the study areas. Primary data was collected through a random sampling household questionnaire survey, fieldwork, and informal qualitative interviews with the residents and officials.

Keywords: urban densification, economic sustainability, sustainable transportation, utility services, infrastructure, public transport.

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Balancing Economic Sustainability with Densification: A Case Study of Dhaka

Syeda Jafrina Nancy [α] & Roxana Hafiz [σ]

Abstract- Economically sustainable urban residential neighborhoods are characterized by adequate provision of physical infrastructure including transport facilities and utility services. The built urban fabric of residential areas of Dhaka has been undergoing densification operation over the past decades without considering the physical infrastructure capacity of these areas in terms of accessibility and provision of transportation and utility services. This intervention eventually exerted pressure on the existing infrastructure and caused negative externalities like traffic congestion, pollution, and water clogging. Thus, this paper aims to investigate the impact of densification on residential areas of Dhaka through the lens of economic sustainability. Seven residential areas from Old and New Dhaka that underwent various degrees of densification were selected as the study areas. Primary data was collected through a random sampling household questionnaire survey, fieldwork, and informal qualitative interviews with the residents and officials. Various published literature, newspaper articles, plans, and reports from government archives, Capital Development Authority (RAJUK), Dhaka South City Corporation (DSCC), and Dhaka North City Corporation (DNCC) provided the secondary data. The analysis is carried out in two parts. In the first part the impact of densification on accessibility to transportation facilities and utility services is analyzed in terms of availability of the services, distance to the bus stops, average travel time, modal choice, and residents' satisfaction level. The second part explores the relationship between density and aspects of economic sustainability through Pearson's correlation test. The findings revealed that public transportation is more accessible in lower-density areas than the higher-density residential areas owing to the road network pattern. A significant service delivery gap except for water supply was observed regarding the provision and quality of gas, electricity, sewerage, and garbage disposal services across all the study areas. Overall, density was found to have a negative association with the accessibility to physical infrastructures indicating that high-density residential areas of Dhaka do not have increased access to public transport and utility services which is contrary to the expected benefits of high-density living. A comprehensive density planning with an integrated sustainable transport plan needs to be formulated where viable public transport like Bus Rapid Transit (BRTs) systems and waterways may mitigate the situation from further worsening.

Keywords: urban densification, economic sustainability, sustainable transportation, utility services, infrastructure, public transport.

Author: e-mail: nancy1976bd@yahoo.com

I. Introduction

Densification of cities is a worldwide practiced contemporary strategy to contain urban sprawl and support sustainable urban development. The higher-density cities yield several benefits including reduced land consumption, reduced transit through shorter trip lengths to avail most amenities, improved energy efficiency of buildings, and increased provision for open spaces and walkability (Long et al., 2011). Other benefits include social interaction and community cohesion (Bahadure and Kotharkar, 2012). In addition, the reduced level of GHG emission in compact cities due to the restrained use of cars benefits the global environment (Litman, 2008, Newman and Kenworthy, 2000). Efficiencies in transport systems and utility infrastructure through shorter distribution networks significantly help to conserve energy and thereby make the city economically sustainable. When urban compaction is not accompanied by a consistent transport and infrastructure policy a host of negative externalities may occur, such as increased traffic congestion, pollution, and other social issues. Given the growth of the world's urban population, there is a need to increase the built environment of the cities. Densification is a strategy generally used to accommodate the growing urban population without compromising further consumption of valuable land resources. However, balancing urban intensification with sustainable transport policy has always been in the core debate of economic sustainability. The situation becomes more challenging to incorporate a sustainable transport system in an already urbanized area of a city and, therefore, requires a comprehensive assessment of the state of the urban context and the site-specific potential and threats involved in undertaking such intervention.

Dhaka witnessed a phenomenal growth of population after the independence of Bangladesh when it's status raised from Provincial Capital to the Capital of a sovereign country. The existing Master Plan 1959 of the city was conceived based on a relatively lower population forecast. To tackle the subsequent population growth from the sudden influx of migrants and natural increase the government opted to densify the existing housing stock. But as the densification strategy was implemented without paying due consideration to the possible consequences on the built environment, utility services, and the traffic situation, a

host of urban issues emerged. Over the period from 1995 to 2005, the increase in the roads of Dhaka accounts for only five percent, while population and traffic have increased by over 50 percent and 134 percent respectively (DTCB, 2005). Consequently, the increase in traffic and pollution became more explicit among the negative externalities caused by urban intensification. According to the World Bank analysis, many residents of Dhaka have experienced a lack of access to basic services and in the last 10 years and the average traffic speed has dropped from 21 km/hour to 7 km/hour, only slightly above the average walking speed (Bird et al., 2017). In addition, around 200,000 non-motorized rickshaws with no dedicated lanes ply through the streets of the city besides motorized vehicles making the traffic situation more taxing. Dhaka the home of approximately 20.6 million within an area of 306.38 sq. km. is one of the most polluted (Air Quality Index (AQI) of 215 on 21 December 2019) cities in the world. (Siddiqui et al., 2020). Transport service and infrastructure are analogs to the lifeline of any city and play a huge role in its sustenance and economic growth. The ongoing urban densification is exerting unprecedented pressure on the infrastructure system of Dhaka posing an ever-increasing threat to the economic sustainability of the city. Therefore, this paper focuses on the urgent need to assess the impact of densification intervention from the perspective of economic sustainability.

II. Methodology

Due to the saturated state of Old Dhaka, the city went through a continuous horizontal expansion with a series of low-density planned residential areas along the north-south axis dictated by topographical constraints up to the 1970s. Dhanmondi was the first planned residential area of New Dhaka followed by the sequential development of Gulshan, Banani, Pallabi, and Uttara. From the mid- 1990s in response to the growing demand for housing urban intensification started taking place in these areas at varying pace and time depending on the provision of physical infrastructure. Therefore, to examine the effects of the ongoing densification process on the economic sustainability of the residential areas of Dhaka Megacity these seven residential areas with varied gross density, age, social class, location (inner core, middle and peripheral), and settlement pattern from both Old Dhaka (Luxmi Bazaar and, Wari) and New Dhaka (Dhanmondi, Banani, Gulshan, Pallabi, and Uttara) were selected as study areas. Primary data was collected through a household questionnaire survey, informal interviews, and extensive fieldwork while, neighborhood land use plans, the Master Plan of Dhaka, the Strategic Transport Plan, density data, planning ordinances, and circulars related to building regulations collected from Capital Development Authority (RAJUK), Public Works Department (PWD), Dhaka North, and South City Corporations contributed to developing an insight into the process of land use allocation, urban consolidation and infrastructure planning the study areas underwent periodically.

The questionnaire survey was employed to understand the related household demography, residents' perception of density, travel behavior of the residents, quality, and access to public transport, availability of alternative modes of transport and types of trips taken by the residents, provision, and quality of utility services and residents' satisfaction level regarding the facilities. The total number of residential plots in each sample area is considered as the whole population for each study area and household per plot is considered as a unit of analysis. The total required sample size from all the study areas was estimated to be (291+277+280+357+284+353) = 1842 households at the confidence level of 95% with a marginal error of 0.05%. The questionnaires were distributed to randomly selected respondents and a total of 1623 responses were received. Gross population density has been considered as the indicator of the population density of the study areas. The analysis was done in two parts. The first part focused on the residents' perceptions about the prevailing density and the selected aspects (access to transport and utility services) pertinent to economic sustainability by analyzing the responses from the questionnaire survey and corroborating them with the informal qualitative interviews of the residents. Primary data from the questionnaire survey was analyzed through simple descriptive statistical tools (frequency distribution) to assemble or reconstruct the data in a meaningful and comprehensive manner and was presented in the form of charts, tables, graphs, etc. The second part examined the relation between density and sustainability aspects based on the residents' satisfaction level associated with the selected aspects of economic sustainability by using Pearson's correlation test. These findings were then interpreted in detail with their theoretical underpinnings contributing to a better understanding of the consequences of the ongoing densification process in the residential areas of Dhaka that might serve as a guide for formulating a comprehensive and consistent transportation and infrastructure plan coherent with urban densification policy in the future.

III. Aspects of Economic Sustainability

The economic sustainability of the urban areas depends on the provision of public infrastructure facilities that principally comprises transport facilities and utility services. These aspects were examined through a set of indicators presented in Table 1. Therefore, the economic sustainability of the residential

areas is assessed based on these two criteria discussed in the following:

Table 1: List of economic sustainability indicators

Aspects of economic sustainability	List of indicators	Number of indicators
Accessibility to Transport Facilities	• Availability of public transport facilities • Average distance to nearest daily use transport nodes	2
Accessibility to infrastructure (Utility services)	• Well maintained infrastructure	1

Sources: Adapted from Stewart, 2010; Neighborhood Sustainability Indicators Guidebook, 1999; Neighborhood Sustainability Indicators Guidebook, Minneapolis, 1999; Seattle Sustainable Neighborhoods Assessment Project, 2014.

a) Accessibility to Transportation Facilities

The public transport in Dhaka primarily comprises buses only. The high-density areas are better connected through public transport service in terms of the average distance of bus stoppage and availability of buses. However, density alone is not the factor that facilitates easy accessibility, but the type and layout pattern of the road network also has a vital role to play as the residential areas which are laid along primary thoroughfare seem to have better accessibility. This is evident in the case of Wari which despite being a high-density residential area has poor access to public transportation. As the nearby major transport corridor is not located in the vicinity of the area inhabitants must travel long distances to reach the closest bus stop located in the Old Central Business District of Gulistan.

Table 2: Residents' opinion regarding the availability of public transport (Bus)

Location	Availability of Public Transport (Bus)	Non-Availability of Public Transport (Bus)
Wari	18	82
Luxmi Bazaar	27	73
Dhanmondi	52	48
Banani	53	47
Gulshan	41	53
Pallabi	63	37
Uttara	61	39

The percentage is based on the number of responses.
Source: Field Survey, 2015

From analyzing the residents' modal choice, it was found that due to the incompatibility of the narrow intertwining street pattern of Old Dhaka for motorized vehicles the residents relatively rely more on non-motorized vehicles for travel purposes than the residents of New Dhaka. The ownership of cars is rather few in Luxmi Bazaar and Wari. However, Wari has comparatively more car owners than Luxmi Bazaar due to its gridiron street pattern conducive to car traffic. But most of the people of Wari depend on other means of public transport rather than the bus as the bus stops are not available within a radius of 10-minute walking distance. The survey findings show that only 23% of office goers and 15% of students rely on the bus as the chief mode of transport for their daily business trips. As Wari does not have adequate schools 52% of the parents use rickshaws and 20% auto-rickshaws as the primary mode of transport to drop their children to the schools of the nearby wards. A small percentage (8%) of the inhabitants whose children study in English medium schools of Dhanmondi use their cars. Conversely, an array of educational institutions is situated in the vicinity of Luxmi Bazaar (within a radius of 1 km), and thereby, around 72% of students do not use any motorized vehicles (43% foot and 28% rickshaws). Most of the female students at Jagannath University are found to reside in rental accommodation in the area of Koltabazar and Rokonpur of the study ward which is located within walking distance of the university campus. The figures from the survey (Table 4) indicates a higher percentile of the inhabitants of Old Dhaka (Wari 57% and Luxmi Bazaar 72%) depending on non-motorized mode of transport while a significant percentage of the inhabitants of New Dhaka (Dhanmondi 76%, Banani 81%, Gulshan 85%, Pallabi 54%, and Uttara 55%) are dependent on motorized transport for daily school trips.

Table 4: Percentage of the inhabitants using various modes of travel for study purposes

Location STUDY	Non-Motorized Transport		Motorized Transport		
	Walk %	Rickshaw %	Taxi/ CNG auto-rickshaw %	Bus %	Car %
Wari	5	52	20	15	8
	57%		43%		
Luxmi Bazaar	43	29	14	12	2
	72%		28%		
Dhanmondi	3	21	25	14	37
	24%		76%		
Banani	4	15	14	20	47
	19%		81%		
Gulshan	4	11	22	6	57
	15%		85%		
Pallabi	8	38	8	36	10
	46%		54%		
Uttara	8	37	14	21	20
	45%		55%		

The percentage is based on the number of responses.
Source: Field Survey, 2015

Most of the inhabitants of Luxmi Bazaar are businessmen by trade whose business enterprises are located within Sutrapur and Kotawali *thana* (administrative unit). This medium to small-scale commercial establishments mainly comprise printing presses, wholesale shops of household goods, and small-scale factories. Therefore, to reach their workplaces which are near their houses most of them travel on foot, by rickshaw or motorcycle. Only 44% of the service holders who are employed in various public, private, and other corporate offices in the locations of Mohakhali, Motijheel, and Farmgate commute by bus to their workplaces. There are direct bus routes from the Victoria Park bus stop to Mohakhali, Gabtoli, Elephant Road, Farmgate, Khilket, Uttara, Gazipur, Savar, and Jatrabari. BRTC bus services are not available in this area, only private buses ply these routes. The situation of Old Dhaka regarding the accessibility to transport is expressed through the interviews of the residents of Luxmi Bazaar-

"I have been working in the Judge court for the last 8 years. I live in Luxmi Bazaar. Every morning I take a rickshaw which is easily available along my lane to reach the court. It takes around 15 to 20 minutes to reach the court if I catch the rickshaw by 7:20 am. Otherwise, I might get caught in a traffic jam which usually starts taking place from 8:00 to 9:00 am. The situation in the evening is quite different. I often face traffic jams caused by the regular traffic of the launch terminal in Shadarghat at these hours. Sometimes the situation becomes so acute that rickshaws remain still standing for hours. In such cases I usually cross through the traffic jam on foot and take a rickshaw from the other side of Victoria Park…this saves a lot of time". (Interview with a resident of Luxmi Bazaar, September 2015)

"I run a press in the Hrishikesh lane. We have been living in Rokonpur since my grandfather built our house there. Usually, I drop my daughter at Bangla bazaar school by motorbike before I get to work. To avoid traffic congestion, we set off early by 7:30 am. Generally, the trip does not take more than 10-15 minutes to reach my workplace after dropping her." (Interview with a resident of Luxmi Bazaar, September 2015)

For running daily errands like buying vegetables, groceries, and shopping, inhabitants of Old Dhaka (Wari and Luxmi Bazaar) rely more on walking and rickshaws. The wet markets of both New and Old Dhaka are located within a walking distance of 11–20 minutes and are usually reached by rickshaw. Furthermore, the higher number of convenience stores and chain supermarkets like Agora, Meena Bazaar, and Nandan particularly in New Dhaka attracts the residents to do their groceries from there by using cars. The width of the access roads of the New residential areas varies from 18 feet to 24 feet. Many of these access roads are not accompanied by pedestrian pathways. The ones which have footpaths are having regular break-ups at regular short intervals for providing vehicular entry to the flanking residential or commercial plots. The frequent breakups in the pedestrian pathways make them inconvenient for smooth pedestrian movement and therefore, discourage people from using them. However, pedestrian pathways are relatively better functioning in Banani and Uttara which are accompanied by separate by-lanes for the access of vehicular traffic to the road-facing plots while keeping the pedestrian flow uninterrupted. The residents of both Uttara and Mirpur rely more on alternative modes of public transport like rickshaws and auto-rickshaws for their daily shopping. Residents do their daily groceries by foot or by rickshaw (57% in Uttara and 51% in Mirpur) from nearby neighborhood wet markets or street vendors. An increase in the convenience stores and chain shopping malls (Agora, Meena Bazaar, Aroma Bazaar, Swapno,

Stop n Shop, etc) on the secondary roads of Uttara since the last 6-7 years has made shopping in these stores easier for the residents who can easily access them by rickshaws or by foot from almost all the sectors of Uttara. Overall, the choice of travel mode of the residents of New Dhaka is quite contrary to Old Dhaka. People in these areas show a higher propensity towards car use, which is partly due to the planned street layout and partly to the unavailability of suitable public transport like feeder or shuttle service. Dhanmondi displays a moderate use of cars, Banani has a relatively higher share of car users and most of the residents of Gulshan are exclusively automobile-dependent for almost all kinds of daily trips regardless of the traveling distance.

Table 5: Percentage of the inhabitants using various modes of travel for work purposes.

Location	Non-Motorized Transport		Motorized Transport		
	Walk %	Rickshaw %	Taxi/ CNG auto-rickshaw %	Bus %	Car %
Wari	5	27	35	23	10
	32%		68%		
Luxmi Bazaar	12	60	14	12	2
	72%		28%		
Dhanmondi	2	10	28	24	36
	12%		88%		
Banani	4	15	14	20	47
	19%		81%		
Gulshan	-	17	22	4	57
	17%		83%		
Pallabi	8	21	14	47	10
	29%		71%		
Uttara	8	31	14	27	20
	39%		61%		

The percentage is based on the number of responses.
Source: Field Survey, 2015

Dhanmondi is resided by upper-middle-income class who are using cars mostly for going to work (36%), study (37%), and shopping (41%) (Field survey, 2015). Though Dhanmondi is located along a major thoroughfare of *Mirpur Road* the bus routes and frequency of buses lag in meeting the demand. This was evident from the interviews of several service holders who cannot rely solely on the bus service for their daily commuting. A significant number of office goers who use cars are likely to drop their children at school by car on the way to their office which explains the higher incidence of car usage in school traffic during the peak hours in this area. One of the reasons for the lack of public transport is embedded in the development process of the area. As the plan of Dhanmondi was designed as a high-class car-oriented neighborhood exclusive for the elites, diplomats, and dignitaries, the public transit system was not a concern in its initial phase of planning. The only public transport BRT service was launched in the 1960s in Dhanmondi which adequately served the needs of the residents then. But from the onset of the 1990s as the area was increasingly undergoing the construction boom initiated by the rising housing demand for the upper-middle and middle-income groups. This in turn raised the demand for public transport and other supporting facilities in the locality. The only school (Dhanmondi Boys School) in the area was not sufficient to meet the growing demand. As a result, more schools were constructed which gradually proliferated into an unprecedented number of educational institutions of various scales. The posh character and locational criterion of this area soon promoted to set up other commercial establishments mainly shopping and health care facilities including general and specialized hospitals. Offices and banks were also established but comparatively fewer than shopping, educational, and health care facilities. However, the relatively lower percentage of offices does not generate a regular inflow of office-going commuters in the area. Most of the Branded commercial outlets of Dhanmondi serve the need of the neighborhood and beyond and are usually availed by car owners from all over the city (Nancy, 2004). So, the prevalence of a lesser percentage of office-going commuters could be a reason for the negligence of the private transport companies to supply more buses on this route.

