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Research Article

Sustainable Approach to Regenerating Residential Form and Density: Case in Dhaka

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This paper presents principles and praxis of sustainable approach to maintaining targeted "residential regeneration by density" yet achieving innovations in urban form in a contextual scenario of Dhaka City, the capital of Bangladesh. It is evident from the context that Dhaka is experiencing a dramatic transformation in residential density due to demographic changes during the past two decades due the concentration of social, administrative, institutional, recreational, small-scale industries, and associated housing facilities. The transformation is visible in residential built footprint, significantly due to the demand-driven and density-led market, originated from low rise and low density and transforming to high density high rise. This transformation has been consistently threatening social and environmental realm indicated by depletion of garden houses; reduction of public parks; shrinking walkways; deletion of setback for ventilation and sun shade from trees; slowing down mobility; and obstruction of physical and visual permeability. The paper discussed a pragmatic approach that professionals have adopted to control the density and to introduce scopes for innovative urban forms by way of applying floor area ratio (FAR) methods and further discusses the merits of the methodological process of exercising morphology with a set of new building rules without undermining the market demand.

1. Strength of Urban Form and Density in Regeneration

Regeneration occurs in varying forms and depends on the level of urban deterioration; frequency of changing functions and land uses; speculative real estate market; and socioeconomic transformation affected by globalization [1]. Regeneration in Dhaka city adopted the method of "transformation by densification" in response to the competitive real estate market; globalization; rising affluent societies; rapid demographic shift; and deterioration of built forms, while Dhaka has shaped as one of the popular destinations for major socioeconomic and administrative development. This triggers pulling effects of population from the peripheral cities and other districts for job; education; health and judicial services; administrative support; and for major urban realm [2, 3]; all these have been pushing Dhaka's growth limit to the north (Figure 1).

Dhaka city's concentration is a one way demographic shift since reciprocal distribution of population to other districts rarely happens mostly due to other locale being weakly connected by infrastructure and being less attractive for job seekers [4, 5]. This phenomenon has caused Dhaka City to have reached megacity status, being one of the highest densities in the world, with over 10.23 million reached in 2008, which is about 40% of the urban population and 6% of the national population of the country, having 155 million people [6]. Overcrowding of people in the city has posed threat to the existing social and physical infrastructures, significantly deteriorating environmental, social, economic, and political conditions, coupled with inadequacies of capacity of the necessary infrastructure, despite Dhaka being the centre of economic activities [7]. Jahan [8] suggests that a significant part of this urbanisation is taking place in these developing countries due to the dual process: (a) natural growth within cities and (b) large numbers of rural-urban migrants in search of jobs and opportunities. Often this happens despite widespread antiurbanisation policies, which aim to balance development and to sustain rural economies [9].

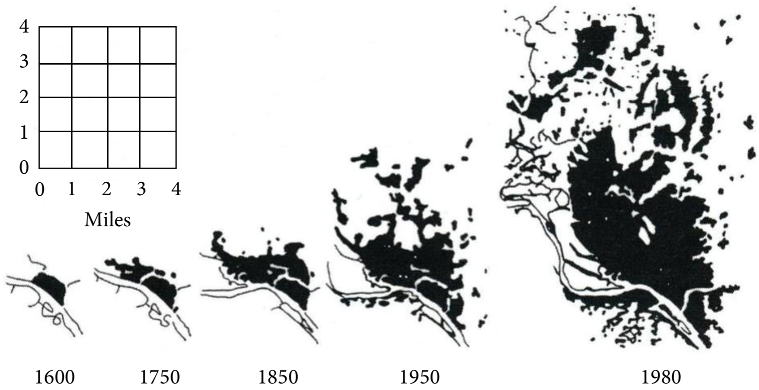

Figure 1: Urbanization in 380 years Dhaka [10].

Jahan [8] and Dewan et al. [11] suggest and further endorsed this phenomenon of migration as RUM (rural-urban migration), due to both push and pull factors and due to gross disparities in socioeconomic opportunity between urban and rural areas. Further frequent natural disasters in some regions encourage large flow of migrants from rural to the large cities. For various reasons, Dhaka is an attractive destination for the rural migrants. Rapid urban growth tends to overwhelm cities where the struggle to develop infrastructure, mobilise, and manage resources has negative consequences for the environment [12]. Moreover, Dhaka is dominated by the presence of a huge informal sector, garments industries for global economic activities, which are accommodated by massive conversion of housing and other functions and further by intensifying the inner urban areas. It has been estimated that about 65% of all employment in the city is in the informal sector [13].