On the other hand, Banani and Gulshan still retain their status as up-scale residential neighborhoods and most of the residents own cars. The accessibility to public transport is better in Banani than in Gulshan as it is located right along with one of the prime arteries of the city (*Dhaka Mymensingh Road*). Furthermore, Banani houses a higher percentage of offices than Dhanmondi which ensures a daily flow of commuter traffic to the area. In effect of this, more private buses are serving this route than Dhanmondi and the intersections of the area

are subjected to heavy traffic congestion most of the time. The bus stop is located on the main thoroughfare which is far beyond walking distance of the residents. This is also a factor discouraging the residents from using public transport.

Gulshan is exclusively a high-class residential area with a diplomatic zone housing most of the embassies. The bus service in this area is also inadequate and mainly used by commuters from all over the city. The existence of a diplomatic zone also discourages public transport services for security concerns. As the upper-class residents are more used to cars most of them are not bothered about the availability of public transport in the area and remain oblivious about it which was reflected in several interviews of the residents of this area who have no idea about the public transport facilities of their residential area. The survey findings presented in Tables 4 and 5 show that around 83%- 85% of the residents are car-dependent for most of their daily outdoor activities.

Mirpur and Uttara are found to have good connectivity with the rest of the city through the public transport system. More than 36 bus routes are served by both private and public buses which regularly ply across the major thoroughfare of Dhaka Mymensingh Road connecting these areas. Mirpur is a middle-class residential area from where most people commute to Uttara, Banani, Gulshan, and Motijheel regularly for work. From 2003 up to 2010 Mirpur and Uttara were served mainly by BRTC double-deckers with a few private buses along this route. The good connectivity of Uttara gradually encouraged many offices and commercial activities to be established there. As a result, the number of commuters to Uttara from Mirpur increased and this made Mirpur a preferable location for the private bus companies to escalate the provision of bus services along this route. The quality and frequency of BRTC service declined when the Volvo double-decker buses were replaced by the new low-cost single and bi-articulated buses and were subsequently taken over by the private bus companies.

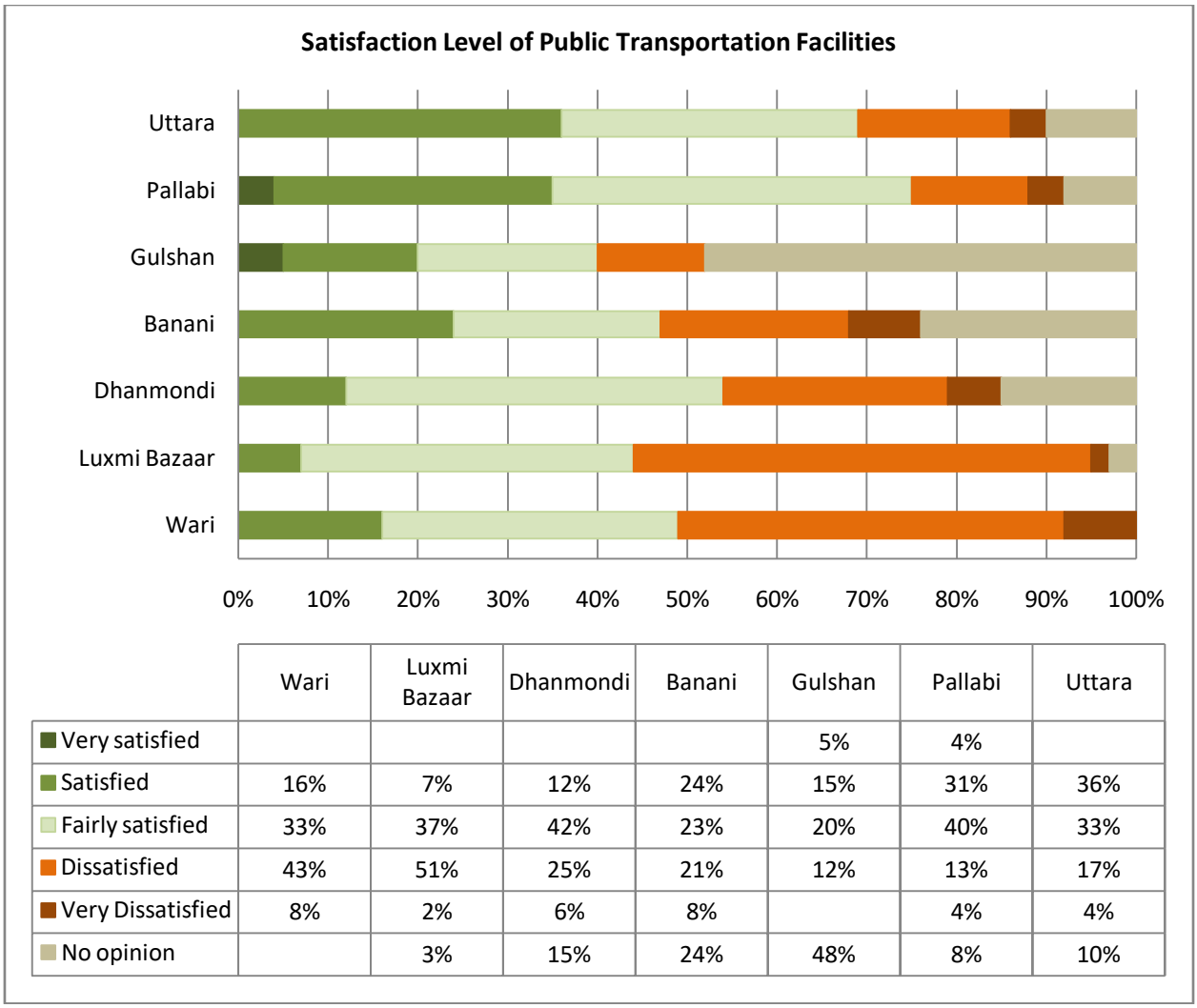
Residents' Satisfaction with Public Transportation Facilities

Regarding the satisfaction level of transportation facilities, Wari and Luxmi Bazaar display contrasting opinions from the respondents. Despite belonging to Old Dhaka, around 91% of respondents of Luxmi Bazaar have expressed their satisfaction in various degrees, while in Wari only 51% have shown positive remarks, and the rest are dissatisfied with the provision of public transport facilities. Both Wari and Luxmi Bazaar have one bus stop, but it takes comparatively less time to reach the bus stop in Luxmi Bazaar (5-10 mins). In the case of Wari, there is no bus stop within the neighborhood and the nearest bus stop is situated in Gulistan which takes around 15-20 minutes to reach. The distance and lack of bus stops and vehicle occupancy rate are significant factors for the higher rate of dissatisfaction in Wari as asserted by some of the respondents:

> *"I live in Wari and regularly go to Dhaka University to attend my MBA classes. I would rather travel by bus as the fare is comparatively lower than the rickshaw. But the nearest bus stop is in Gulistan which is quite far away from Wari. To avail the bus, I need to take a rickshaw to get there first and then board the bus. But had even reached the bus stop, often it becomes difficult to ride the bus as most of the time it is found overcrowded. So, the only choice left for me is taking a rickshaw or auto-rickshaw which is easily available within the neighborhood but not cost effective. The situation remains the same on the way back home. I just wish for an affordable and comfortable mass transit system that could help reduce the sufferings of students like me." (Interview with a student residing at Wari, March 2015)*

Dhanmondi is served by about 40 bus routes along *Mirpur Road* with 10 routes along *Satmasjid Road*. There are 3 bus stops, located respectively along Road No. 4, Shukrabad and in Jikatola. But from the survey, it was found that, for most of the residents (82%) the average time to reach these bus stops is more than 10-15 minutes by rickshaw. In addition, the frequency of these buses is not adequate to meet the demand. Therefore, people tend to use cars and other modes of motorized vehicles to reach their destinations on time. These factors can explain the relatively higher rate of dissatisfaction (25%) in Dhanmondi than in other new residential areas of Dhaka regarding public transport.

Chart 1: Satisfaction level of the respondents regarding public transport facilities



	Wari	Luxmi Bazaar	Dhanmondi	Banani	Gulshan	Pallabi	Uttara
Very satisfied					5%	4%	
Satisfied	16%	7%	12%	24%	15%	31%	36%
Fairly satisfied	33%	37%	42%	23%	20%	40%	33%
Dissatisfied	43%	51%	25%	21%	12%	13%	17%
Very Dissatisfied	8%	2%	6%	8%		4%	4%
No opinion		3%	15%	24%	48%	8%	10%

Source: Field Survey, 2015

The overall satisfaction level of Banani is 47% and the overall dissatisfaction level is 29% regarding public transport. However, 24% of the respondents have not given any opinion. This is partly due to the affluent high-class status of the residents who are mostly automobile-dependent for their daily activities. The area is served by two bus stops located at the two far ends of *Kemal Ataturk Avenue* (Kakoli and Baridhara stops). Most of these public transports (bus, auto-rickshaw, taxi) are used by commuters and the residents are least concerned about its provision. Besides cars, the residents occasionally use other modes of transport like rickshaws and auto-rickshaws for traveling within the neighborhood with which they are found to be quite satisfied. The same scenario can be observed in Gulshan where almost all the residents are car users and thereby do not depend on public transport. As non-users of public transport, most of the residents (48%) were unable to express their opinion regarding the issue. The good connectivity, provision, and frequency of the bus service have yielded an overall higher satisfaction level with public transport both in Pallabi (75%) and Uttara (69%).

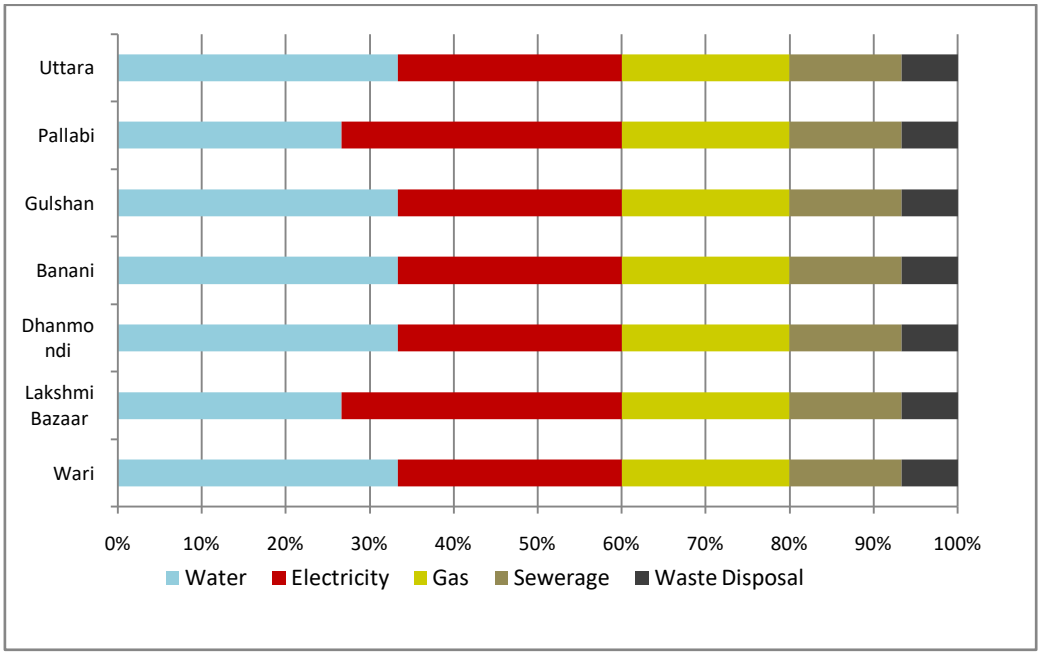
The survey findings indicate that the road network pattern of the residential areas plays a significant role in the provision of public transportation facilities as planned areas enjoy better connectivity than unplanned areas. The satisfaction level, in general, reflects similar outcomes where the residents of unplanned areas are found dissatisfied while residents of planned areas displayed a higher level of satisfaction. But other factors like income level also influence the satisfaction level as the higher-income groups are less dependent on public transport and they are least bothered about its provision and quality. However, the accessibility to public transport in terms of distance from bus stops to the neighborhood also plays an important role in the satisfaction level as it is clear from the responses of Wari that despite being a planned residential area the longer distance to the bus stop prevents inhabitants from using public transport.

IV. Accessibility to Infrastructure

This aspect covers the utility service infrastructure which includes water, electricity, gas, sewerage services, and waste disposal systems of the study areas. Overall, from the survey, it was found that there is a significant infrastructure and service delivery gap in utility services except for water supply across the majority of the study areas. From the observation, it was found that regarding the availability and quality of the utility services, water supply ranks first place in all the study areas. The deficit between the demand and supply of water is the lowest as Dhaka Water and Sanitary Authority (DWASA) produces 2420 MLD against a demand of 2250 MLD (DWASA, 2015). However, the residents of Luxmi Bazaar and Pallabi have complained of the periodic irregularity in the supply and quality of water which is chiefly due to the system loss caused by leakage in pipes, lack of proper operation and maintenance, and unauthorized connections. A study by GKW Consultants conducted in 1996–97 indicated that about 20% of water loss can be contributed to leaking pipes and joints and the rest to administrative inefficiencies including non-metered connections, no billing, under billing, unauthorized connections, pilferage etc (Haq, 2006). The illegal connections in these areas made by unskilled laborers are often not leak-proof and result in contamination of water. In addition, a major part of the water pipes in Luxmi Bazaar installed by the public utility is over 50 years old and needs to be replaced. To ensure continuous supply water is stored in the underground reservoir and then pumped to the overhead tank of each building while deep tube wells serve larger housing complexes at New Dhaka. Dhaka city has sanitation coverage of around 70%, of which a water-borne piped sewerage system covers merely 30% and the rest is handled through conventional septic tanks (ibid). Areas like Pallabi and part of Old Dhaka (east) are not covered within the water-borne piped sewerage network and the system of sewerage collection and conveyance is also in poor shape. During the monsoon, the storm drains are often overflowed with sewage for lack of proper drainage system. The respondents of Dhanmondi, Gulshan, Banani, and Uttara complained about frequent breakdowns and blockage of the sewerage system due to the insufficiency of sewer lines in terms of length and diameter and the frequent road digging for making new connections and repair of sewers.

On the other hand, the residents of Luxmi Bazaar and Pallabi have reported having better service regarding electricity supply than water. This may be attributed to the presence of fewer large-scale shopping malls and other commercial facilities in the locality contributing to increased power saving. Nonetheless, frequent power cuts occur in all the study areas which indicates that the overall electricity demand is higher than the supply. The frequent power cuts are mostly experienced in summer due to the high consumption of electricity. The government has adopted the policy of closing off the commercial establishments after 8:00 pm to mitigate the deficit of power supply. The policy seemed to have improved the continuity of power supply as revealed in the survey result. There is an ongoing crisis of natural gas, due to production shortages, pipeline leaks and, illegal and excessive gas connections also reflected in the responses of the households experiencing the supply disruption. At present for fuel safety government promotes LPG cylinders in the newly constructed buildings instead of pipeline supply of natural gas. The waste disposal service has been reported to be in the least acceptable condition in all the study areas. There are open garbage disposal points situated along the arterial and access roads which pollute the surrounding environment as well as hinder the traffic movement and create traffic congestion. The waste management system is assigned to the city corporations. But as these organizations are not capable of handling the duty properly due to lack of funding and human resources the responsibilities of collection, disposal, and management can be assigned to the private sector. Overall, most of the residents of the study areas have ranked the power service in second place while gas, sewerage, and waste disposal service take third, fourth, and fifth place respectively in terms of accessibility and quality of the service.

Chart 2: Ranking of utility services in the study areas



The percentage is based on the number of responses
Source: Field Survey, 2015

V. Relationship between Density and Economic Sustainability Aspects

The aim of the analysis carried out in this research was to explore the relationship between density and the selected aspects of economic sustainability of the study areas. The analysis process used simple correlations (Pearson's correlation) to examine the basic relations between density and the two selected aspects of economic sustainability. The Gross Density of the study areas has been selected as the density parameter. The correlation between density and the indicators of each selected aspect of sustainability was examined individually and then the overall impact of density was determined from the average values of the indicators of each aspect. The results of the correlation analysis are presented in Table 6 and followed by the interpretation of the findings.

Table 6: Relationship between density and aspects of economic sustainability

	List of indicators	Density relationship (Ward wise - gross population density	Overall impact of density
Accessibility to Infrastructure facilities	Accessibility to public transport	negative	negative relationship-higher density residential areas have lower accessibility to infrastructure facilities.
	Access to utility services	negative	

Source: Questionnaire survey 2015

Among the aspects of economic sustainability, accessibility to public transport was found to have a negative association with the physical density of the study areas which implies that higher-density areas are not well served with public transport while no significant association was found between density and infrastructure which suggests that the provision of utility services (gas, electricity, and water) in the residential areas have not yet gone beyond the threshold. However, higher density is found to be negatively associated with services like sewerage and garbage disposal in all the study areas.

VI. Summary Findings

a) Accessibility to transport facilities

Though the literature suggests that higher-density areas are supposed to have better access to public transport facilities, the results of this research are contrary to this expectation. The residential areas of Wari and Luxmi Bazaar have one of the highest densities but

do not have higher accessibility to public transport facilities in terms of the average distance of bus stops, availability, and frequency of buses. The organic settlement pattern, narrow access roads, and the distance from transport corridors of these settlements are partly responsible for this. For both the residents of Luxmi Bazaar and Wari, it takes about 20–25-minute walk to reach the nearest bus stops (700m-850m) and again must wait for another 10-15 minutes as the buses are not that frequent or overcrowded. Overcrowding is caused by carrying an extra number of standing passengers on board. In addition, there is no monitoring authority to regulate the fare. Consequently, the residents of Old Dhaka rely more on alternative modes of both motorized and non-motorized vehicles like rickshaws, bicycles, motorcycles, auto-rickshaws (CNG), and to a lesser extent on cars. Conversely, the relatively lower-density residential areas of New Dhaka are found to have better access to public transport facilities. This is due to the gridiron pattern layout of these settlements where the access roads of each block end up in the adjoining primary and secondary roads. Despite inadequate transit provision, the number of routes and frequency is higher than Old Dhaka and it takes about 15–20-minute walk for most of the residents to reach the nearest (350m-550m) bus stop. This explains the higher satisfaction level of the residents of New Dhaka. Overall, the present condition of public transport in terms of service quality, frequency, fare policy, vehicle occupancy rate, and lack of routes, is not satisfactory and therefore, does not ensure the sustainability of the residential areas in terms of the accessibility to public transport facilities. Due to the lack of adequate public transportation infrastructure and management, people are constrained to increase their reliance on cars accounting for the registration of 78240 private cars from 2011 to 2016 (BRTA, 2016). The higher traffic load with persistent traffic congestion is contributing to increased vehicular emission (Iqbal et al., 2014) posing a constant threat to the health of the city dwellers.

b) Accessibility to utility services

The accessibility of utility services was also found negatively associated with high density which indicates that high-density residential areas are not still provided with adequate utility service. Though theory claims that higher densities ensure higher accessibility to utility services the opposite scenario has been observed in Dhaka. This indicates an overall shortage of utility facilities not able to meet the demand. Therefore, from the viewpoint of accessibility to infrastructure, both the transport and utility services have a negative association with density which cannot ensure the economic sustainability of these residential areas.