Regeneration, unlike many other examples in the west being a positive intervention [14], is less desirable in Dhaka due to its inherent weaknesses that fail to visualise a bigger picture of sustainable urban development derived from an appropriate urban form, the consequence of which is a series of urban crises. The significant crises are discussed below.

Crisis 1. Over 70% residential development falls under extreme compact condition devoid of any architectural merit and often labeled as "slum." One way journey creates pressure to housing and associated functions that triggers developers to undertake a series of regeneration from low to high density that visibly and measurably dominate Dhaka's skyline. This triggers surplus population, as "symphonic action," seeking residential spaces within the compact and closely knitted housing solutions (Figure 2).

Analysis of Crisis 1. This crisis is inherently rooted in the outdated building and planning bilaws, which is derived from building to building spatial quality. Due to the old and inappropriate building bilaws as illustrated in Figure 2, drastic measures were required. *Building Regulations in Dhaka City* (till 2006) essentially existed for the following purposes, with the Bangladesh National Building Codes (BNBC) actively recommending environmental controls through [15].

(a) *The Building Construction Act, 1952* guide setbacks building heights and so forth in urban areas; prevents haphazard construction of buildings and excavation of tanks; controls and regulates safety, comfort, appropriateness of materials, building services, and so forth of proposed building. These controls are imposed by means of *maximum allowable floor area* in relation to the site through *road width, building height, and set back from boundary* (Figure 3).

(b) *The Town Improvement (TI) Act 1953* regulates proposed building development on its immediate and the city environment by preparation of master plans, improvement schemes, their implementations; controls development, by improvement and expansion of Dhaka by opening up congested areas; laying out of altering streets; providing open spaces for the purpose of ventilation or recreation; demolition or construction buildings; acquiring land for the said purpose; and rehousing of persons displaced by the exclusion of improvement schemes.

(c) *Building Construction Rules 2008* seek to control development plot-by-plot and case-by-case by development control on setbacks, site coverage, construction of garages, access to plot, provision of lift, land use of that particular plot, and height of building, restricting the height referring to BC Rules 1996.

(d) *Bangladesh National Building Code (BNBC) 2006* ensures optimum return of substantial portion of national resource invested in building construction, in both public and private sectors and to achieve satisfactory performance of any construction, which is felt by the stake holders for reasonable modifications for which the modifications of the Code began in 1992 and was completed by the end of 1993.

(e) Land Development Rules for Private Housing 2004.

As a result of the above bilaws, social and environmental benefits were negligible, such as poor ventilation passage between buildings for surface cooling effects; poor percentage of greenery compared to hard surfaces resulting in "urban heat trap" and "heat island effects"; lack of privacy; lack of

Figure 2: Increasing density and expanding footprint are supported by weak building bilaws (Photo credit: Quazi M Mahtab-uz-Zaman, 2006).

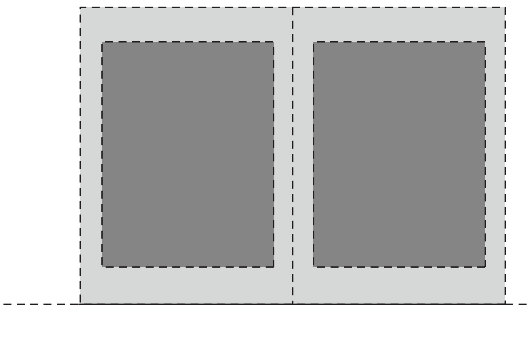

Figure 3: Old set back rules allow ineffective linear spaces (Graphics by Quazi M Mahtab-uz-Zaman, 2013).

Figure 4: Densification of residential area (Google Map accessed in 2004).

immediate social spaces for physical and social activities since a major proportion of public realm (parks and open spaces) have been converted into built-up areas (Figures 4 and 5). In the paper of Dewan and Yamaguchi [16] as referenced in Byomkesh et al. [17], it was revealed that almost 80% of the land in Greater Dhaka that was nonurban in the 1960s (i.e., it contained vegetation, open spaces, wetlands, and cultivated lands) has drastically been reduced to about 40% by 2005.

Crisis 2. Urban Confinement and Sedentary Lifestyle Due to Lack of Social Space for Children and Elderly People. The dense built form as illustrated in Figure 5 causes ill-health effects, especially amongst children and elderly due to their limited and diminishing mobility pattern. This relates to the World Health Organization's findings of "Sedentary lifestyle" that is a major underlying cause of death, disease, and disability. Crowding, poverty, crime, traffic, low air quality, and a lack of parks, sports and recreation facilities, and sidewalks make physical activity a difficult choice as this is evident in São Paulo, where approximately 70% of the population is inactive due to higher urban density. For Dhaka, it may be even more vulnerable as a growing number of children and elderly have recorded health ailments. Record shows that air pollution kills 15,000 Bangladeshis each year [18], where World Bank [13] report suggests saving of $200 to $800 million, which is around 0.2 to 0.3% of GNP (Gross National Product) by controlling air pollution, and urban development is one of the strategies to respond to this crisis. Current patterns of urbanization and motorization are also associated with more sedentary lifestyles, diminished space, and opportunities for physical activity.