VII. Discussion and Recommendations

Given the summary findings, it can be said that high-density developments when unguided are prone to generate increased traffic concentration, overloaded infrastructure, poor spatial qualities, and urban inefficiencies which have been observed in the case of Dhaka. The vertical expansion of the city has stretched to an extent where disadvantages in terms of the transport system and infrastructure provision are becoming increasingly unsustainable and beyond the limit of acceptable thresholds of the city. From the empirical observations, the transport system is the most affected in the current context of Dhaka. Densification strategy when formulated needs to be integrated with viable and consistent transportation planning. The best practices of densification strategies around the world reinforce this fact. An example of successful densification practice is Curitiba where structural axes for public transportation integrated with urban land use were created redirecting the city's growth from a concentric radial to a linear pattern ((Rabinovitch, 1992; Pienaar *et al* 2005). Along these axes, the density zones of differing densities were distributed.

The city of Dhaka is deprived of an efficient public transport network system. According to Caminos and Goethert (1978), at least 20%-25% of the urban land should be dedicated to road space to facilitate a smoothly functioning transport system in a modern city. According to the STP 2005, Dhaka has a road space of 9% of its total urban area, even after the implementation of the Dhaka Urban Transport Project (DUTP) and the Dhaka Integrated Transport Project (DITP), which is far less than the recommended standards. Furthermore, the development of new roads has been slower than the growth in the number of vehicles (80% in the last decade). In addition, according to the official records of Dhaka City Corporation (DCC), the mixing of different modes of transport i.e., both motorized and non-motorized transport (rickshaws 3,00,000 in number accounting for 15.2% of the traffic and occupying 73% of the road space) has been cited as a major reason for the persistent traffic congestion in the city. The unguided densification has contributed to an escalation in the number of automobiles from 4734 in 2004 to 10913 in 2011 (BRTA 2012). This leads to increased traffic congestion which is further aggravated by the greater number of on-street illegal parking in the absence of adequate parking facilities. Multi-storied parking lots, traffic calming, and designated lanes for buses may improve the situation. To maintain a balanced street and car ratio ceiling needs to be imposed on the registration of new cars. The current FAR rule for designing high-rise buildings does not consider the impact of the car traffic generated by them which could be controlled through area-based density planning. The Observations

also indicated that the construction of multi-story buildings along the major transport corridors without adequate provision for parking of construction vehicles, storage of construction materials, etc. in contravention to the Building Construction Rules 2006 (BCR) has contributed to the recurring gridlocks on certain principal corridors.

The number of buses through the period of 2004 to 2011 increased from only 1147 to 1318 buses (BRTA, 2012) which is highly inadequate for a megacity like Dhaka. This is partly due to the inadequate road infrastructure as well as the monopoly of a handful of influential private companies running the bus sector with the BRTA (STP, 2005). Alam and Habib (2003) pointed out that more than 60 percent of the roads of Dhaka are found to remain congested carrying 25 percent more traffic than their capacities and around 50 percent of these roads are incapable of supporting a vehicular speed limit of more than 15 km/ hr. during the peak hours. By introducing BRTs covering the entire city propensity towards automobile usage can be reduced. Newman and Kenworthy (1989) indicated that public transport becomes viable at net densities between 90 to 120 persons per hectare (gross densities of 30-40 plots/ hectare) and walking becomes viable at a net density of 300 persons per hectare. The gross densities found in the study areas range between 81 to 737 persons per hectare making these settlements viable for public transport. In addition, the geological feature of the terrain dictates the city to adopt linear development which is suitable for adopting a mass transit system. The Government already had planned for Mass Rapid Transport systems (MRTs) through the introduction of the elevated light rail. However, the Bus Rapid Transit (BRT) service with designated bus lanes instead of expensive elevated rail tracks may prove cost-effective in terms of installation and operation. Again reviving the waterways through a network of interconnected lakes, canals, and river water-based public transport systems may be introduced. Private sector participation needs to be encouraged for funding such projects.

Besides an efficient transport system for a natural disaster-prone (i.e., earthquake and flash floods) city like Dhaka, it is crucial to develop an accessible matrix of urban streets and open space system to ensure a safe and rapid evacuation of people. A growing body of research indicates that an accessible street network based on people's movement patterns and density and other morphological aspects including land use, building density, distribution of public open space, and emergency shelter are the key considerations for effective rescue and recovery planning (Ahmed, 2016). A planned accessible network for emergency routes would promote community awareness regarding preparedness and mitigation programs in post-disaster situations. Preparation of site-specific evacuation plans is of high priority, especially for every organically planned locality of Dhaka. A network of access roads connecting the public buildings with nearby open spaces could prompt safe evacuation during a disaster including earthquake and fire hazards.

Density is a crucial factor in determining the allocation of infrastructure and public service delivery in residential areas. There is an inverse relationship between density and infrastructure costs (Arenas, 2002). The growth of Dhaka is largely characterized by mid-rise apartment buildings with population densities ranging from 81 to 737 persons per sq. km. (BBS, 2011). However, the city has expanded vertically in response to the limited provision of the line infrastructure and amenities. The rapid densification caused a significant infrastructure and service delivery gap in terms of gas and water supply, especially in the older parts of the city. For New Dhaka, the water supply infrastructure that was installed earlier for lower-density settlements became insufficient for higher-density living. To address the problem of low pressure in the supply lines, water is pumped to the overhead tanks from the underground reservoirs to serve the upper floors. The increased water consumption exerts extra pressure on the subsoil water and results in lowering the water table which may lead to land subsidence (BUET 2000). Rainwater harvesting in conjunction with ground and surface water supply systems may solve the crisis. In addition, 30% of Dhaka has water-borne piped sewerage coverage and the rest rely on on-site sanitation through septic tanks and soak pits (Haq, 2006). With the rising production of sludge, these septic tanks need to be frequently cleaned which is not cost-effective in the long run either.

Observations indicated that the frequent digging of all types of roads for installation, repair, and shifting of utility service lines throughout the year causes huge snags in traffic flow and increases traffic congestion. The installation of underground service ducts underneath the sidewalks, largely practiced in western cities, may help avoid such hassle. These service ducts are usually 5ft x 7ft in dimension containing all the utility lines in various service trays. With all the utility lines within a single duct underneath the sidewalk, the vehicular road remains free from unnecessary digging whenever a new utility connection or repair is required. The survey revealed that most of the access roads in the new residential areas are accompanied by pedestrian pathways where this system can be engineered. It would also diminish the need for installing the series of electric poles with exposed high voltage wiring not only poses danger but also creates an ugly streetscape. The underground ducting would improve the visual image of the neighborhoods by offering a clear street view. Despite the high installation cost involved in replacing the existing system, the benefits may outweigh the overall cost, in the long run, making the neighborhoods more sustainable. The system can be implemented in the

upcoming public and private housing projects having sufficient road width with sidewalks.

VIII. Conclusion

Densification in connection to the compact city model is recognized as an effective strategy for reducing travel demand and ensuring access to basic services for the urban dwellers which in turn contributes to the economy of the city. But if densification interventions are implemented without considering the limitation and potential of the prevailing infrastructure adverse outcomes may surface as indicated by the findings of this research evident in the sector of transport and utility services of Dhaka. However, to avoid the unintended outcomes urban densification policy should consider the compatibility of the existing physical infrastructure and their potential for expansion with the proposed density. Before setting the density of buildings, it is necessary to assess the outcome in terms of projecting various development scenarios considering the site-specific potential and challenges. The extent of urban densification should also comply with the residents' needs and cultural expectations.

Nonetheless, urban intensification supported by a well-integrated consistent infrastructure policy can promote the economic sustainability of the city in many ways including, reducing travel activity, vehicle occupancy rates, and fuel consumption per capita causing reduced emissions and carbon footprint, and improving air quality (WBCSD, 2004; Dalkmann and Brannigan, 2007; Joumard and Gudmundsson, 2010; Kane, 2010; Litman, 2007; Ramani et al., 2011). Similarly, reducing the need for stretching trunk infrastructure in a compact city can conserve energy and fuel economy. Given the current situation, Dhaka requires a range of rationally supportive and feasible policies for the transport sector to maximize the mitigation potential by shifting to multi-modal options. This could be achieved by reviving the waterways of the city and increasing reliance on inclusive and transit-oriented transport like Bus Rapid Transit (BRT) and rail-based mass transit. However, to avoid unintended outcomes densification intervention should be guided by site-specific densification policies supported by a rationalized, comprehensive, and sustainable physical infrastructure and transport plan.

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A Comparative Study of the Irrigated Zones of Jaguaribe-Apodi and Morada Nova from a (Un)Sustainable Perspective

By Jessie Coutinho de Souza Tavares, Roberto Ney Ciarlini Teixeira & Mônica Mota Tassigny

University of Fortaleza in Law School

Abstract- Large-scale government-sponsored irrigation is a feasible alternative to the development of semiarid regions, such as Northeastern Brazil, provided perennial rivers and reservoirs are available. Brazilian irrigation projects have also generally promoted the participation of farmers as informed agents in the process, encouraging training and education towards agribusiness. The purpose of this explorative and descriptive study was to analyze and compare the sustainability characteristics of the Jaguaribe-Apodi and Morada Nova irrigation zones in light of the triple bottom line model (Elkington, 2012), based on information from 18 interviews conducted in September 2015 to November 2015 and submitted to discourse analysis. Triple bottom line sustainability envisages a balance between three dimensions: social, environmental and economic.

Keywords: semiarid climate. subsistence farmer. sustainability. jaguaribe-apodi irrigation zone. morada nova irrigation zone. triple bottom line.

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A Comparative Study of the Irrigated Zones of Jaguaribe-Apodi and Morada Nova from a (Un)Sustainable Perspective

Jessie Coutinho de Souza Tavares [α], Roberto Ney Ciarlini Teixeira [σ] & Mônica Mota Tassigny [ρ]

Abstract- Large-scale government-sponsored irrigation is a feasible alternative to the development of semiarid regions, such as Northeastern Brazil, provided perennial rivers and reservoirs are available. Brazilian irrigation projects have also generally promoted the participation of farmers as informed agents in the process, encouraging training and education towards agribusiness. The purpose of this explorative and descriptive study was to analyze and compare the sustainability characteristics of the Jaguaribe-Apodi and Morada Nova irrigation zones in light of the triple bottom line model (Elkington, 2012), based on information from 18 interviews conducted in September 2015 to November 2015 and submitted to discourse analysis. Triple bottom line sustainability envisages a balance between three dimensions: social, environmental and economic. Such a balance was not observed in our study due to insufficient awareness of environmental issues. However, focusing on a specific context and moment in time, the exploratory study design made it difficult to extrapolate our findings. Future studies could expand the discussion on the sustainability of irrigation zones by using data triangulation in longitudinal designs.

Keywords: semiarid climate. subsistence farmer. sustainability. jaguaribe-apodi irrigation zone. morada nova irrigation zone. triple bottom line.

I. Introduction

Portuguese documents from the time of the Empire describing the coastal areas in Northeastern Brazil, more specifically the semiarid lands of Ceará, mention 'infertile soils' and a failed attempt at occupying the territory in 1603 on part of Pero Coelho de Souza and the indigenous community under his command (Pompeu; Tassigny, 2006). This 'infertility' may be more appropriately described as seasonal aridity.

Awareness of the regional phenomenon of prolonged droughts as a crisis scenario emerged after the social upheaval associated with the dry season of 1877. The imperial government dealt with adverse climate conditions mostly by distributing food and creating emergency aid programs for rural populations, but it also encouraged studies in order to identify the root cause of the problem and propose feasible solutions to neutralize it (Neves, 2002).

Later, desiring to further mitigate the negative social impact of prolonged water scarcity, the republican government established a drought relief agency ('Inspetoria de Obras Contra as Secas', later renamed 'Inspetoria Federal de Obras Contra as Secas') which did much to expand knowledge of the climate, water resources and sanitation (Magalhães et al, 1991; Pompeu; Tassigny, 2006). In the same period, the federal government adopted a series measures in semiarid regions, such as the building of reservoirs and dams capable of storing rain water for use in the dry season. This period became known as 'the hydraulic era'.

During the military government (1964-1985), irrigation was resumed as a public policy with the purpose of maintaining an environmental and socioeconomic balance in semiarid regions. Within predetermined perimeters set up and managed by public agencies, water was distributed in equitable amounts to fruit and vegetable croppers.

Irrigation projects in semiarid Ceará date back to 1890 when a large dam and reservoir ('Cedro') was built in the city of Quixadá. Other contemporary drought relief projects used drilled wells and plate-assembled water storage tanks (Pompeu; Tassigny, 2006) until organized irrigation zones were established.

The first irrigated zone ('Morada Nova') was established in the mid-1970s to allow subsistence croppers to rise to the level of micro or mid-sized business owners and to prepare the semiarid backlands of Ceará for future farming enterprises oriented towards the export market (Sousa, 2010).

Equipped with pipelines to bring water from different reservoirs in Ceará and other technically advanced infrastructure, the project met the needs of a variety of farmers settled in the irrigation zone and allowed stabilizing productivity regardless of the season and despite droughts (Pontes et al, 2013).

As specified in Law #12.787/13, the irrigation zone plan is part of the National Irrigation Policy and has as its main objectives encouraging the expansion of irrigated land in the country, increasing productivity, and making local agribusiness more competitive. The project was intended to generate economic growth and support

Author α: Professor at University of Fortaleza in Law School.
e-mail: jessiecoutinho@unifor.br
Author σ: Ph.D Professor at University of Fortaleza in the Post-Graduation Program of Business and Management.
Author ρ: Ph.D Professor at University of Fortaleza in the Post-Graduation Program of Law.

the region's ecological, political and social development. In other words, the project was expected, on the one hand, to minimize ecological impacts by making sustainable use of native species and resources and, on the other, to promote the social and educational development of subsistence croppers so as to allow them to participate proactively in the political process and reject, if they so wish, initiatives stemming from the corrupt old 'drought industry'.

Sustainable development is essentially a process of change in which exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance current and future potential to meet human needs and aspirations (Brandon, 1999). Thus, two aspects highlight the necessary involvement of the individual and of the values underlying sustainable action: the philosophy allowing to understand the relationships between the different complex factors must be shared in a public consensus, and a comprehensive framework must exist in such a way that the complex inter-relationships can be made to aid communication, understanding and the growth of knowledge (Brandon, 1999).

A number of studies focused on the irrigation zones in Ceará have been published, offering relevant and critical socioeconomic analyses (Sousa, 2010; Pontes et al, 2013; Rigotto; Freitas, 2012). Evaluations of the sustainability of the regions benefited by these irrigation zones have revealed the potential of the project and have shed light on the perspective of the small farmers settled on lands adjacent to the irrigation zones.

In this study, we looked into the social, environmental and economic impacts of the Jaguaribe-Apodi irrigation zone in Ceará and its potential for sustainability in light of the triple bottom line sustainability model proposed by Elkington (2012).

II. Irrigation Zones: Legal Basis and Government Programs

Beginning in the 19th century, the history of irrigation in Brazil may be divided into four stages (França, 2001). Originally, the purpose was to make rational use of existing water resources, such as the São Francisco river, and thus put an end to the paradox that semiarid Brazil has one of the world's greatest water reserves but also one of the smallest areas of irrigated land. According to Bursztyn (2008), Northeastern Brazil has the equivalent of 11 billion m^3 of water stored up and less than 3,000 ha of irrigated land.

The drought relief agency established in 1909 ('Inspetoria de Obras Contra as Secas') was made into a federal autarchy in 1945 and renamed DNOCS ('Departamento Nacional de Obras Contra as Secas', currently governed by Law #4229/63). Covering the states Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia and part of Minas Gerais, DNOCS develops public policies for the redistribution, channeling and use of water resources in semiarid regions impacted by recurrent droughts (Brasil, 1963).

The early stages of irrigation consisted of minor interventions directed at specific targets and not informed by well-defined national policies and programs (França, 2001). However, these early efforts at implementing irrigation and drainage soon became ineffective due to lack of persistence on part of the agencies involved (França, 2001).

The late 1960s saw the beginning of the second stage of the history of irrigation. The government, then under president Médici, created the Group for Integrated Studies on Irrigation and Agricultural Development (GEIDA) (Bursztyn, 2008) and, with the purpose of mapping and managing the country's water resources, launched the Pluriannual Irrigation Program (PPI) in 1969 and the National Integration Program (PIN) in 1970 (França, 2001).

President Médici also ordered the creation of the First National Plan of Development (I PND) which proposed to expand irrigation by 130,000 ha during a 4-year period (1975-79). This goal was incorporated into the PIN (Bursztyn, 2008).

Two programs under the umbrella of the National Integration Program (I PNI), the National Program for the Rational Use of Irrigable Lowlands (PROVÁRZEAS) and the Program for the Financing of Irrigation Equipment (PROFIR), sought to create opportunities for private enterprises to enter drainage and irrigation zones or purchase 'corporate plots' on public land. Although these irrigation programs were government initiatives, they strongly encouraged private participation (Bursztyn, 2008; França, 2001).

The third stage of irrigated agriculture in Brazil started in 1986 with the establishment of the Northeast Irrigation Program (PROINE) and the National Irrigation Program (PRONI). Again, the priority of the federal government was to strengthen the private sector, but with a difference: a clearer distinction between the roles of the public and private sector in the development of irrigation projects, and government action limited to large infrastructure works (hydraulic and electric support and macrodrainage). Private enterprise was expected to handle everything else (França, 2001, p. 40).

Experience gathered throughout the first three stages had made it clear that a new approach to irrigation was necessary. Thus, in the fourth stage, starting in 1995, the National Irrigation and Drainage Policy was revised. The new approach was materialized in the New Irrigation Model Project (França, 2001).

The earliest attempts at irrigating the semiarid soils of Northeastern Brazil were supervised by IOCS (now DNOCS) in the early 1940s and involved the

construction of reservoirs and irrigation canals (Pompeu; Tassigny, 2006).