Reduction of natural assets like parks, protected green space and gardens, street trees, and landscaping reduces the opportunity for vital ecosystem, green lungs absorbing, and filtering air pollution or as acting as filters for waste water.

Crisis 3. Removal of Sustainable Microclimate in Built Residential Environment. Compact residential morphology reduces cross ventilation, heat exchange, and cooling effects. The microclimate that generates the level of habitable environment is mostly devoid of natural light, natural ventilation, and privacy as a result of the close property lines and lack

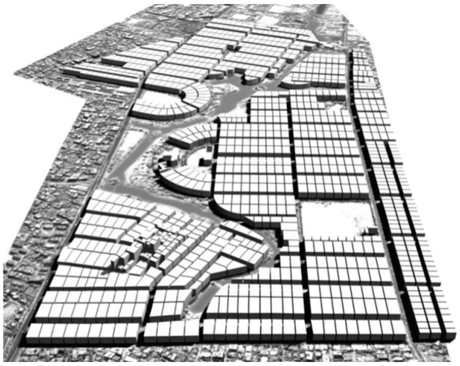

Figure 5: Simulation of densification of morphology (Photo credit: Abdullah, 2004).

Figure 6: Densification and urban heat generator (Photo credit: Abdullah, 2004).

Figure 7: Awaiting removal of remaining greeneries for densification (Photo credit: Abdullah, 2004).

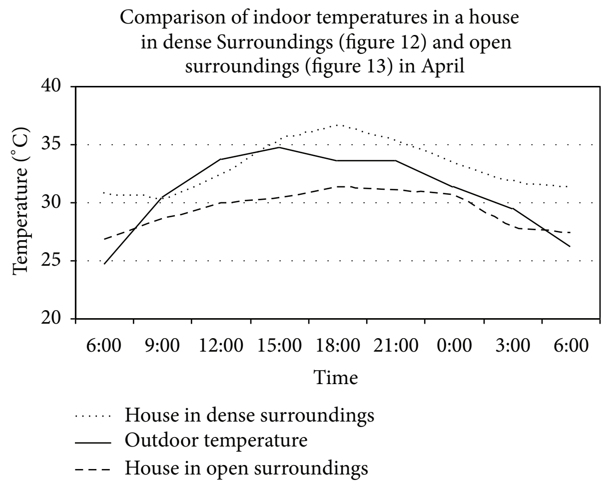

Figure 8: Temperature difference between house in dense built up areas versus house with greeneries [22].

of vegetation (Figures 6 and 7). Urban heat island is amongst other elements of discomfort that forces residences to rely on mechanical cooling and ventilation system. Therefore, urban heat island (UHI) is seen as a major man-made consequence of urban morphology, as Tran et al. [19] identifies that the rapid urban transition in Asia with large proportion of population relying on increasing energy consumption significantly affecting the quality of life while further worsening micro-climatic condition (Figure 8). Moreover, as urbanization becomes more intense with revised density, urban-rural temperature differences also increase as recorded in other megacities (Figures 9, 10, 11, and 12) [20, 21].

Crisis 4. Reduction of Ground Water Table and Surface Water Flow due to Increasing Impervious Surface Areas. Bangladesh is a rain dominated country, and Dhaka is no exception. Dhaka receives on average about 448 mm of rain in 6 hours, measuring about 2000 mm annual rainfall during monsoon season [23], but the benefit of having such volume of rain is slim due to city's dense urban development, thus creating no opportunity for ground water recharging. Dhaka city had networks of rivers, ephemeral water bodies, and canals that could drain excessive water during rainy season, but demographic pressure, expansion of built environment and impervious surfaces, and reclamation of these channels have resulted in additional problem of water logging and lessened the capacity of ground water recharging [23].

Figure 13 illustrates a common scene of surface water flow during heavy rain causing urban flooding and simultaneous fresh water crisis due to lack of underground water recharging. It is estimated by Water and Sewerage Authority (WASA) of Dhaka in 2011 that urban ground water is decreasing at the rate of 6 meters in 7 years [24], which means reducing the benefit of having underground fresh water (Figure 14). This is also pointing to any future probability of having liquefaction from underground porosity created from losing water within the geomorphological structure. Therefore, Figures 13 and 14 are two extremes of the same cause of natural degradation.

The Haq prediction from the recent Rain Forum [25] suggests that ground water level at central part of Dhaka is reducing 3 mm each year. This postulates the “aquifer” actions by drying of natural wells and triggering contamination of water and a possible land subsidence [26].

Crisis 5. No minimum standard of Public Realm—Pedestrian and Green Space. Densification process forces the public realm out of the “zoning” and “space distribution calculation,” resulting in the lack of pedestrian and other public realm. Moreover, the densification of land uses without sustainable measures to reduce vehicular traffic volume poses additional threat to air pollution leading to health hazards (Figure 15).

A general scene of this negligence is the overflow of social contact point and retail anchor areas coexisting with parking space (Figure 15), which all get diluted and juxtaposed in an

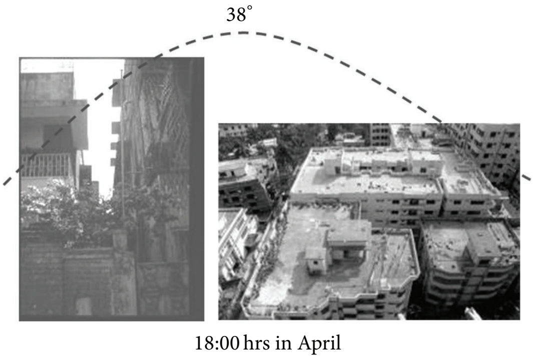

Figure 9: Temperature reading on dense built up area (Photo credit: Abdullah, 2004).

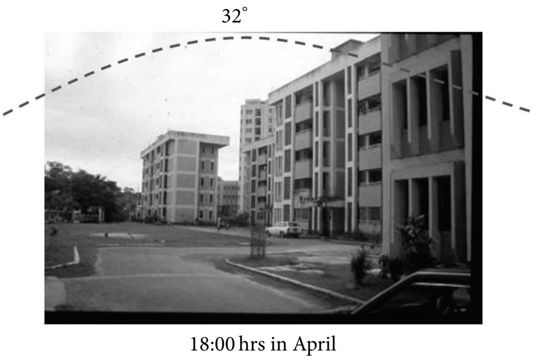

Figure 10: Temperature in dispersed settlement (Photo credit: Quazi M Mahtab-uz-Zaman, 2004).

Figure 11: Densification profile in Google Earth.

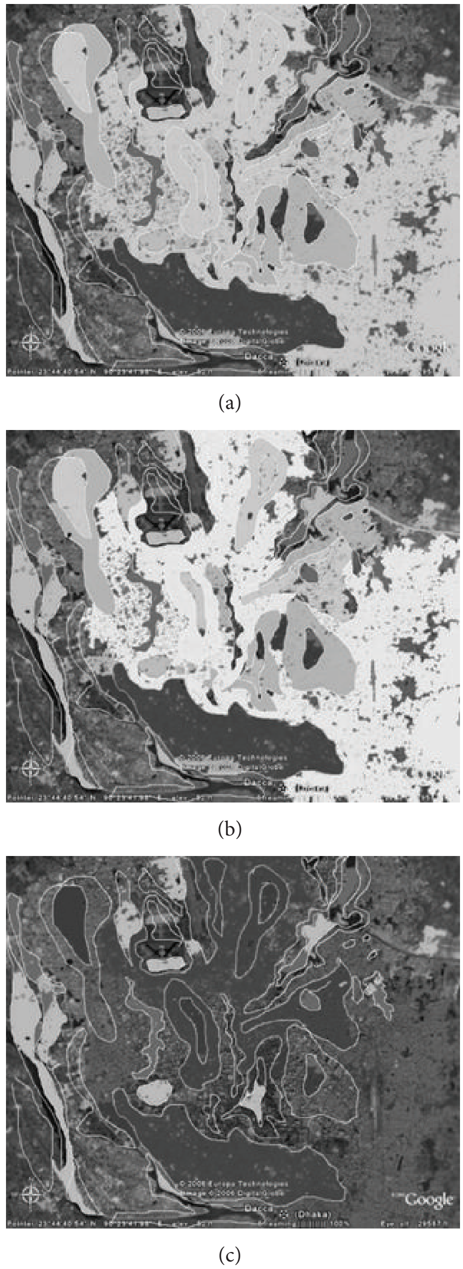

Figure 12: Simulation of urban heat island effects interpreted and redrawn from remote sensing data (increasing heat island from top to bottom) (Graphics by Quazi M Mahtab-uz-Zaman, 2006).

awkward position and which otherwise should have properly laid down with controlled planning process.