Then, in 1959, the Northeastern Superintendency of Development (SUDENE) was established, having as its priority the development of irrigated agriculture. This produced favorable results in the Experimental Fields of Bebedouro and Mandacaru in 1963-64, a restructuring of the technical and administrative structure of DNOCS and Companhia Vale do São Francisco (CVSF), and the foundation of the Executive Irrigation Group for Agricultural Development (GEIDA) in 1968 (França, 2001).

In 1973, the Integrated Plan for the Mitigation of the Consequences of Drought in the Northeast registered an irrigated area of 2,500 ha in the region, including the large public reservoirs and the pilot irrigation zones in Morada Nova (Ceará), Bebedouro (Pernambuco) and Mandacaru (Bahia) (Carvalho, 1973).

Studies sponsored by GEIDA identified 62 technically feasible projects in the Northeast. This was used to inform the first stage in the National Irrigation Plan. Concerns about water scarcity in the Northeast also led to the establishment of the PIN in 1970 which determined at the federal level that projects benefiting the Northeast were urgent and should be prioritized (França, 2001).

The guidelines of the I PND (1972) established the goal of 40 thousand ha of irrigated farm land. This was incorporated into the PIN and defined as urgent. The II PND (1974) concluded that Northeastern Brazil had large but poorly managed water resources. This prompted the setting of new goals involving a wide range of agencies, such as SUDENE, DNOCS, the Superintendency of the Development of Vale do São Francisco (SUVALE, now CODEVASF), the Brazilian Agricultural Research Agency (Embrapa), Banco do Nordeste (BNB) and Banco do Brasil (BB) (França, 2001).

The 'Nordeste' project had no strategies for public irrigation. It was prepared for the I PNI in 1982 and followed federal government guidelines for incentives to private enterprise, as shown by the granting of special credit and the allotment of outright grants for infrastructure. When PROFIR was established in 1982, an official rural credit line was opened for investment in irrigation projects which were emerging in some parts of Northeastern Brazil (França, 2001).

PROINE and PRONI, both established in 1986, were run by the *ad hoc* Ministry of Irrigation in partnership with DNOCS, CODEVASF and the National Department of Sanitation (DNOS), with the goal of reaching one million ha of irrigated land by 1990 in the Northeast alone (Albuquerque; Monte; Paula, 2010).

The National Office of Irrigation (SENIR) was created in 1990 under the Ministry of Agriculture and Agrarian Reform and charged with implementing the National Irrigation Program through DNOCS and CODEVASF, since DNOCS had been extinguished at this point (França, 2001).

A few years later, in 1996, the Program for the Emancipation of Irrigated Zones (PROEMA) was established following the guidelines of the National Program for Irrigation and Drainage (PRONID). The main purpose was to provide educational and organizational training for the farmers in the public irrigation zones, with emphasis on the technical and managerial skills required for management transfer (Albuquerque; Monte; Paula, 2010, p.2).

This transfer of management was made possible with the passage of Law #10.204/01. The law determined a 5-year deadline for DNOCS to completely implement PROEMA and permanently transfer ownership from the State to private legal entities or farmer associations (Brasil, 2001).

The goals of PROEMA and PRONID were supported by the PPI in the 4-year period 2004-2007 by creating two new programs: the Irrigated Agriculture Development Program and the Public Irrigation Zone Management Transfer Program (Albuquerque; Monte; Paula, 2010). The criteria of the latter were defined entirely by the State, without taking into account the farmers' undestanding of the situation (MI, 2013), despite the fact that the State declared to consider the emancipation of the irrigation zones a direct expression of the farmers' socioeconomic interests.

DNOCS, under the Ministry of National Integration (MI), had resources allocated as determined by the law, making it possible to meet the goals of PROEMA by 2011. This initiative by the MI required resources to be invested primarily in mid-sized and large irrigation zones, which at the time amounted to twenty-one (Albuquerque; Monte; Paula, 2010).

Surveys conducted by the MI on the management, land ownership status and maintenance of irrigation zones were used to subsidize the Pilot Investment Project. The project focused on 10 of the 21 previously selected irrigation zones with the aim of achieving emancipation by December 2007 (Albuquerque; Monte; Paula, 2010).

Currently, issues related to irrigation policy, emancipation and transfer are governed by Law #12.787/13, which however, according to Albuquerque, Monte and Paula (2010) and Dourado et al (2006), lacks clarity regarding the government's objective with the transfer of management of the public irrigation zones. Figure 1 provides an overview of the government plans and programs described up to this point.

Figure 1: Government plans and programs created between 1969 and 2005 to implement and support irrigated agriculture in the semiarid region of Northeastern Brazil.

Plan or program		Year
PPI	Pluriannual Irrigation Program	1969
PIN	National Integration Program	1970
I PND	First National Plan of Development	1972
	Integrated Plan for the Mitigation of the Consequences of Drought in the Northeast	1973
II PND	Second National Plan of Development	1974
PNI	First National Irrigation Plan	1982
PROVÁRZEAS	National Program for the Rational Use of Irrigable Lowlands	1982
PROFIR	Program for the Financing of Irrigation Equipment	1982
PROINE	Northeast Irrigation Program	1986
PRONI	National Irrigation Program	1986
	Projeto Novo Modelo de Irrigação	1995
PRONID	National Program for Irrigation and Drainage	1996
PROEMA	Program for the Emancipation of Irrigated Zones	1996
	Pilot Investment Project	2005

Source: The authors (2015).

III. Sustainability, Elkington and the Triple Bottom line

Throughout modern history, governments have made efforts to find a balance between the interests of society, the economy and the environment, but the notion of sustainability wasn't popularized until the 1960s (Oliveira, 2015). The earliest movements towards sustainable societies were inspired by influential books, such as "Silent Spring" (Carson, 1962) which documented the environmental harm caused by the indiscriminate use of pesticides. Elkington (2012) centered his work on the ternary of economic prosperity, environmental protection and social equity, but also pointed out the difficulty in drawing clear limits between these dimensions (Oliveira, 2015).

In the 1990s, the notion of sustainable development was expanded beyond the economic-financial realm. The first report of human development provided new and more refined definitions, which enriched the debate worldwide (Veiga, 2006).

These new ideas and insights made society aware of the need for a better understanding and management of the interactions between society, the economy and the environment. According to Elkington (2012, p. 110), the burgeoning global perspective of sustainability required an urgent redefinition of the meaning of concepts like social equity, environmental justice and corporate ethics to better envisage the multiple dimensions of capital, not just the physical and financial aspect, but also social, human and natural capital.

By the end of the 20th century, the World Business Council For Sustainable Development introduced the concept of eco-efficiency, a philosophy concerned with creating more value with less impact. This helped clarify the notion of sustainability and led to further discussions on the possibility of harmonizing financial and social priorities (Elkington, 2012). The result was the so-called triple bottom line model of sustainability proposed by Elkington (2012). In this model, the social component reflects concerns with the impact of business on communities, the environmental component reflects resource use and emissions of pollution, while the economic component reflects economic efficiency (Barbieri et al, 2010, p. 150).

In the delimitation of Elkington's model (1997) the questioning about the possibility of a sustainable capitalism initially arises. Despite the negative response, the author suggests a business movement focused on rethinking strategies, considering that "businesses need stable markets (...) and must have the necessary technological, financial and management skills to overcome the sustainability transition" (ELKINGTON, 2012, p. 52).

This transition would not be able to suppress the search for profit, as the main characteristic of capitalism, however, this search is refined from a transformation of the mission and values of the companies, directing them not only to the valorization of

the three pillars (planet, profit, people), as well as consolidating sustainable and renewable actions in the stages of the trade and production system.

These reflections moved society towards developing teachings that would make possible an interaction between man and society, allied to the economy and the environment, and in this sense "the social dimension reflects the concern with the impacts on communities; the environmental dimension concerns the use of natural resources and the emission of pollutants; the economic dimension refers to economic efficiency" (BARBIERI et al., 2010, p. 150).

The focus on the difficulties generated from the points of intersection between the social, environmental and economic pillars is not capable of functioning as a way of annihilating capitalism in favor of sustainability or vice versa; in fact, a "sustainability crisis" emerges from this impasse, which must be resolved with business movements that invest in labor capable of preserving the planet, and consequently, breaking with the paradigm of only obedience to economic-financial progress , since the concerns turned to sustainability not only brought new perspectives but also a greater refinement of its concept.

With regard to the economic pillar, profit is highlighted here as a point of support for the organization, as well as its operational sustainability, and also in this perspective, the detailing of capital in physical capital, including the machinery that makes up the organization, financial capital and human capital, as "a measure of experience, capacity and other knowledge-based assets of individuals who make the organization move" (ELKINGTON, 2012, p. 112).

The viability of the economic field (profit) demands business action with regard to providing annual reports that traditionally pervade only the financial behavior of the organization; considering the first and second points of intersection between the three pillars, said reports should not only indicate economic movement, but also indicators of natural and social capital, emphasizing that natural capital indicates both what is essential for the balance of the ecosystem, and what has renewable potential; and social capital, in turn, emphasizes the results resulting from the human grouping that integrates the organization.

Environmental issues (planet), which gained greater coverage from the 1970s, raise the third point of intersection, triggering in managers an awareness directed to the standardization of a fit in the classification of "environmentally sustainable company". In this case, organizations that seek the "sustainable" designation must formulate analyzes capable of discriminating the interactions that are taking place between the company and the environment (ELKINGTON, 2012).

Returning to the developments inherent to capital, there is a need for organizations to understand the concept of natural capital so that they can become environmentally sustainable, and in this sense, natural capital is divided into: critical natural capital, representing what is essential to life and ecosystem integrity, and renewable natural capital, that can be renewed (e.g. through seeds or relocation of sensitive ecosystems), reclaimed (environmental alternatives or desert recovery) or substituted (increased use of man-made substitutes such as solar panels in place of limited fossil fuels) (ELKINGTON, 2012, p. 117).

This pillar also emphasizes environmental accounting, forecasting financial indicators through the glimpse of revenue and cost, as well as the delimitation of performance factors capable of strengthening investments aimed at preserving the environment and assessments related to the environmental impacts of organizations.

In the discussion between the economic and environmental pillars, the first point of intersection is represented by the development of eco-efficiency with the production of goods and services "at competitive prices, which satisfy human needs and bring quality of life, and at the same time, reduce the environmental impact to a level at least equal to the sustainability capacity of the resource given by planet Earth" (MACIEL; KHAN; ROCHA, 2018, p. 28).

With regard to the social pillar (people), the concept of human capital is resumed, considering issues such as health, education and skills in a micro sense, and society's health and potential for wealth creation in a macro sense.

Regarding the point of intersection between the environmental and social pillars, the viability of companies focusing on education and training on environmental issues, as well as environmental justice, and intra and intergenerational equity, is highlighted. In short, with regard to the socio-environmental aspect, the characterization of a sustainable company has as a representative of social capital the development of joint work and at all social levels, a movement that strengthens ethical values and overcomes social differences.

Finally, from the intersection between the environmental and social pillars, discussions arise discussions that are constant, but more present in times of crisis, inherent to downsizing, unemployment and business ethics; in other words, organizations enter increasingly delicate scenarios with regard to the relationship with employees, bringing greater energy to the scope of business ethics.

This reflection ratifies the relevance of organizational actions and their impacts on the environment, and the balance between them and social issues assuming the same degree of relevance, concluding that a balanced interaction between companies and the environment would not be possible coexisting with instabilities social.

IV. Methods

This was an exploratory, descriptive and qualitative study, with emphasis on the relevance of social structures and the human phenomena they comprise (Haguette, 1997).

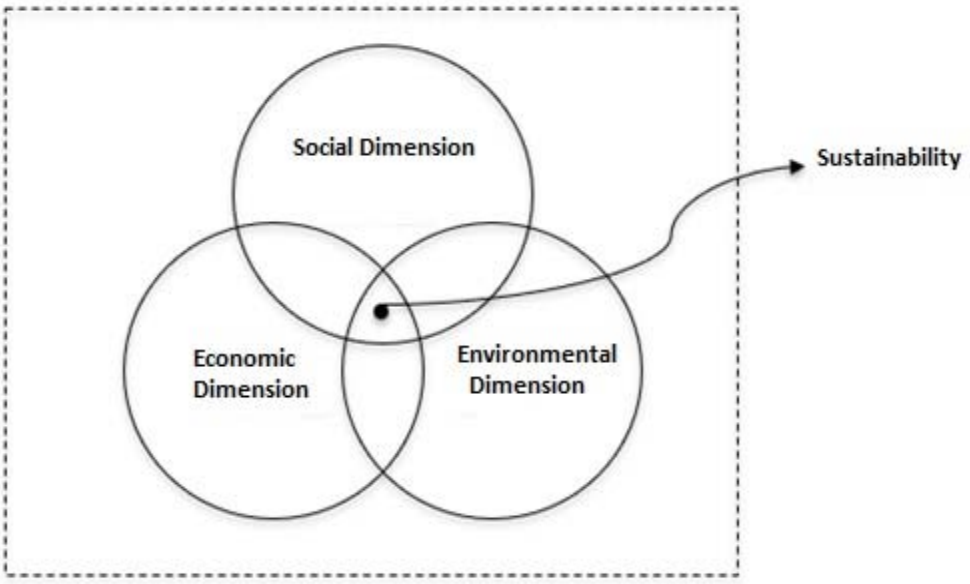
Qualitative research processes descriptive information which cannot be quantified. Thus, the results of the present study cannot be presented statistically or graphically and require subjective interpretation, involving not just emotional perception but also an understanding of the greater context of which the object of study is an unseparable part (Minayo, 2007).

Information was collected through an extensive review of the literature and in person using a semistructured instrument designed to explore the topic in depth by way of qualitative interviews (Bauer; Gaskell, 2017; Minayo, 2007). The instrument featured 8 items focusing mostly on regional improvements (schools and health services), agricultural procedures, impact on local business, job and income generation, and regional money flow.

The 18 respondents were stakeholders of the Jaguaribe-Apodi and Morada Nova irrigation zones at the time of the study (September 2015 to November 2015) and included 5 agricultural technicians from the Producers' Association of the Jaguaribe-Apodi Irrigation Zone (FAPIJA), 2 school directors partnered with the irrigation project, 1 researcher from the Institute of Technological Education (CENTEC), 4 members of a community ('Cabeça Preta') adjacent to the irrigation zone, 4 members from the Morada Nova irrigation zone and 2 residents in the city of Limoeiro, which is near to the irrigation zones. In the sections below, the respondents are identified merely by the letter 'R' and a number from 1 to 18 to protect their privacy.

The respondents were recruited by snowball sampling, a non-probability sampling method in which existing study subjects recruit future subjects from among their acquaintances (Bracarense, 2012). The interviews were recorded in full and submitted to discourse analysis based on the concept of language as mediator between man and the natural and social order (Orlandi, 2010, p. 15).

The framework adopted in the study allowed to analyze the respondents' input according to three dimensions or 'pillars' of sustainability: social, environmental, and economic—also referred to as the 'triple bottom line' (Figure 1).



Source: The authors.

Figure 1: The triple bottom line model of sustainability.

The interview instrument was pretested twice to identify possible deficiencies. Interviewing was discontinued when content saturation was achieved (Minayo, 2007).

V. Results and Discussion

In our analysis, emphasis was given to responses covering all the dimensions of the triple bottom line model: social (reflecting concern with how communities are impacted), environmental (reflecting the use of natural resources and the emission of pollution), and economic (i.e., economic efficiency) (Barbieri et al., 2010, p. 150).

Within the social dimension, the respondents stated that the establishment of the irrigation zone led to improvements in schools and made more skilled labor available for work with irrigated crops and health care services. Approximately six thousand formal jobs were created:

R 12, 2015	"One of the benefits of the irrigation zone was the expansion of the schools. Because of the partnership, the number of regular students increased, as did the number of technical courses in Agronomy." (Jaguaribe-Apodi irrigation zone)
R 4, 2015	"With regard to education, I have only good things to say. Because of the activities in the irrigation zone, CENTEC and IF opened schools in the region, offering courses in Agronomy, Irrigation and Farming". (Jaguaribe-Apodi irrigation zone)
R 5, 2015	"The irrigation zone fostered development in the region. Before the zone was established, my father had crops but only during the rainy season. Then my family received a plot of irrigated land which allows farming all year round. The zone harbors 324 families plus dependents, totaling from five to six thousand jobs." (Jaguaribe-Apodi irrigation zone)
R 13, 2015	"I have lived in the Morada Nova Irrigated Perimeter since I was six years old. I came here in 1976, when the project really started to work. When my family arrived here, we received a piece of land that, according to the DNOCS, measured four hectares. In this space, it was up to us to establish a permanent home and dedicate ourselves to the cultures requested by the DNOCS. My father, my brothers and I were responsible for growing the rice, which had to be harvested and bagged to be delivered to DNOCS every six months in the rendering of accounts." (Morada Nova irrigation zone).
R 14, 2015	These improvements in health and education here were only at the beginning of the project. As time went by, the perimeter was abandoned and today there is no more improvement) in these areas. (Morada Nova irrigation zone)
R 16, 2015	At the beginning of the project everything was wonderful. There was an improvement in health and a lot of training courses were offered, but today you don't see that anymore. This project has been abandoned for some time and the lack of water has made it much worse. (Morada Nova irrigation zone).

In the Jaguaribe-Apodi irrigation zone, the social aspect most consistently addressed by the respondents was job and income generation. This is in harmony with the tenets of Elkington's theory, according to the social pillar (people), which indicaates that the concept of human capital is resumed, considering issues such as health, education and skills in a micro perspective, and society's health and potential for wealth creation in a macro perspective. On the other hand, as pointed out by Oliveira (2015, p. 68), corporate activities impact society through changes related to the safety of products and services, training and education initiatives, allocation of money and time, and income and job creation for disadvantaged groups.

According to Elkington (2012, p. 123), a sustainable organizational complex should consider human capital within the scope of the social pillar, "in the form of health, skills and education, but should also encompass broader measures of health for society and wealth creation potential. By analyzing the data collected in the field, it was possible to diagnose that education, skills and potential for wealth creation are interdependent factors, since their implementation lies in the work improvements offered by technical education organizations, which not only increase the breadth of knowledge of the population involved, but also induce an increase in the practice of modernized agriculture and, consequently, an increase in family income and regional profitability.

In these parameters, it was observed that the social dimension presents constructive references in the irrigazion zone Jaguaribe-Apodi. The Morada Nova irrigation zone presented relevant social developments at the beginning of the project, but they did not last.

Environmental issues (planet), gained greater coverage from the 1970s, calling managers to an awareness directed to the standardization of "environmentally sustainable" spaces. In this case, organizations that seek the "sustainable" designation must be capable of discriminating the interactions that are taking place between the company and the environment (ELKINGTON, 2012).