Byomkesh et al. [17] identify the disappearing green spaces in Greater Dhaka that have been providing "a number of natural, economic, and social benefits." The reason for this disappearance is clearly due to the rapid population increase and rural-urban migration leading to the fragmented landscape. Dewan and Yamaguchi [16] also reveal that, in 1960, Dhaka had 80% of the land being nonurban having vegetation, open spaces, wetlands, and cultivated lands, which has reduced to 40% by 2005 due to urbanization and ill-planned

Figure 13: Flood and heavy surface water flow to built-up coverage [27].

Figure 14: Ground water depletion is creating water crisis in neighborhood supply [28].

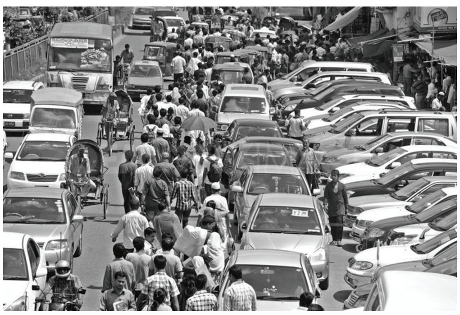

Figure 15: Traffic and rising air pollution [29].

built environment. Reduction of greeneries is calculated as having only 8% tree coverage compared with the standard of 20% required for achieving healthy urban environment, and these reflect on the total loss of greenery of about 8617 ha in 30 years (1975 to 2005) [17]. These further point to the difficulties that residents face in keeping buildings cool naturally.

Urban Auditing. Accumulation of all the above crises (item 1 to 5) indicates a set of evidence that is attributed to (a) having lack of appropriate building regulations and urban planning agenda; (b) rapid urbanization and increasing density without appropriate emphasis to environmental and social spatial quality; and (c) can be summarized as having a "shortsighted" approach to density and increasing "amnesia in innovative morphological distribution." Moreover,

(i) increasing density and its effects on infrastructure have never been scrutinized, which led to overburdening of water and sewerage system in the city, and that allowed minimum social space in shelter design and development;

(ii) built professional never felt to deal with the element of "density" and applied to morphological process;

(iii) it was never realised that decisions made on density profile can have significant impact on health, urban environment, productivity of cities, and on human development as a whole [30].

Opportunity for Mitigating Crises. (FAR to recover/recreate/make provision for URBAN SPACE *for saving Dhaka*). To combat the above crises, it is identified that "urban form" has the potentiality in its inherent capacity to bring environmental as well as social benefits subject to a proper manipulation and use of formal arrangement within the limited plot area. Integrated master plan began to consider formal arrangement within Good Governance since 2004 with intervention from a multiprofessional body under the Institute of Architects Bangladesh.

It was felt the need for innovative approaches to bring

(i) balance between rapid urbanization, densification [31, 32] and socio-environmental qualities, where environmental plans needed to be integrated with the city master plan, as this is significant element which has already been established as part of good governance by many countries (49% of the world's cities have established urban environmental plans [33]);

(ii) floor area ratio (FAR) has been identified as a critical tool, which is common for many countries (Figures 16 and 17).

The new building regulation 2007 [*Mohanagar Imarat Nirman Bidhimala (MINB) 2007*] [34] was developed with the help of a multiprofessional team aiming to instigate flexible morphology yet maintaining a mandatory open space (or maximum land utilization of 30 to 40% of total lot area for a residential plot), setback, ground coverage, and floor area ratio (FAR) (Figures 18, 19, 20, 21, 22, and 23). It eliminates mandatory height limitations of buildings and enables design of more liveable and open spaces allowing design flexibility and provision of natural lighting and cross ventilation within built spaces. This is an enhancement of the traditional methods of urban development legislation DMDP Urban Area Plan that generated guidelines for development management [35]. DMDP recommends that current RAJUK continue to develop 6 storey buildings only within the planned developed; for any high density, development should be scrutinized reflecting on the needs where existing infrastructure provision is sufficiently higher, aiming to generate higher density.

2. Morphological Exercise to Restore Social and Environmental Balance

For more details see, Figures 18–23.