As for the environmental dimension of sustainability, stakeholders are generally concerned with the abundance and natural diversity which sustain the ecosystem, whether it be fauna or flora, or the atmosphere or soil and water (Oliveira, 2015, p. 65). Our respondents described modifications related to the irrigation zone as harmful to the regional environment. For example, areas destined for environmental preservation were in many cases invaded, deforested and used for agriculture:

R 3, 2015	"The Jaguaribe-Apodi project was very large and its implementation undeniably caused some permanent damage to the regional fauna. I am sure some species were driven out." (Jaguaribe-Apodi irrigation zone)
R 6, 2015	"A negative aspect of the irrigation zone was what happened to the environmental preservation areas, also called green areas. Although DNOCS and the Association set aside these areas for preservation, many farmers invaded them and used them for crops." (Jaguaribe-Apodi irrigation zone)
R 16, 2015	"The project was a very good thing for the population, but we cannot deny that there was aggression. Yes, there was, but it was to improve people's lives". (Morada Nova irrigation zone).
R 14, 2015	"When I arrived here, the project was already finished, but those who have lived here for a long time say that there was a lot of felling of native trees". (Morada Nova irrigation zone).

About the interviews, it is important to point out that the respondents who made up the group of farmers recognize the environmental devastation and the invasion of preservation areas, however, it was noticeable that from the point of view of this social segment, the procedures carried out with the objective of guaranteeing the farmer greater range of work activities cannot be considered as something of a negative nature.

Another negative aspect within the environmental dimension was the obligatory use of agricultural chemicals. According to the respondents, the use of chemicals was supervised daily by a technician who would determine how much should be used for each crop and explain how to use personal protection equipment to prevent direct contact with the chemicals. However, the respondents believed that awareness of the proper use of agricultural chemicals was insufficient and that, as a result, some farmers handled the products inappropriately and were injured:

R 11, 2015	"The only negative aspect of the irrigation zone is the agricultural chemicals. It is necessary to spray the amount of poison that the crop demands. Without chemicals, no production."
R 7, 2015	"The question of agricultural chemicals is still not settled in the irrigation zone. Today we defend proper use of chemicals in moderate amounts and with personal protection equipment, but there are still cases of farmers who are contaminated by direct contact with the poison."

As we have seen, the third bottom line of Elkington's model (2012) is economic efficiency. While financial capital focuses on corporate profit, natural capital reflects the interaction between profit and the environment, and social capital reflects society's potential for collective action by diffusing, implementing and maintaining values like loyalty, honesty and interdependence (Oliveira, 2015).

In the Jaguaribe-Apodi irrigation zone, the observed economic aspects were as positive as the social aspects: All the respondents agreed that the existence of the irrigation zone led to considerably higher individual wages and that local business had benefited from transactions involving produce from the irrigation zone.

However, the respondents from the Morada Nova irrigation zone had a different point of view: the project brought significant changes on its beggining, but the small social and economic aspects that changed for the best, improving the population's quality of life were visible only on the initial phase of the project. The Figure 2 shows a house of the Morada Nova irrigation zone on its original structure, and the figure 3 shows a abandoned warehouse with tractors on the same irrigation zone.

Source: The authors

Figure 2: House on its original structure on the Morada Nova irrigation zone

Source: The authors

Figure 3: Abandoned warehouse with tractors on the Morada Nova irrigation zone

R 8, 2015	"The establishment of the irrigation zone improved the living standard of many people. Much of the unemployment in the region disappeared thanks to job opportunities provided by firms opening branches here." (Jaguaribe-Apodi irrigation zone)
R 9, 2015	"In the irrigation zone, formal employment is decisive for many people's monthly income and I can assure you the production here has been very beneficial for businesses in Limoeiro and other neighboring towns." (Jaguaribe-Apodi irrigation zone)

Sustainable development is essentially a process of change in which exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance current and future potential to meet human needs and aspirations (Brandon, 1999). Two of the dimensions of the triple bottom line model reveal a positive influence of the Jaguaribe-Apodi irrigation zone on the quality of life of local stakeholders: the social dimension and the economic dimension. Nevertheless, when sustainable development is evaluated in light of the triple bottom line, the outcome is compromised by the environmental dimension, especially with regard to the use and handling of agricultural chemicals. This is made clear by the respondents' use of the word 'poison' to describe these products.

R 1, 2015	"The plants need agricultural chemicals. It's impossible not to use them."
R 10, 2015	"The irrigation zone does not harm the environment in any way. All the land here is used only for farming. Nothing is polluted here."
R 1, 2015	"We tried to mitigate the damage caused by agricultural chemicals by providing supervision, starting with the maintenance of protective equipment and the disposal of empty packaging."

An important point that was caught in the interviews was the issue of water in irrigation zones: they make it clear that the fundamental aspect that allows the zones to function continuously is the availability of water resources. This dependency character was also corroborated in interviews with two commercial representatives who work in the city of Limoeiro, close to the irrigation zones:

R 17, 2015	"You must have already seen on the irrigation zone itself that water has an influence on everything. This repercussion is not very different here. The lack of water there has repercussions here as well. As much as the perimeters have taken a leap in trade in Limoeiro and even other municipalities, this development has already had a decline due to water rationing".
R 18, 2015	"Believe me, even tourism here in the region suffered from water rationing. The hotel chain here in Limoeiro is going through a big decline. It's been a while since we received representatives from fruit growing companies, and we also haven't received tourists who always come to visit the waterfalls here in the region."

VI. Final Considerations

The interviews conducted for this study suggest the triple bottom line was not achieved for both the Jaguaribe-Apodi and the Morada Nova irrigation zones when all the dimensions of sustainable development were taken into account. Considering the Jagauribe-Apodi irrigation zone, positive results were observed for the social and economic dimensions, especially with regard to job creation and income expansion, both of which favor social mobility, and with regard to the level of consumption and the perception of well-being.

In the Morada Nova perimeter, the assistance nature of the project was pointed as very relevant at the beginning, and so its results both on social and economic aspects. However, these social and economic aspects cannot be proven, because the project was abandoned.

The input provided by our study reinforces the diffusion of values and ideas underpinning the notion of sustainable development, as the respondents converged towards the view that irrigation projects should be informed by a mindset of environmental responsibility.

The challenge posed by the drought-ridden lands of Northeastern Brazil can be overwhelming for subsistence croppers, leading them to see irrigation projects essentially as emergency measures and therefore as good and sufficient, regardless of deficiencies in the environmental dimension.

Both irrigation zones showed that the environmental aspect related to the improper use of agricultural chemicals, aggravated by inefficient monitoring, suggests the perspective of sustainability was compromised and that triple bottom line sustainability was not achieved in the region. It also points to the emergence of an environmental awareness favoring non-conventional paradigms in which survival hinges on the balance between man and the environment, rather than on simply meeting basic material needs. The study highlights the need for a sustainable approach and for adopting zero-waste growth models with a holistic view of environmental, political and social aspects.

Our study has some limitations. For example, the concept of sustainability is still open to debate and refinement, potentially affecting our conclusion that the irrigation project falied to achieve the triple bottom line proposed by Elkington (2012). To put our findings in perspective, studies using different methodologies or based on different sustainability frameworks should be conducted. Another limitation is the exploratory nature of the study, focusing on a specific context and moment in time, making it difficult to extrapolate our conclusions outside these bounds. Future studies could expand the discussion on the sustainability of irrigation zones by using data triangulation in longitudinal designs.

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An Investigation of the Densification Process of the Residential Areas of Dhaka

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GJHSS-B Classification: LCC: HT169.B5

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An Investigation of the Densification Process of the Residential Areas of Dhaka

Syeda Jafrina Nancy [α] & Roxana Hafiz [σ]

Abstract- Dhaka is one of the most densely populated megacities of the world with demography of over 20 million people. With an annual population growth rate of 4.2% Dhaka is set to face the challenges of habitat crisis, lack of communal facilities, and constant pressure on transportation and infrastructure. In response to the demand of the rapidly growing population and scarcity of developable land, urban consolidation through vertical expansion was carried out without any proper diagnosis of the sites or any contextually appropriate densification policy. The unguided nature of densification not only brought a transformation in the urban landscape but also in the built form itself by infusing the concept of compactness into them. The compactness of multi-storied dwellings is often found to compromise with the livability condition posing questions on residential sustainability. Drawing on three residential areas of varied density, age and, settlement type this paper, therefore attempts to investigate the trend of densification of the densifying residential areas of Dhaka in terms of the spatial quality of the built form its effect on the built environment. Key methods of data collection employed extensive field surveys, observations, measurements, map analysis, satellite imagery analysis, interviews with officials, and block surveys for detailed analysis of FAR, land coverage in plot and block level, height, land use pattern, and other design aspects of the built form. The survey findings were analyzed through descriptive statistical methods including frequency distribution and presented through tables, charts, and cross-analysis charts contributing to a better understanding of the ongoing trend of densification. The findings indicate that the spatial quality of the built environment was largely compromised in terms of inadequate ventilation and solar access, loss of acoustic and visual privacy, obstruction of view, and leftover unusable open spaces. However, the interior dwelling spaces conforming to the acceptable standard is suggestive of a moderate degree of urban consolidation. By investigating how urban densification has transformed the urban fabric and residential environment, the study reveals the unintended consequences of unguided densification in Dhaka.

Keywords: urban densification, built environment, spatial quality, sustainability, floor area ratio, dhaka megacity.

I. Introduction

Densification has become a widely practiced method to decrease urban land consumption through concentrated development. The dense compact city is argued to leverage a range of social, environmental, and economic benefits leading to sustainable development (Haughey, 2005; Jenks & Dempsey, 2005; Owen, 2009; Urban Task 2 C.T. Boyko, R. Cooper/ Progress in Planning 76 (2011) 1–61 Force, 1999, 2005; Williams, Burton, & Jenks, 2000). The compact urban form benefits city dwellers by providing services and amenities within walking distance and thereby reducing the need for automobile traffic, reducing GHG emissions, and saving energy (Williams, 2000; Kamal-Chaoui & Robert, 2009). It also fosters community cohesion through increased social interaction. Other co-benefits of high density are linked with urban vitality and diversity of streets promoting safety and security to its residents (Jacobs, 1961; Sung & Lee, 2015). The growing body of literature indicates density as a fundamental constituent of sustainable urban form but its successful application to attain sustainable development is critical. This is partly due to the complexity inherent to the nature of the phenomenon of density itself. As pointed out by Churchman (2009) density encompasses both objective and subjective attributes. The objective aspect is measurable and is generally measured in two ways: population density and dwelling density. The dwelling density can be expressed through measures like net residential density, gross residential density, floor area ratio, and so forth. Nonetheless, the complexity in quantifying density lies not only in its measuring metrics but also in the concepts of mid, low, and high densities subjected to regional and cultural variations. The subjective aspect of density is the perceived density which is defined as an individual's perception of density in a given area where the perception is shaped by a city's age, history, context, culture, geography, policies, attitudes, and economy (Smith, 1984). However, the negative connotation of density is crowding which is created when the perceived density is experienced as too high.

Densification operations when undertaken by merely increasing the number of dwellings may not always lead to sustainability. Sustainable urban development through densification can be achieved by addressing the qualitative aspect of density embedded in the social and cultural context. The design of higher-density development should focus on improving the quality of life through incorporating culturally responsive quality design, higher land use mix, increased accessibility, and greater connectivity to avoid any unintended outcome. Instead of maximizing density planners should focus on optimizing density to keep proceeding in the trajectory of sustainable development. Densification of residential areas in Dhaka started gaining momentum in the mid-1990s in response to the

Author α: e-mail: nancy1976bd@yahoo.com

growing population due to natural growth and rural-urban migration. According to the World Population Review since independence in 1971, the population of Dhaka grew from 1,523,000 to over 18 million in 2016. The government responded to the housing crisis by densifying the existing residential areas without a proper diagnostic study of the site condition or projection of any future development scenarios. In the absence of any densification policy urban consolidation commenced in two phases: first by the transformation of the low-rise buildings up to six stories followed by the construction of higher buildings in the next phase with the introduction of Floor Area Ratio (FAR). This ongoing trend not only transformed the urban fabric but has brought significant changes in the spatial quality and living environment of the residential areas of Dhaka. This paper, therefore, intends to investigate the spatial quality of the residential built environment of Dhaka at both the building and block levels.

II. Methodology

The study is an explorative research. To investigate the densification process three residential areas i.e., Uttara (Ward No. 1), Dhanmondi (Ward No. 49), and Luxmi Bazaar (Ward No.78) of varied density, age, and street patterns have been selected as study areas from the inner old city core, middle and peripheral locations of Dhaka. Ward is the smallest municipal administrative unit of Dhaka city under the jurisdiction of the City Corporation. The older settlement of Luxmi Bazaar represents one of the highest densities while the relatively newer residential areas of Dhanmondi and Uttara have medium and low density. The density of the residential areas was taken from the gross density profile of DAP 2010. For a detailed examination of the building densification process, four blocks from each study ward were selected. But as the old residential area of Luxmi Bazaar is characterized by an organically developed street network the physical boundary of any block was difficult to demarcate. Therefore, instead of blocks three lanes with plots flanking on both sides were selected (as shown in Fig 1, 2, & 3) to conduct the detailed studies. Fieldwork employed block survey documenting the design characteristics of the built forms in terms of Floor Area Ratio (FAR), land coverage at plot and block level, height, building form, and height, land use pattern, and net residential and population density at block level, provision of natural ventilation, daylight and view, spatial quality of the residential environment. Land coverage values at plot and block levels are calculated from building footprints and land boundaries of individual plots and block boundaries respectively. The trend of densification in the study blocks were studied through analyzing the satellite imagery. Sketches and photographic registration enhanced the qualitative insights. Interviews with government officials provided information on the building by-laws and area redevelopment scheme. Secondary data includes maps, land use plans, and government records collected from Dhaka North City Corporation and Dhaka South City Corporation, as well as newspaper articles, journals, and relevant published literature. Analysis was carried out through simple descriptive statistics tools (frequency distribution) to assemble or reconstruct the data in a meaningful and comprehensive manner and was presented in the form of tables, charts, graphs, etc. contributing to a better understanding of the trend of densification taking place in the residential areas.

Fig. 1: Location of study blocks, Uttara

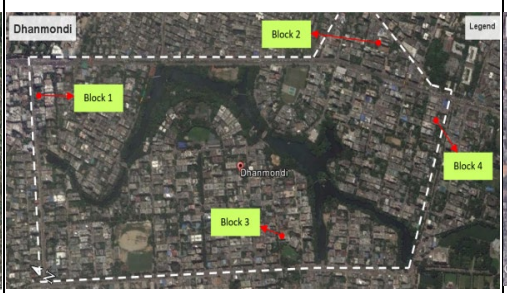


Fig. 2: Location of study blocks, Dhanmondi

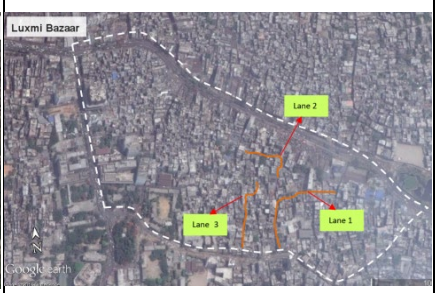


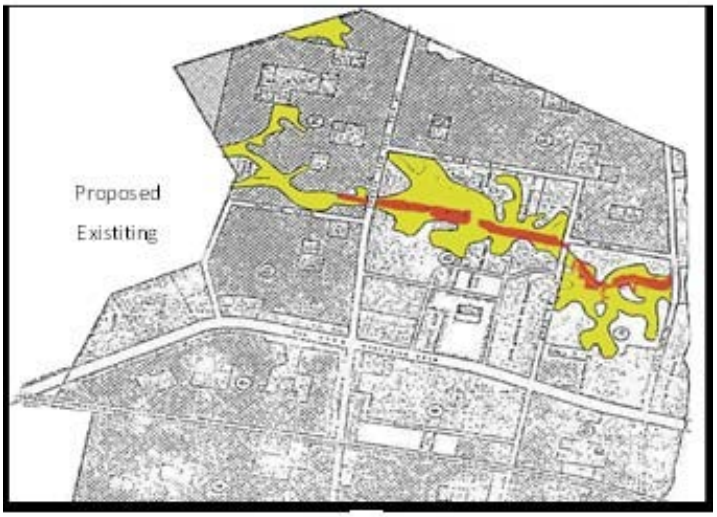
Fig. 3: Location of study lanes, Luxmi Bazaar

a) Uttara Residential Model Town (Ward No. 01)

i. *Land use Pattern and Building Guidelines for Uttara*

Uttara was planned as a satellite town with the aim of decongesting the inner city and provides accommodation for the low and middle-income group. In 1965 Dhaka Improvement Trust (DIT) acquired 2344 acres of flood free high land at the northern periphery of Dhaka along the major north south corridor (*Dhaka-Mymensingh Road)*. In the original plan around 53% of the land area was assigned for residential accommodation and 47% for civic administration, light industries and recreation, playfields. But later more residential plots were added at the expense of the existing open spaces due to political intervention.

Despite Open Spaces and Wetland Protection Act 2000, much of the Uttara lakeside open spaces were converted to residential use in the process while open spaces of sector 1 was sold to developers by Capital Development Authority (RAJUK) (Nilufar, 2013). Consequently, the original number of plots were subdivided into 4302 serviced plots and distributed in 5, 7.5, 4 and 3.25 *kathas* (1 *katha* = 720 sq.ft.) to upper middle income govt. officials instead of the initially intended low-income class. Uttara originally had 14 sectors distributed on both sides of the thoroughfare. Later expansion took place on the far west with new sectors (Uttara Residential Area (3rd Phase). The grid iron street pattern has divided the western part of Uttara into rectilinear blocks with more than 44 plots per block arranged in two rows. However, the oblong blocks of eastern part has relatively larger plots. In response to the growing demand the initial narrow commercial strip on the primary road was later expanded by assigning the commercial land use in the road front blocks on both side of *Dhaka-Mymensingh Road*. In addition, the plots along the secondary roads of *Jashimuddin Avenue* and *Sonargaon Janapath* were later assigned for commercial ribbon development. Though the commercial activities on the secondary road of *Ravindra Sharani* are intensifying it is still not declared as commercial zone.



Source: DCC, 1990

Fig. 4: The encroach ent of water body, Uttara

Source: Field Survey, 2016

Figure 5: Land use map of Uttara

ii. *Changing landscape of building heights in Uttara*

Most of the allotters belonged to the affluent class, government officials and offshore residents who had kept their allotted land vacant for over a decade for land speculation and construction of post-retirement homes. As a result, more than half of the plots remained vacant till the late 1970s. During that time the density of Uttar was very low. Only the sectors 1 to 9 were inhabited with dispersedly located tin shade row houses and single-story houses. With the completion of road network and access to utility services by 1984-85 the construction of 2 storied buildings exacerbated in all the sectors. However, up until the end of the 1980s the area was still sparsely inhabited and predominated with 1-2 story houses. Higher building construction activity initiated from the 1990s by real estate developers with profit maximizing agenda. The plot owners opted to construct multi-storied buildings in collaboration with private developers for monetary benefits. Although the height restriction of civil aviation authority did not allow buildings above 6 story the emergence of this trend diminished the construction of single and two storied buildings and by 2001 about 67% of the vacant plots were occupied with 6 storied buildings. A second wave of transformation started from the onset of 2014 with the promulgation of Building Construction Rule (MINB2008) that eliminated the height restriction with the introduction of FAR. This rule stimulated rapid redevelopment activity with taller buildings reaching up to 12 to 14 stories, mostly in the vacant plots and in plots adjacent to the secondary roads both permitted and unpermitted for commercial activities. This development trend contributes to a generation of isolated vertical habitats (7-14 storied) developed amidst clusters of low-rise and 5-6 storied buildings in Uttara (Table 1).

Figure 6: Emerging high rise commercial buildings along the secondary street of Uttara

Figure 7: Jagged skyline of Uttara

Table 1: Trend of building height change in Uttara (2004 – 2016)

No. of Stories	Block 1			Block 2			Block 3			Block 4		
	2004	2010	2016	2004	2010	2016	2004	2010	2016	2004	2010	2016
1	1	2	3	4	2	2	-	-	-	-	-	4
2	1	2	2	3	4	2	2	2	2	-	-	-
3	3	3	2	2	3	3	-	-	-	1	1	1
4	-	1	1	1	2	1	1	1	1	-	-	1
5	2	2	2	2	4	4	1	1	1	-	3	4
6	5	5	5	2	2	2	7	8	16	-	5	20
7	-	-	2	-	-	-	-	5	9	-	4	9
8	-	-	-	-	-	1	-	3	3	-	1	1
9and above	-	-	1	-	1	4	-	-	2	-	1	1
Total	12	15	18	14	18	19	11	20	34	1	15	41

Source: Field survey August 2016 and satellite imagery
Note: Total No. of Plots in Block 1 = 18, Block 2 = 20, Block 3 = 44, and Block 4 = 54

In the four blocks where detailed studies were conducted, the number of 6 and above 6 story houses were 5, 2,7 and 0 in Block 1, 2, 3 and 4 respectively in 2004 which turned to 5,3,16 and 11 in 2010 and 8, 7, 30 and 31 in 2016. The vacant plots of the study blocks gradually started filling up from 2004 while the low-rise houses were replaced by 6 and above 6 storied buildings (Table 1). However, the vacant plots of peripheral blocks like Block 4 is subjected to construction of high rise buildings from 2010 and onwards. Overall, the number of vacant plots ranges from 1-13 in about 18% blocks of Uttara at present. The large number of vacancies in the peripheral blocks until 2008 indicates that densification started relatively at a later phase in Uttara i.e. after 2014.

iii. *Floor Area Ratio (FAR)*

The maximum floor area ratio for older buildings observed in Block 1, 2, 3, 4 ranges from 0.3 to 5.6 while in Block 3 the highest FAR observed for new buildings was 9. The approved ratio of older buildings ranges from 4.2- 4.8. This indicates violation of the allowable limit set by the Building Construction Rules 1996 (BCR). On the other hand, the newly constructed buildings have a floor area ratio ranging in between 4.8 to 5.9 which shows a slight deviation from the permissible range of MINB 2008. Out of 112 surveyed in Uttara 55 mid- and high-rise buildings are built according to the new FAR rule, where 6 are commercial and the rest are residential buildings.

Table 2: Floor Area Ratio of Blocks 1, 2, 3 and 4 Uttara (2016)

FAR	Block 1	Block 2	Block 3	Block 4
0.1 – 0.5	-	1	-	4
0.5 – 1.0	2	-	-	-
1.0 – 1.5	1	3	-	-
1.5 – 2.0	2	1	-	-
2.0 – 2.5	1	2	-	1
2.5 – 3.0	-	2	-	-
3.0 – 3.5	1	-	1	-
3.5 – 4.0	2	3	-	1
4.0 – 4.5	-	1	4	13
4.5 – 5.0	5	-	6	17
5.0 –5.5	1	1	11	-
5.5 – 6.0	2	1	8	4
6.0 – 6.5	1	-	4	-
6.5 – 7.0	-	1	1	-
7.0 – 7.5	-	1	-	-
7.5 – 8.0	-	-	-	-
8.0 – 8.5	-	1	-	-
8.5 – 9.0	-	1	-	-
Total	18	19	35	40

Source: Author's calculation; Field survey January 2016

iv. *Plot coverage*

Field work results from Uttara indicate that most of the plots with 6 storied buildings had higher plot coverage of 75%-80% which is above the recommended setback of BCR 1996. While the recommended maximum ground coverage was 70 percent, field observations showed that out of 112 surveyed plots, 27 of the older buildings had 81 to 90 %, 47 new buildings had 71- 80% percent and the rest had 61 to 70 percent coverage. In general, the plot coverage of 40% of the surveyed buildings are beyond the recommended limit of BCR 1996 and MINB 2008. The high coverage is mostly evident in 60% of plots where buildings were constructed before the introduction of FAR. Even 10% of the buildings currently undergoing construction are still following the former setback rule as their plan had been approved before the promulgation of MINB 2008. According to the guidelines construction work should commence within 3 years of plan approval otherwise new approval is required. But the delayed construction of these earlier approved buildings indicates another violation of the law.

Table 3: Plot coverage in Uttara

Plot coverage (%)	Number of Plots	Percentage
50 or less	3	2.61
51-60	6	4.21
61-70	32	27.8
71-80	47	40.8
81-90	27	23.4
91-100	-	-
Total	112	100.0

Source: Field Survey, 2016

v. *Ground Coverage at block level*

Overall, the blocks of Uttara show a modest ground coverage because some blocks still have a few numbers of single and double storied dwellings with less footprint while a significant number of plots in many blocks are still vacant which reduces the overall land coverage at block level. However, blocks with greater number of mid-rise buildings (e.g., Blocks 1&2) have a block coverage of around 76% as the mid-rise buildings have plot coverage of 80% which is beyond the set limit of 70% according to BCR 1996.

Table 4: Land coverage at block level in Uttara

Block	Total area (sq.ft)	Total built up area (sq.ft.)	Land coverage per block (%)	Average Block coverage
1	79200	60480	76.3	67.9%
2	36000	27360	76	
3	126360	77922	61.6	
4	64800	48060	57.8	

Source: Field Survey, 2016

Block 2 has a greater number of commercial and mixed-use buildings (10 out of 19) as it is located along *Ravindra Sharani* Road. Most of the older mid- and high-rise buildings have a plot coverage (90%) exceeding the ratios recommended in the former setback rule of 1996. The zoning ordinance along the secondary street of *Ravindra Sharani* is not permitted for commercial use yet. But due to the paucity of designated commercial plots in the Master Plan, many of the influential plot owners had acquired the permit of converting their residential plot to commercial use on basis of public demand or through exerting political influence on the local authority. The findings indicate a flexibility and non-compliance in adherence of the Master Plan and BCR rules by the developers and plot owners. However, Block 2 has one of the lowest net residential densities (97 units/ hectare) due to the increased number of commercial and mixed-use buildings.

Figure 8: Dark alley between buildings

Table 5: Net Residential Density and Net Residential Population Density at block level in Uttara

Uttara		
Block	Net Residential Density (NRD) units/hectare	Net Residential Population Density (NRPD) persons /hectare
1	201	886
2	97	850
3	135	767
4	316	982

Source: Field Survey, 2016

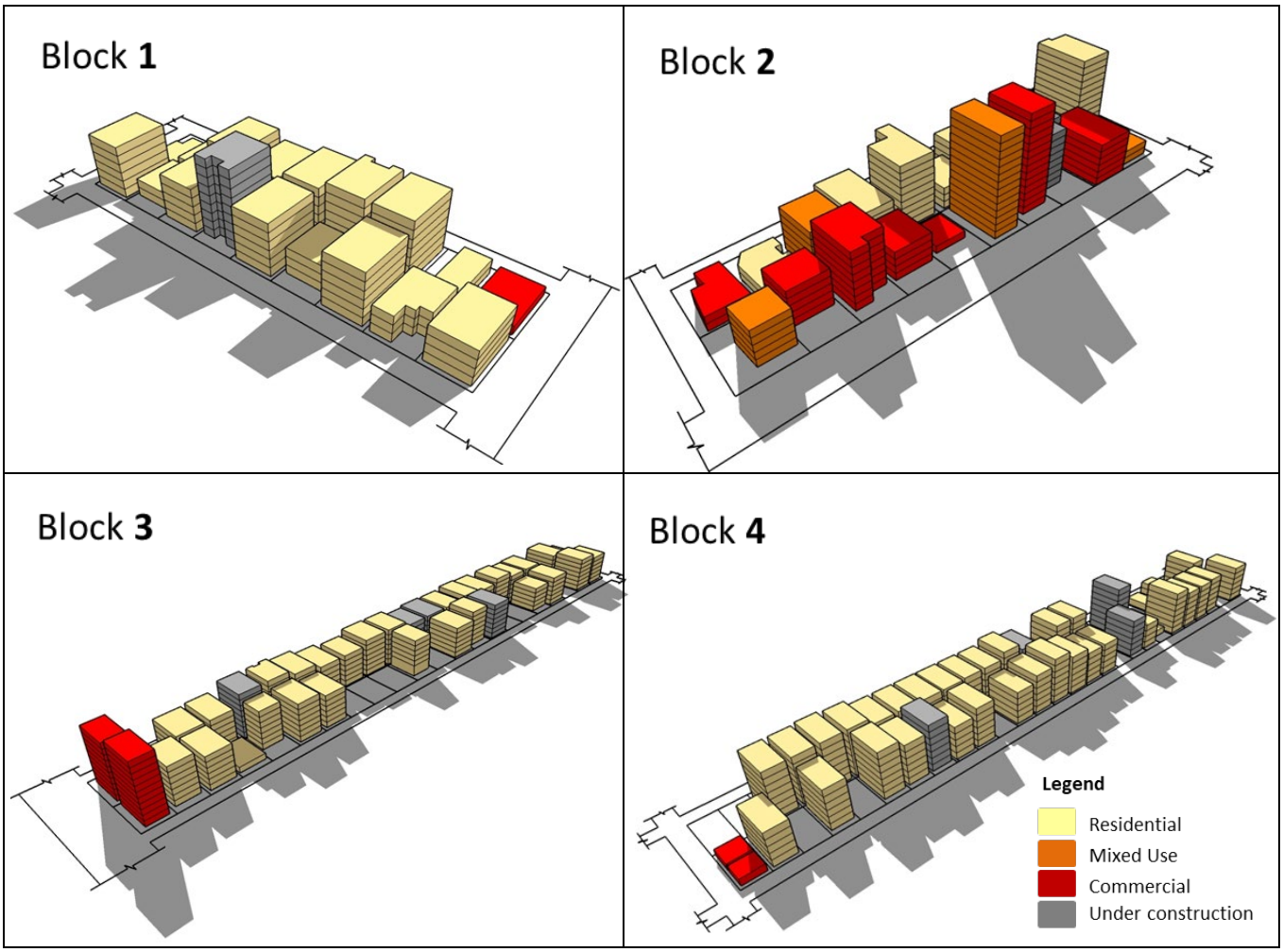
In Block 3 out of 44 plots (6 *kathas*) 22 plots are occupied with 6-7 storied buildings, 12 plots have buildings of older construction while 9 plots are still vacant. The plot coverage is around 65%-70% in the MINB 2008 abiding buildings and a highest of 80% - 90% in the older buildings exceeding the prescribed level. The peripheral Block 4 of Sector 12 has 54 plots with 13 vacant plots and is occupied by 6-7 storied residential buildings forming a continuous skyline. Around 97% of the buildings have two units per floor making the net residential density relatively higher i.e., 316 units per hectare than the other study blocks. The buildings cast shadow on the adjacent access roads and causing dark alleys even in the afternoon. The plots are the smallest (3.25 *kathas* or 2340 sq.ft.) available in Uttara and permissible of higher plot coverage around 80% according to FAR. Since high-rise buildings above 7 stories are not feasible for smaller lots the buildings are of 6-7 storied with plot coverage of 70%-80%. Six plots have a maximum coverage ranging from 83% to 85% which is a violation of the law. Only 14 buildings out of 41 complied with MINB 2008 properly while others slightly violated by raising the height of the front porch and guard room. In addition, the dark narrow setback space between the buildings cannot provide any meaningful use. Much of the development activity in this block started after 2011 for its peripheral location and for the late completion of the secondary road of *Sonargaon Janapath.* Overall, the linear plot configuration of the elongated blocks as well as the close juxtaposition of similar height buildings does not offer adequate provision for solar access, airflow and privacy contributing to a cramped situation.

Figure 9: Block 1, Uttara

Figure 10: Block 2, Uttara

Figure 11: Block 3, Uttara

Figure 12: Block 4, Uttara



Source: Field Survey, 2016

Figure 13: Shadowing of the blocks and adjacent roads, Uttara

vi. *Spatial growth pattern in Uttara*

The emerging spatial growth pattern of Uttara depicts that the residential area is heading towards a compact settlement pattern with varying height, size, and plot coverage. Around 10% of plots are still vacant and another 10%-15% with 1-2 storied dwellings. The similar height buildings juxtaposed to each other is resulting in poor spatial qualities of the indoor living environment in most of the blocks. The problem is further intensified in the longer blocks having more than 20 plots in a row. This type of block layout reduces the plot frontage likely to create cramped development. Since development is taking place plot by plot basis two types of skylines seems to be emerging where blocks along the primary roadside are forming an informally broken skyline pierced by 10-14 storied towers at irregular intervals and the inner blocks having a uniform skyline formed by rows of 6-7 storied residential buildings. Overall, such a spatial development pattern causes jagged skyline. In addition, the tower blocks are casting shadow on the adjacent buildings and streets creating dark corridors and hampering privacy of the adjacent low and mid-rise buildings. Densification is still in its infancy stage in the sector 5, 10, 12 and 14 but in the rest of the 11 sectors it had reached the 'optimum stage' for the proliferation of commercial activities acting as catalyst to the densification process.

Figure 14: Closely juxtaposed buildings forming uniform skyline.

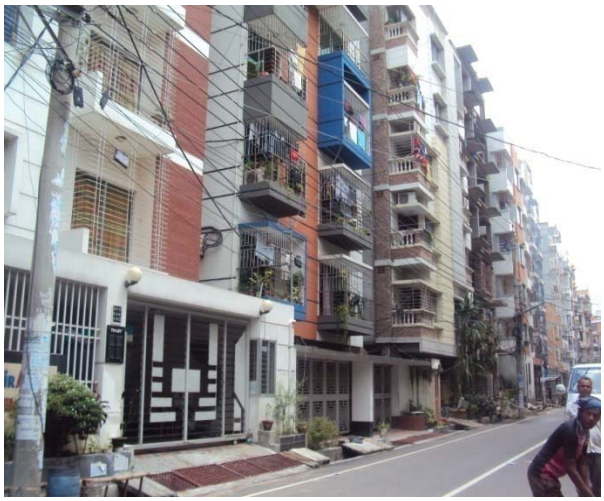


Figure 15: Mandatory open space is covered with roof of the extended porticos.

b) Dhanmondi Residential Area (Ward No. 49)

i. *Land Use and Building Guidelines for Dhanmondi*

Public Works Department (PWD) prepared the Master Plan of Dhanmondi Residential Area with 1000 plots (15–33 decimals) and buildings of not more than 3 stories. DIT acquired the land in 1950 along the north south corridor of *Mirpur Road* for the accommodation of government officials. The allotted serviced plots were of 5,8,10 and 20 *katha*s (14400 sq.ft.). Starting from the 1970s single story residences accommodating high profile political leaders and ministers, embassies started to emerge, establishing the area as a diplomatic zone. By that time Dhanmondi could be characterized as a low-density settlement predominated by evenly dispersed single storied dwellings. The only multi storied building was the 3 storied Polish Embassy during this period. Other than the residential use 9.2% of the entire area was designated for open space and playground, 9.2% for water body, 0.9% for mosque and 0.9% for school making it a posh picturesque neighborhood. Dhanmondi Boys High School was the only school in the area. Commercial land use was restricted ensuring security of the diplomatic zone. President Ata-ur-Rahman first flouted the law in 1985 by building the Garden Market in Dhanmondi on Road no. 7 altering the rule by sanctioning 20 feet depth from the road front for commercial uses (Ahmed et.al, 2009). This encouraged the construction of more commercial establishments in the area. From 1985 onwards commercial activities of varied scale and type started to develop in Dhanmondi in a haphazard manner. These include retail shops, small groceries, Chinese restaurants etc. The diplomatic status of the area contributed to a price hike in the land value of Dhanmondi. The accessibility and connectivity of Dhanmondi being along a major transport corridor was favorable for further development activities but the high land price was holding back the middle class from investing till the late-1980s. Therefore, considering the development potential and its locational advantage, the diplomatic zone was moved to a peripheral location by the 1990s. This decision rapidly transformed the spatial landscape of Dhanmondi with a construction boom of 6 storied buildings in the following decade owing to the decrease in land value and developers' involvement in the housing sector encouraged by the neo-liberal policy model of the government. In absence of a redevelopment framework, the zoning, height ceiling was determined by using Government Notices, Orders and Circulars issued by the PWD and Ministry of Housing and Public Works during the period of 1995 to 1996. The bye law for subdivision of the plots laid out for Dhanmondi further accelerated the construction of 6 storied buildings. As the government does not allow subdivision of plots below 5*katha* (335 sq.m.) the second and third generation landowners of Dhanmondi had to either sell or construct multi-storied buildings with apartments distributed among the beneficiaries. In addition, the current landowners (successors of the original owner), who are economically obsolete find agreement with the developers to be an easy solution for redevelopment (Afrin et al., 2012). The PWD Circular of 1st May 1996 allowed commercial activities compatible to neighborhood scale on all the plots on both sides of *Mirpur Road, Satmasjid Road* and *Road No. 16(old 27)* with 15% "Conversion Fee". The establishment of modern shopping malls and hospitals like *Rapa Plaza* and *Ganoshasto Bhaban* further drove the development of commercial activities along *Mirpur Road.* The height limitation of 6 stories with no restriction on the number of flats was allowed according to the decision taken by the Jahiruddin Committee in 1996 and notified through a circular. Consequently, the overall density increased 3-fold times than the initial density with higher density gradients towards the primary roads. The proportion of single-story houses diminished to 42% and further down to 65% in 2000 and 2004 respectively

(Author's calculation from satellite imagery). In response to the growing demand and weak enforcement of guidelines the commercial activities of varied scale and nature started infiltrating into the inner blocks illegally. This type of commercial invasion started degrading the neighborhood livability by generating traffic concentrations. In 2008 with the introduction of FAR and elimination of height restriction further increased the density. Another phase of transformation is currently underway where the 6 storied buildings are increasingly being replaced by 12 to 14 storied mixed-use towers.