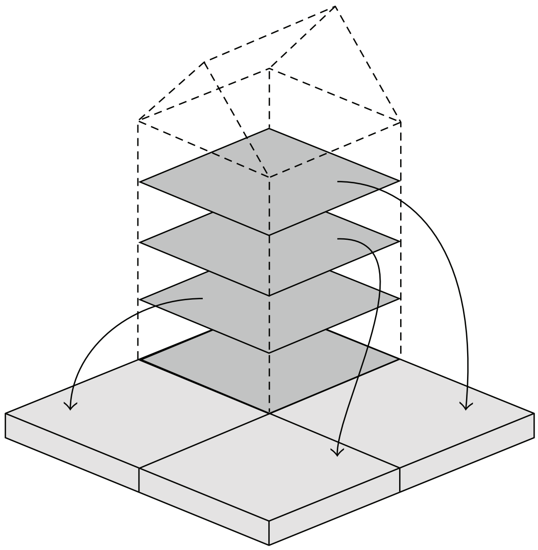

Figure 16: Concept of FAR (Graphics by Abdullah, 2004).

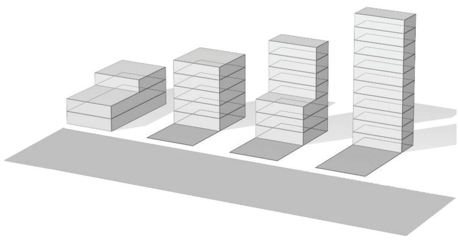

Figure 17: Concept and advantage of FAR (Graphics by Abdullah, 2004).

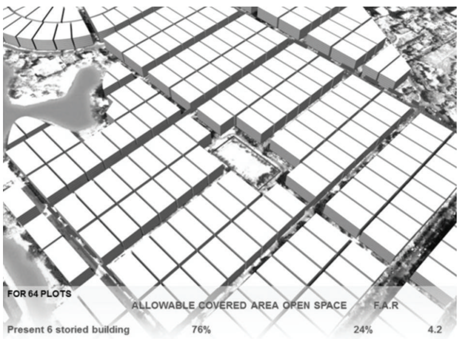

Figure 18: Simulation of existing morphology from old building regulation (Graphics by Abdullah, 2004).

Figure 19: Actual scenario of existing morphology (Graphics by Abdullah, 2004).

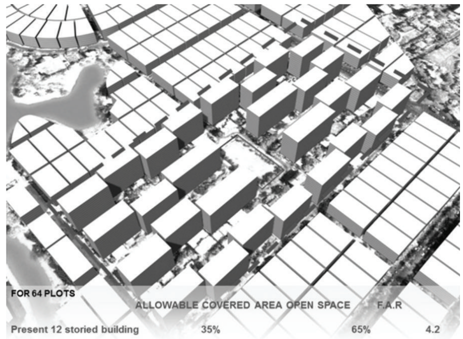

Figure 20: Applying FAR 4.2 by rearranging in 12 storied buildings with achievable 35% covered area and recouping 65% open area (Graphics by Abdullah, 2004).

Figure 21: Example of FAR 4.2 outcome (Photo credit: Quazi M. Mahtab-uz-Zaman, 2004).

Figure 22: Morphology as generated from existing building regulation having FAR 4.2 (Photo credit: Abdullah, 2004).

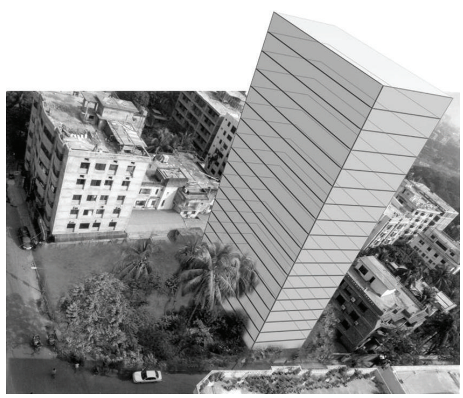

Figure 23: Simulated morphology as generated from FAR 4.2 with injection of social and environmental spaces (Photo credit: Abdullah, 2004).

3. Methodology of Morphological Exercise

Floor area ratio (FAR) is the fundamental element of the morphological exercise as FAR allows a variety of built and open space ratio for greater innovations and thereby generating opportunity for social and environment spaces. A fixed area of 4 residential blocks having 16 residential buildings was chosen, where regeneration would take place or regeneration would be recommended for future changes. These 16 residential blocks are 6 storied each as per old building regulation having linear set back rules as illustrated in Figure 2, which generated around 4.2 FAR if calculated in density. As the target is not to increase the traditional density per hectare, the new residential morphological footprint has been applied with the same 4.2, but allowing more spatial variance as the FAR allows generating flexible morphologies and building footprint. The result of this exercise is a number of options for variable heights ranging from 10 to 18 storied buildings (Figures 18–23), yet recouping more spaces for gardens and other environmental spaces, such as opportunity for ground water recharging from annual rain water; air flow; sun-shade and sun-casting where ever needed.