Table 6: Land Use of Dhanmondi Residential Area

Land Use	Area (acre)	Area (%)
Total residential area (plot)	298.3	61.4
Roads	89.6	18.4
Water body	44.6	9.2
Park and playground	44.7	9.2
Mosque	4.7	0.9
School (public and provided in the original plan)	4.4	0.9
Total Area	485.9	100

Source: Public Works Department, 1958

Source: DSCC, 2011

Figure 16: Land Use Map of Dhanmondi

ii. *Changing landscape of building height in Dhanmondi*

During the 1970s the posh residential area was predominantly a low-rise low-density settlement surrounded by green spaces and water body. Most of the plots had 1-2 storied house form with ample space in the front and backyard for gardening. The pattern started changing from late the 1980s and rapid transformation took place in the following one and half decades forming a matrix of 6 storied buildings in the regular blocks formed by the grid iron pattern road network. From 2008 the uniform continuous skyline of 6-storied buildings started breaking haphazardly with 12 to 14 storied isolated towers of mixed use and commercial functions particularly along the primary and secondary roads of the area. Similar trend also emerged on the access roads (18-24 feet) of some inner blocks.

Figure 17: Dhanmondi

Table 7: Trend of building height change in Dhanmondi (2004 – 2016)

No. of Stories	Block 1			Block 2			Block 3			Block 4		
	2004	2010	2016	2004	2010	2016	2004	2010	2016	2004	2010	2016
1	10	5	6	-	-	-	5	2	1	5	4	4
2	4	8	3	1	2	2	4	2	2	6	4	3
3	3	2	2	1	1	3	2	4	1	3	1	1
4	-	-	-	1	1	-	1	1	2	1	1	1
5	-	-	-	1	1	1	-	-	1	4	4	4
6	4	4	6	1	9	11	5	6	6	6	10	11
7	1	1	1	-	-	-	-	1	1	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	1
9and above	-	4	6	-	-	1	-	1	5	-	2	4
Total	22	24	24	6	8	18	17	17	19	25	24	29

Source: Field survey January 2016 and satellite imagery
Note: Total No. of Plots in Block 1 =18(initial) and 24(present) 24, Block 2 = 9 (initial) and 18(present), Block 3 = 12(initial) and 19(present), and Block 4 =17 (initial) and 29 (present)

iii. *Floor Area Ratio (FAR)*

The Floor Area Ratio (FAR) was found ranging from 2.50 to 6.25 in the surveyed blocks. For plot area above 5-6 *katha* the recommended maximum Floor Area Ratio for residential buildings is 3.75 and 3.50 for residential cum commercial uses according to MINB 2008. And for larger plots (Above 9-10 *katha*) the maximum recommended FAR is 4.00 and 6.00 for residential and commercial buildings respectively. One 6 storied building on the corner plot of Block 3 had a Floor Area Ratio of 6.3. Though the building is constructed before 2008 but still the higher horizontal expansion is a violation of the allowable setback of BCR1996. Further observations in the areas zoned for mixed land use revealed an average Floor Area Ratio that ranged between 4.8 to 9.1 in the newly constructed buildings indicating the lack of monitoring to ensure the compliance of the recommended FAR (Table 4.14). Out of 95 buildings surveyed, 14 are recent construction.

Table 8: Floor Area Ratio in of Blocks 1, 2, 3 and 4 Dhanmondi

FAR	Block 1	Block 2	Block 3	Block 4
0.1 – 0.5	7	-	1	1
0.5 – 1.0	3	1	1	3
1.0 – 1.5	3	2	1	3
1.5 – 2.0	-	1	-	3
2.0 – 2.5	-	4	1	1
2.5 – 3.0	-	-	1	-
3.0 – 3.5	-	2	2	2
3.5 – 4.0	-	3	1	1
4.0 – 4.5	1	-	1	1

4.5 – 5.0	3	5	5	4
5.0 –5.5	1	-	-	5
5.5 – 6.0	-	-	1	-
6.0 – 6.5	-	2	1	1
6.5 – 7.0	1	-	1	-
7.0 – 7.5	2	-	-	1
7.5 – 8.0	2	-	1	-
8.0 – 8.5	2	-	1	-
8.5 – 9.0	-	1	1	-
9.0 – 9.5	-	-	-	3
Total	25	21	20	29

Source: Author's calculation, Field survey January 2016

iv. *Plot coverage*

Results from field observation revealed that around 52.4% of the plots have plot coverage ranging between 71- 90% while 17.9% plots with low rise dwellings have modest coverage of less than 50% to 60%. The new buildings maintained the mandatory open space with 25% soak able ground. Only a few plots with buildings constructed before 2007 had higher coverage ranging from 91 to 100 percent. This indicates the tendency of the landowners and developers to illegally extend the plot coverage driven by profit maximization agenda.

Table 9: Plot coverage in Dhanmondi

Plot coverage (%)	Number of Plots	Percentage
50 or less	7	11.4
51-60	4	6.5
61-70	16	26.2
71-80	18	29.5
81-90	14	22.9
91-100	2	3.27
Total	61	100

Source: Field Survey, 2016

v. *Ground Coverage at block level*

Blocks 1 and 2 indicates modest ground coverage of about 65.2 and 63 percent respectively. However, the average block coverage is found to be 72.6%. This is partly due to the significant number of the remaining 1-2 storied dwellings and the new high-rise buildings following the MINB 2008 properly.

Table 10: Land coverage at block level in Dhanmondi

Block	Total area (sq.ft)	Total built up area (sq.ft.)	Land coverage per block (%)	Average Block coverage
1	792000	516600	65.2	72.6%
2	115200	55080	63	
3	184400	158760	86.1	
4	230400	175840	76.3	

Source: Field Survey, 2016

Block 1 provides a glimpse of the changing trend in terms of building function. This block had initially 18 plots (20 *kathas*) which were later sub divided into 24 plots. As being located along the secondary road (Road No. 27old/16new) Block 1 had been rezoned for commercial land use in 1996 through government circular and about 54.5% of its buildings had been transformed from residential to mixed uses since then. Out of 24 plots 14 plots are occupied with high and mid-rise while the rest have 1-2 storied dwellings. The high-rise commercial buildings overlooking the adjacent low-rise buildings intrude on the privacy of these dwellings. Most of the new high-rise buildings comply with FAR rules by having a plot coverage ranging from 60 to 70 percent while the older constructions had violated the BCR 1996 rules.

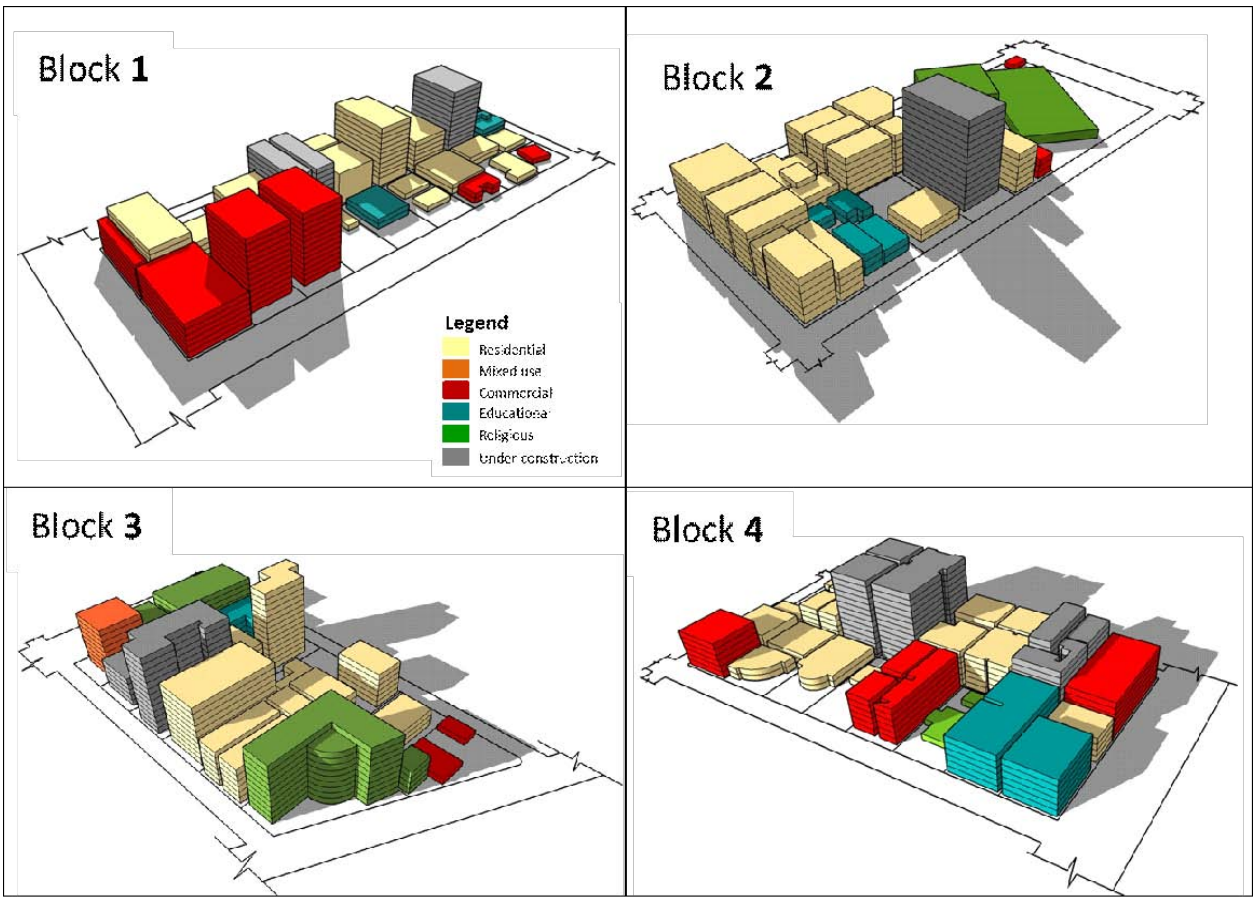
In Block 2 the original nine (20 *kathas*) plots have sub divided into 18 plots. Out of 18 plots 15 are occupied with mid- and high-rise buildings, and the rest of the 3 plots with low rise buildings. In terms of plot coverage Block 2 indicates a pattern with a highest 78%-80% which is causing encroachment of privacy and blockage of ventilation and sunlight in the interior rooms. The block has a 4 storied school, karate training center and a heritage site (*Shahi Eid Gah* and 6 storied mosque). The school is housed in a residential building

and is not permissible land use here. The access roads around this block are 18-20 feet wide, which is sufficient for the traffic caused by the school during peak hours. Furthermore, a significant portion of the effective of width of the access roads around the school serves as parking spaces for the school buses which even worsens the situation.

Table 11: Net Residential Density and Net Residential Population Density at block level in Dhanmondi

Block	Net Residential Density (NRD) units /hectare	Net Residential Population Density (NRPD) persons /hectare
1	72	331
2	100	924
3	164	757
4	165	763

Source: Field Survey, 2016



Source: Field Survey, 2016

Figure 18: Shadowing of the buildings and the adjacent roads, Dhanmondi

Block 3 is located in between the primary (*Mirpur Road*) and secondary road (*Green Road*). The block had 12 blocks initially, but later subdivision resulted into a total of 19 plots. Out of the 19 plots, 8 plots have land coverage between 80 to 90 percent housing 4 to 10 storied buildings. The other 3 plots are undergoing the construction of 10-13 storied high-rise buildings complying with MINB 2008 while the older buildings did not adhere to the setback rules of BCR1996 with a land coverage ranging between 80 to 90 percent. Block 4 has one of the highest levels of densification with 80% of its plots occupied with 4-13 storied buildings. In terms of land coverage Block 4 indicates 76.3% with individual plot coverage ranging between 30-85%. Out of 29 plots 13 earlier constructed 4-6 storied buildings have higher plot coverage around 85% and 4 of the newly constructed buildings have plot coverage ranging from 68% to 75%. This indicates a violation of both old and new law. The subsequent subdivision had created three rows of buildings in 30%

of the plots. As this block faces Road No. 2 and *Mirpur Road* along which commercial land use is permitted several commercial buildings occupy the road facing plots. But on the rear side the block faces a university housed in a 5 storied residential building which is incompatible with residential area. The block is predominated by 5-6 storied buildings with three newly constructed 14 storied residential apartments in the middle. These towers have followed the recommended FAR leaving ample setback spaces around. But still these high-rise towers are overshadowing the nearby road and adjacent houses which results in lack of sunlight and privacy in the adjacent buildings.

Figure 19: Requisite side setbacks maintained according to FAR between newly built high rise buildings blocks, Block-4, Dhanmondi

Figure 20: Block 1; Dhanmondi

Figure 21: Block 2; Dhanmondi

Figure 22: Block 3; Dhanmondi

Figure 23: Block 4; Dhanmondi

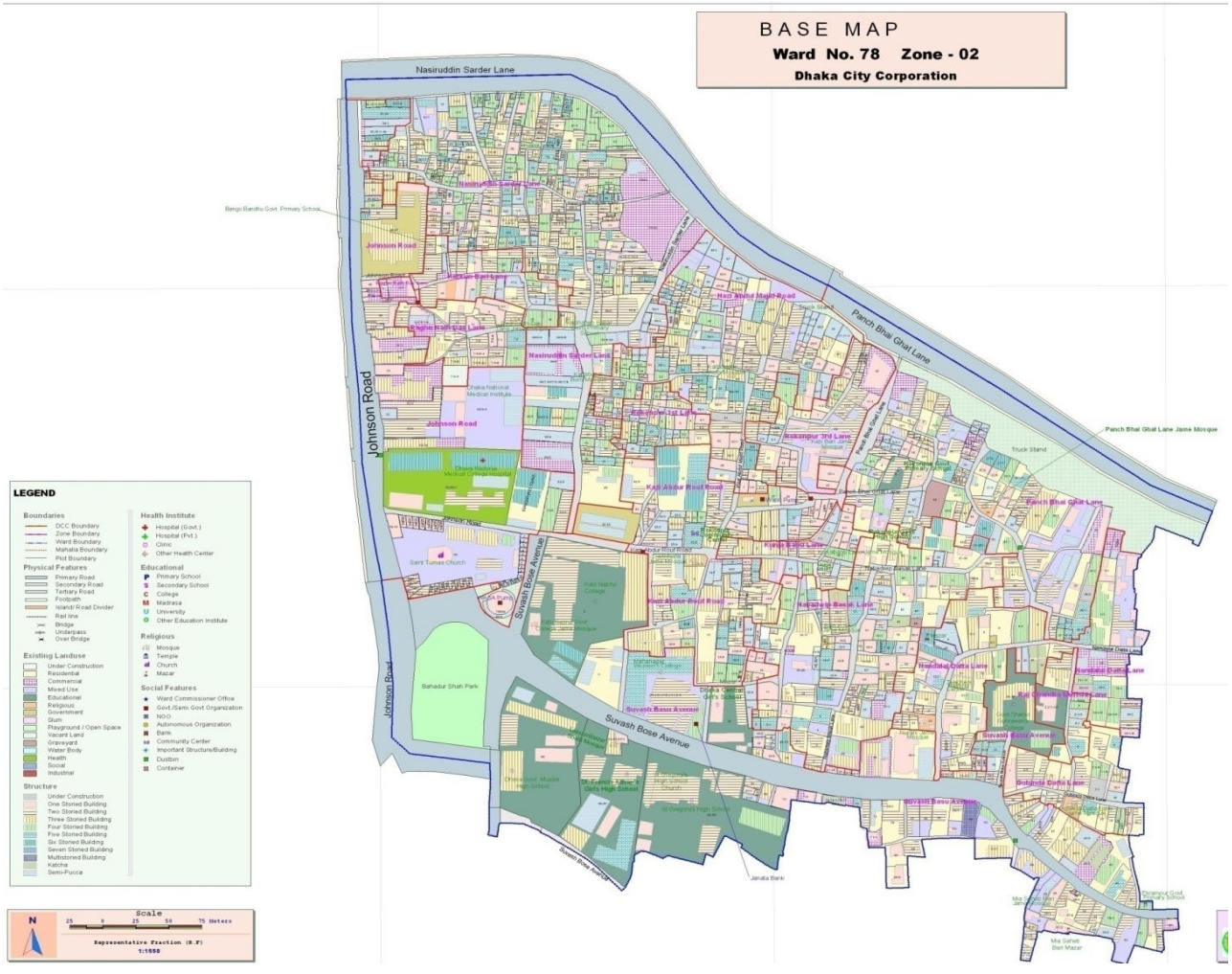
vi. *Spatial growth pattern in Dhanmondi*

The emerging spatial growth pattern in Dhanmondi depicts a compact form of settlement with uniform height pierced by a continuous belt of high-rise towers creating a buffer zone between the major transport arteries and the inner residential blocks. The trend of vertical expansion with mixed land use is relatively faster in the peripheral blocks along the primary (*Mirpur Road*) and secondary roads (*Satmasjid Road*, Road No. 27 and Road No. 2) than the inner blocks. Most of the commercial activities accommodated in these towers are not compatible with neighborhood scale. The weak enforcement of the law is leading to the illegal infiltration of commercial activities across the residential area causing negative externalities like increased traffic concentration, air, and noise pollution particularly intense at the peak hours.

c) Luxmi Bazaar Residential Area (Ward No. 78)

i. *Land use and Building Guidelines for Luxmi Bazaar*

Luxmi Bazaar of Ward No. 72 is one of the oldest residential settlements which predates to the Mughal period. The area can be characterized with a complex organically evolved pattern of narrow winding street network forming the boundaries of different neighbourhoods or *mohallas*. The organic street pattern of Luxmi Bazaar results in a mosaic of plots with a rich diversity of irregular shapes and sizes. However, the settlement has no open spaces. The only open space in the vicinity is the poorly maintained historic Victoria Park. The area is a highly compact settlement predominated by high rise buildings ranging from 5-10 stories. In old Dhaka many structures constructed before partition of India, have been demolished and replaced with new buildings augmented both horizontally and vertically. Most of the buildings have been non-adherent to the Building Codes. However, the area still possesses some historic dwellings conforming to distinct architectural style from the Colonial Period and which are in a vulnerable state for lack of proper maintenance and preservation.