4. Environmental Benefits of Morphology

New morphological exercise under the MINB 2007 enables provision of essential parking, fire escapes, and mechanical spaces for which additional floor areas are permitted. Introduction of FAR of MINB 2007, bylaws, would ensure provision of mandatory open spaces around the building for sufficient light and ventilation to the building and vegetation to grow and reduce chances of any impacts to the macroclimate. By creating 50% of the open space to be unpaved within each built up area, the development site would allow more rain water to recharge the ground water table.

In the context of Dhaka, the benefits are no doubt achievable by the following outcomes of FAR method:

(i) creating air circulation passage/tunnel by increasing set back;

(ii) creating direct sun light passage on open areas by reducing building footprint;

(iii) reducing urban heat island by recreating greeneries on open areas, as Mahmood [18] identifies saving forest and promoting plantation can bring ecological balance in the city;

(iv) reducing cost of artificial air cooling method as a result of increased natural ventilation;

(v) maintaining the existing character of established residential neighbourhoods;

(vi) minimizing the out-of-scale appearance of large homes relative to their lot size and to other homes in a neighbourhood;

(vii) minimizing loss of light and privacy to neighbors caused by the construction of large homes;

(viii) minimizing the environmental damage of tree removal and destruction of natural features which may result from overbuilding, as environmental hazards in Dhaka city by deforestation are severe by cutting down of trees, encroachment and filling of water bodies;

(ix) recharging ground water table as illustrated in Figures 24 and 25, which should be urgently tackled due to the evidence generated from computer model (MAKSENS) [36] that water table would further decline 9–25 meter by the year 2015 and 18–40 meters by the year 2025.

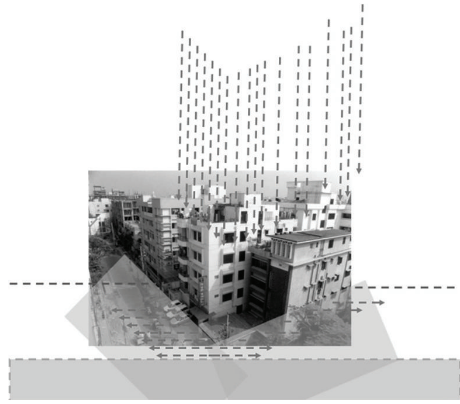

Figure 24: Rain water gets disperse far away from the source and reduction of ground water recharging (Graphics by Quazi M Mahtab-uz-Zaman, 2007).

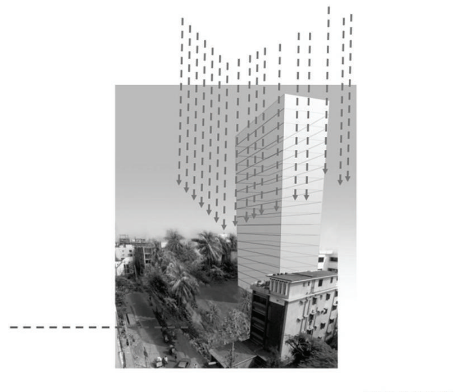

Figure 25: New morphology has potential in inviting rain water and allowing ground water recharging (Graphics by Quazi M Mahtab-uz-Zaman, 2007).

As the major proportion of water is generated from ground reserves, Sarkar and Ali [36], increasing permeability by manipulating ground coverage for water percolation is the only choice for reverting city back to nature.

The presence of greeneries, thus created by morphological transformation, would help regain natural processes, significantly by mitigating local temperature extremes, as McPherson et al. [37] stated that a 10% increase in vegetation reduces cooling and heating energy by between five per cent and ten percent. Vegetation and unpaved ground condition also decrease storm water dynamics, thus helping cities to

Figure 26: Repeating FAR in regeneration areas postulates a bigger change (http://www.skyscrapercity.com/ accessed on 2 May 2013).

Figure 27: FAR thus would inject social and environmental spaces yet keeping the same density profile (http://www.skyscrapercity.com/ accessed on 2 May 2013).

manage the consequences of heavy rainfall, as in the case of Dhaka city (Figures 26 and 27).

5. Social Benefits of Morphology

A series of catalytic effects would trigger from FAR, significantly, the social benefits as follows:

(a) generating greenery and healthy spaces for walking;

(b) injecting and recreating social space within greeneries;

(c) achieving psychological benefits and wellbeing from open spaces;

(d) creating opportunity for privacy and permeability due to injection of open space.