Source: DSCC, 2014

Figure 24: Land use map of Luxmi Bazaar

ii. *Changing landscape of building heights in Luxmi Bazaar*

In the Colonial period the settlement was predominantly occupied by 1-2 storied houses. From the mid-1970s to 1990s, around 35% of the houses were extended up to 3-4 stories. Due to the proximity to the Old CBD and educational facilities, this area has always been a preferable location for rental accommodation. From the late nineties high rise buildings of 6-8 stories with mixed function started to emerge. At present approximately 80% of the area is covered with high rise buildings out of which 30% are 10-12 stories high. Some of the irregular narrow plots created some very slender high-rise buildings which are highly vulnerable to earthquake.

Figure 25: Emergent high-rise buildings in Luxmi Bazaar

Table 12: Trend of building height change in Luxmi Bazaar (2004 – 2016)

No. of Stories	2004	Lane 1 2010	2016	2004	Lane 2 2010	2016	2004	Lane 3 2010	2016
1	11	7	7	14	11	6	6	5	4
2	7	7	6	9	5	4	8	7	4
3	7	7	6	2	3	2	5	4	5
4	4	5	3	2	2	3	1	3	4
5	6	6	7	1	1	3	-	3	3
6	4	3	5	-	4	5	1	3	6
7	2	2	2	-	1	3	1	1	1
8	-	1	3	-	-	-	1	1	1
9 and above	-	-	1	-	-	-	-	-	-
Total	41	38	40	28	27	26	24	27	28

Source: Field survey January 2016 and satellite imagery
Note: Total No. of Plots surveyed: Lane 1 (Nandalal Dutta Lane) = 40, Lane 2 (Nobodip Bashak) = 26, Lane 3 (Panch Bhai Ghat Lane) = 28

iii. *Plot Coverage*

Figure 26: Streetscape of Luxmi Bazaar *(Shubose Bose Road)*

Figure 27: The emerging buildings of Luxmi Bazaar

The existing road widths are less than 60 feet wide making the prevailing FAR guidelines inapplicable for this area. Survey shows that 77.6% plots have plot coverage ranging from 81% to 90% while 9.6% plots have ground coverage of 91%-100%. Many of these plots face roads which are 10-12 feet wide.

Table 13: Plot coverage in Luxmi Bazaar

Plot coverage (%)	Number of Plots	Percentage
50 or less	-	-
51-60	-	-
61-70	4	4.2
71-80	8	8.5
81-90	73	77.6
91-100	9	9.6
Total	94	100

Source: Field Survey, 2016

iv. *Floor Area Ratio (FAR)*

The Floor Area Ratio of the blocks surveyed in Luxmi Bazaar was observed to be ranging from 0.9 to 5.7 in older buildings while the new buildings have FAR ranging from 5.4 to 8. Both the former and recent constructions are violating the recommended FAR to a greater extent. Around 90% of buildings are found not abiding the setback rule. Even high-rise buildings were found with shared external walls in Nobodip Bashak Lane.

Table 14: Floor Area Ratio for Blocks 1, 2 and 3 in Luxmi Bazaar

FAR	Nandolal Dutt Lane	Panch Bhai Ghat Lane	Nobodip Bashak Lane
0.5 – 1.0	4	1	5
1.0 – 1.5	-	1	-
1.5 – 2.0	5	6	3
2.0 – 2.5	5	1	1
2.5 – 3.0	2	3	1
3.0 – 3.5	3	5	-
3.5 – 4.0	2	1	5
4.0 – 4.5	4	2	1
4.5 – 5.0	1	2	1
5.0 –5.5	4	3	6
5.5 – 6.0	1	2	-
6.0 – 6.5	1	-	1
6.5 – 7.0	1	1	1
Total	33	28	25

Source: Author's calculation, Field Survey, 2016

v. *Ground Coverage at block level*

Results from the survey indicate that Luxmi Bazaar has the highest block coverage (89.4%) among the study areas. This implies that almost 90% of the dwellings employed the highest possible ground coverage forming an exceptionally dense settlement pattern. From the reconnaissance survey it was found that the spatial pattern of Luxmi Bazaar had inter woven tree like road networks with cul de sacs contributing to no defined block boundary. Instead of blocks the area is identified through the name of its lanes or streets. Therefore, for detailed study instead of blocks three lanes with the first row of plots along both sides of them had been selected. The aggregate plot areas is considered as the block area for this study.

Table 15: Land coverage at block level in Luxmi Bazaar

Lane	Total area (sq.ft)	Total built up area (sq.ft.)	Land coverage per block (%)	Average Block coverage
Nandolal Dutta Lane	140296	112629	89.2	89.4%
Panch Bhai Ghat Lane	101937	89500	87.8	
Nobodip Bashak Lane	90064	82138	91.2	

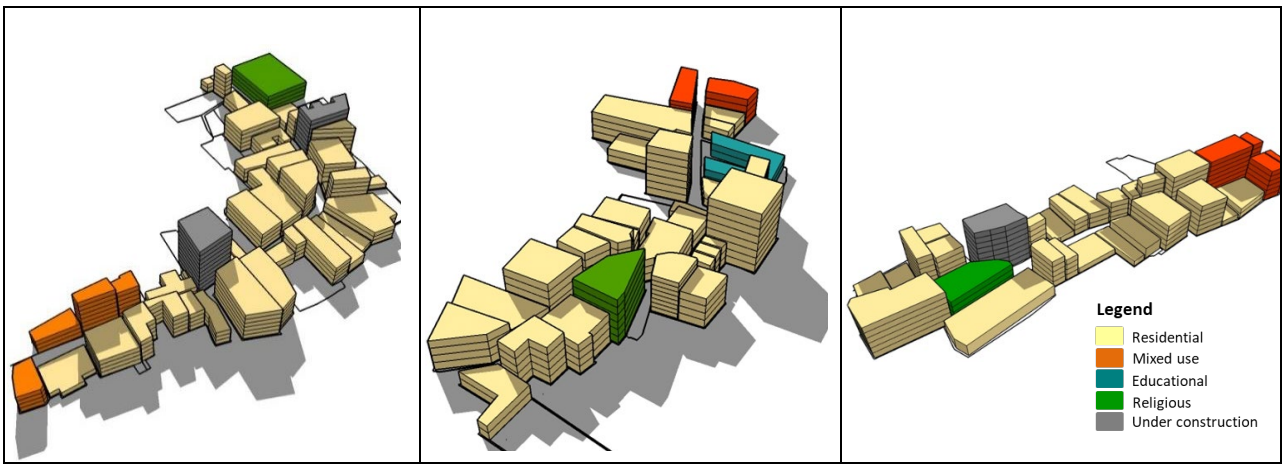
Source: Field Survey, 2016

The result of the empirical observation indicates that Nobodip Bashak Lane has one of the highest ground coverages of 91.2% at block level followed by 89.2 and 87.8% in Nandolal Dutta Lane and Panch Bhai Ghat Lane respectively.

Table 16: Net Residential Density and Net Residential Population Density along the road front plots of the study lanes in Luxmi Bazaar

Luxmi Bazaar		
Lane	Net Residential Density units /hectare	Net Residential Population Density persons /hectare
Nandolal Dutta Lane	128	643
Panch Bhai Ghat Lane	140	701
Nobodip Bashak Lane	220	1104

Source: Field Survey, 2016



Source: Field Survey, 2016

Figure 28: Shadowing of the buildings and adjacent alleys, Luxmi Bazaar

Nandolal Dutta Lane was inhabited by the elite class back in 1950s when this narrow lane was flanked with single and double storied colonial style courtyard houses. The lane has varying width where the highest width is 20 feet and lowest is 15 feet. A significant portion of its residents were wealthy Muslim refugees who migrated from India during partition and purchased property here through exchange system. Most of these Muslim residents were well educated and employed in public and private service (interview of a local resident, November 7, 2015). The residential density of the area increased substantially with the 2nd and 3rd generation of these inhabitants during the decades of the 1970s and 1980s. With the increase in the number of family members people were retrofitting their single-story dwellings with additional floor or rooms. By the end of 1980s a couple of low-rise dwellings were replaced by 5-6 storied mid-rise buildings. With the advent of the fourth generation during the 1990s the redevelopment activity exacerbated with mid- and high-rise buildings. By the end of 1990s around 80% of the single and double storied houses were diminished. At present only 2% of the single and double storied houses are remaining and high-rise buildings of 8-10 are under construction in some of the plots. Most of the new high-rise buildings have plot coverage above 80% whereas the older 4-6 storied buildings have plot coverage ranging from 88% to 89%.

Figure 29: Nandolal Dutta Lane

Figure 30: Nobodip Bashak Lane

Figure 31: Panch Bhai Ghat Lane

Nobodip Bashak lane is characterized by a labyrinth of meandering narrow lanes 5-8 feet spreading out in various directions. Starting from the primary road (*Shubas Bose Road*) the lane is 16 feet wide at its entry point and 4.5 feet in its narrowest part. Both sides of the lane are flanked with 5-6 storied buildings with a maximum 1.5 feet setback space between buildings. In some cases, the distance of the balconies between facing buildings is less than 1.5 feet while two adjacent high-rise buildings are often found sharing the same external wall. The alleys are extremely narrow, often 4 feet wide with open drains on both sides. These alleys are only used as pedestrian pathways with 5-6 storied buildings overshadowing them. Various occupational groups reside here but a significant portion of them are service holders. There are a couple of mixed-use buildings in the entry point and a 4 storied mosque in the middle of the lane. The plot coverage ranges between 80 to 90 percent, in some cases even higher. With the highest plot and block coverage the high-rise dwelling of this dense neighborhood receives minimal solar access and natural ventilation.

Figure 32: Narrow 4 feet wide alleys of Nobodip Bashak lane

Figure 33: Indequate penetration of sunlight

Figure 34: Very close juxtaposition of buildings

Panch Bhai Ghat Lane is dominated by mid and high-rise buildings throughout its length. There is a 6 storied mosque and 2 storied government primary school (*Rokonpur Primary School*) in this lane. With plot coverage ranging from 81%-87% the buildings of this neighborhood are also devoid of adequate sunlight and privacy.

vi. *Spatial growth pattern in Luxmi Bazaar*

The plots of Luxmi Bazaar show a wider range of variation in terms of plot sizes and shapes since the area developed organically. In addition, the plots were subdivided without any planning by-laws and largely guided by Muslim inheritance law. The unguided redevelopment of Luxmi Bazaar with its relatively smaller plot size, has led to crammed housing with highly compromising condition in terms of sunlight, natural ventilation, and privacy. The settlement has already reached the saturation stage with tall buildings forming a densely packed maze-like urban fabric. And if this trend continues unchecked the livability condition will further deteriorate. The means of access for fire rescue operation prescribed in Bangladesh National Building Code (BNBC) should not be less than 4.8m or 14.74 feet. But in many places the width of the narrow lane of Luxmi Bazaar is below standard which makes the settlement more vulnerable in case of fire hazard. The lack of open space and narrow evacuation routes is likely to cause a massive proportion of casualties in case of natural catastrophes like earthquakes.

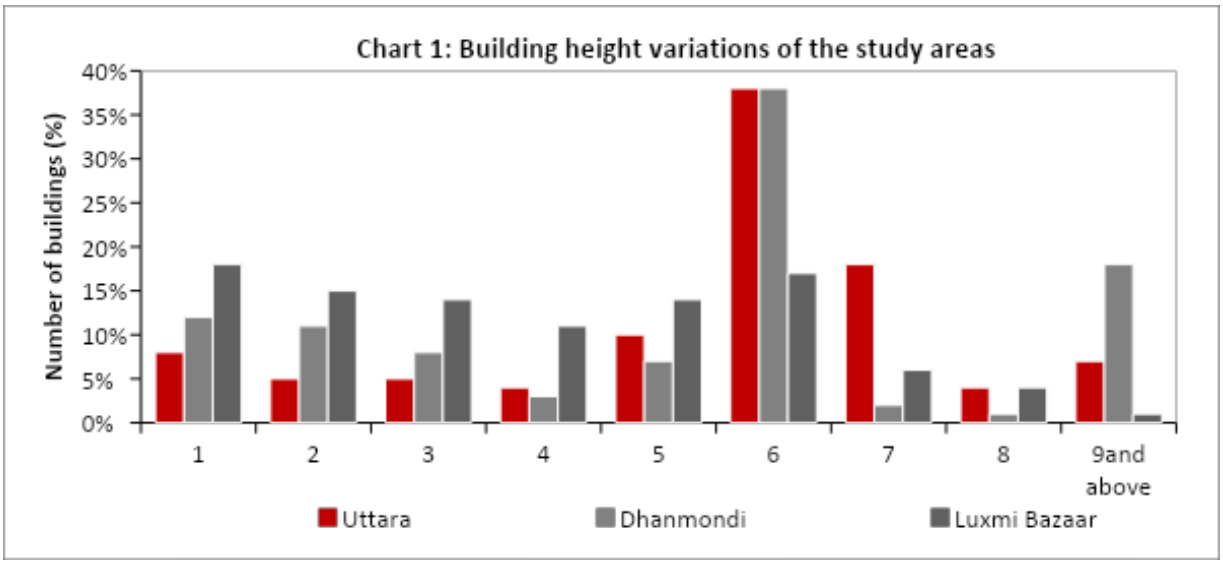
III. Discussion

Overall, the densification process in Dhaka took place in three phases: firstly, by augmenting the low rise (1-2 storied) buildings with additional 1or 2 floors, secondly by infilling the vacant plots and replacing the low-rise buildings with mid-rise (6 stories) buildings and high-rise (above 6 stories) buildings and thirdly by encroaching wetlands for building high-rise residential complexes. The study areas revealed that, around the late 90s redevelopment activity in the existing low-rise buildings used to take place through horizontal expansion and construction of additional floors but in the later phase was done by replacing the low-rise dwellings with high rise buildings or filling up the vacant plots. By 2005 buildings above 7 stories were rampant across the city (STP 2005). In addition, the infiltration of commercial activities in the residential areas intensified the densification process by constructing mixed-use towers. The density gradient was found high along the arterial roads and receding in the inner blocks. Though the inner blocks of New Dhaka have moderate number of high-rise buildings (Chart 1) but if this trend continues unchecked it would deteriorate the spatial quality of both indoor and outdoor environment of the residential areas.

Table 17: Cross case analysis

Density Issues	Uttara	Dhanmondi	Luxmi Bazaar	Emerging Concerns
Building densification guidelines	Absence of any densification guideline BCR 1996, MINB 2008 and Govt. circulars guide the setback, height, FAR and zoning modifications.	Absence of any densification guideline BCR 1996, MINB 2008 and Govt. circulars guide the setback, height, FAR and zoning modifications.	There was no policy guidelines for densification	In New Dhaka developers were violating guidelines on coverage and FAR Weak enforcement of zoning ordinance resulted in infiltration of commercial activities all over the settlement. In Old Dhaka no set back and land coverage rule is followed. FAR cannot be applied here for inadequate road width.
Changing urban fabric Floor Area Ratio (FAR)	Rapid transformation started from 2009 Densification has reached 'optimum stage' in sector 2,4,6,8, 9,7,11 and 13 but densification is still in its infancy stage in sectors 5, 10, 12, 14 Observed FAR 6.0-7.0 and maximum height 14 stories	Rapid transformation started in 2009. Densification has reached 'matured stage' Observed FAR 4.8 - 9.1 and maximum height 16 stories.	Rapid transformation started in 2005. Densification has reached 'saturation stage' Observed FAR 5.4-8 and maximum height 12 stories.	Violation of recommended standards by developers for maximizing profit.
Plot Coverage	Observed maximum coverage in older buildings was 81% instead of recommended maximum plot coverage 70% (BCR 1996) Observed maximum plot coverage in new buildings was 78% instead of recommended 50-60% (MINB 2008)	Observed maximum coverage in older buildings was 85% instead of recommended maximum plot coverage 70% (BCR 1996) Observed maximum plot coverage in new buildings was 82% instead of recommended 50-60% (MINB 2008)	Observed maximum coverage in older buildings was 100% Observed maximum plot coverage in new buildings was 90% in absence of any applicable guideline	Violation of recommended standards by developers for maximizing profit.

Land coverage at block level	Recommended land coverage at block level was 75 and 80 percent for larger and smaller plot blocks respectively Observed maximum land coverage at block level 76%	Recommended land coverage at block level was 75 and 80 percent for larger and smaller plot blocks respectively Observed maximum land coverage at block level 86%	Observed maximum land coverage at block level 91%	
Spatial growth pattern	Jagged skyline due to varying building heights comprising of low, mid and high rise building (10-14 stories) along the primary and secondary roads. Most of the inner blocks have uniform skyline dominated with 5-6 storied buildings	Tall towers (10-12 stories) along the street forming more or less continuous skyline gradually receding towards the inner blocks.		Broken skyline leads to poor visual impression, unused spaces, and loss of privacy for low rise dwellings. The broken skyline of Old Dhaka indicative of the crammed housing condition with dark alleys and uncomfortable indoor living condition in terms of natural ventilation, sunlight and privacy.



Source: Field Survey, 2016

IV. Conclusion and Recommendation

Unguided densification may adversely affect the spatial environment which is evident in this study. In the absence of any densification policy, the residential areas of Dhaka were densified with a single building type (high-rise building above six floors with a small footprint) which tends to decrease natural ventilation, solar exposure, visual and acoustic privacy, and obstruction of views. This further increased the need for artificial lighting and air conditioning, thus increasing energy consumption. Based on the observations the following recommendations are suggested. A comprehensive densification plan based on the site-specific projected density, site potential, land use mix, connectivity, and socio-cultural context needs to be formulated before any densification operation. Instead of sticking to high-rise buildings other housing types preferably mid-rise with high built-up densities suitable for tropical climates need

to be explored. A mix of high, medium, and low-rise buildings with high densities can be achieved through appropriate zoning policies which would decrease the cramped feeling. Plots of higher values may be combined to get the benefit of a higher Floor Area Ratio (FAR). Nonetheless, contextual density zoning for the residential areas of the city needs to be formulated to achieve the desired outcomes of densification.

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15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.
Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

19. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

20. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

21. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

22. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

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Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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