FAR creates flexible spaces within a residential plot by a combination of mandatory and voluntary set back. These spaces allow external room for garden, social meeting place and children play area (Figures 28 and 29) as demonstrated by many contemporary architects who believe in morphological exercise as a dynamic tool for creating variety and innovations. There are other hosts of measurable and non-measurable social benefits [38] that require prior knowledge obtainable from the user at large.

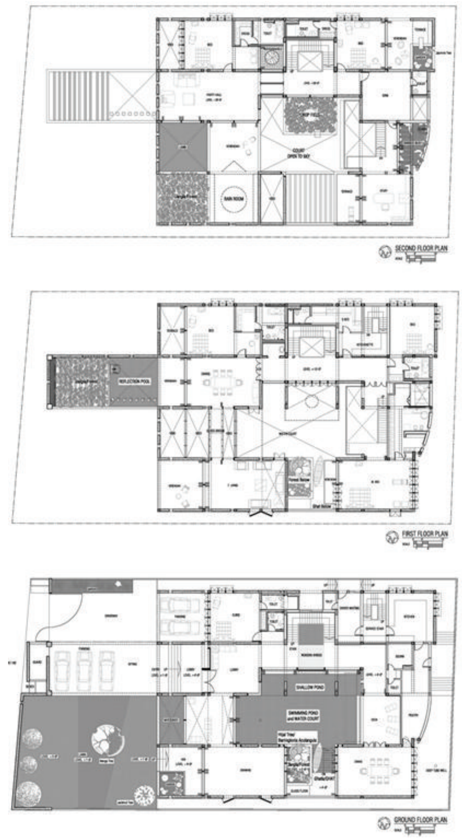

Figure 28: Innovation in building footprint by building morphology (Photo credit Rafique Azam Architect, 2008).

6. Conclusion

(a) Collective effort towards strategic actions (Credit: Quazi M Mahtab-uz-Zaman, 2013). For more details, see Table 1.

(b) Rationalizing urban form as a pragmatic tool. The research presented in this paper concentrated on urban form as an effective tool for social and environmental sustainability and argues that the compact neighbourhood should be retained with proper regards to the green pockets as social and environmental assets, as benefits of compact urban form are applicable in Dhaka city due to mobility pattern and one that is widely endorsed by urban managers and residents alike, taking the example of mixed-use densities as the triggering effects of compact city proved to enhance quality of life ([39]: 1969). Besides the major outcome of the urban form, a long-term objective rests on UHI and the heat island issue by reducing roof surface yet bringing greater varieties in footprint as "interaction between urban density and the generation of greenhouse gases" is a proven phenomenon.

This study reinforces the need to connect architectural design process with two significant sustainable objectives: public health and environmental attributes. The urban form is associated with health and wellbeing as Gottdiener and Budd ([40] : 148) identify that approximately health ailments are outcome of physical inactivity and sedentary lifestyle that result from high density urban form without any provision for

Table 1

Actors	Actions
The Building Construction Act, 1952	Over all built environment—assessment against natural, social, and need-based assessment of density
The Town Improvement (TI) Act 1953	Should recreate natural balance by enforcing stricter control on landscape and skyline legislation
Building Construction Rules 2008	Priority in formulating built-open ratio through FAR and set back from variable road conditions
Bangladesh National Building Code (BNBC) 2006	Should be revised
Land Development Rules for Private Housing 2004	Should enforce control over natural land conversion

Figure 29: Spatial variance for social and environmental attributes (Photo credit: Rafique Azam Architect, 2008).

urban spaces and greeneries. Physical inactivity is estimated to be responsible for some 1.9 million deaths globally every year, as a result of disease such as heart ailments, cancer, and diabetes especially vulnerable for children. Urban conditions should offer children and young people sufficient level of choice, control, and freedom within reasonable boundaries. The child's right to play is recognized in Article 31 of the United Nations Convention on the Rights of the Child, which was ratified and adopted by many countries [41, 42].

This paper, thus, concludes by stating that urban form has strength for maintaining social and environmental sustainability. Although it is understood that "different sizes and shapes of cities imply different geographical advantages" [43], Dhaka city deserves high density and innovative urban form that could embrace greeneries as a mandatory provision. The exercise presented in this paper is an upshot of a pragmatic approach to reconstruct sustainable and healthy city by applying building morphology as a tool for urban regeneration. Further, Dewan and Islam [23] suggest a careful decision of settlement design considering flood plain and various hazard zones (low to high elevated land) should effectively be taken into consideration while designing built form, such as elevated structures around the high flood prone areas would not hinder natural water flow and without infilling low lying areas. Any new decisions on land use and built environment should be obtained through scrutinizing hazard map.

Acknowledgments

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