Journal of Architectural/Planning Research and Studies (JARS) Vol.20(2).2023 https://doi.org/10.56261/jars.2023v20i2.251489

Green infrastructure development for a sustainable urban environment in Chittagong city, Bangladesh.

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Received 26/8/2021 Revised 23/1/2022 Accepted 31/1/2022

Abstract

The urban green infrastructure mechanism became an essential part of the city planning landscape of the 20th century for sustainable urban management. This study investigated the present green space condition in Chittagong city, Bangladesh, and compared it with other cities around the world. The mechanism was studied by reviewing the Master Plan and the Detailed Area Plan of Chittagong city along with a significant number of journal articles, books, and reports. The study found that the city of Chittagong is facing various problems in recent decades with its various problems such as lack of green space, recreational facilities, disasters, public health risks, and many others. It also found that the city's geographical condition is suitable for developing an effective green belt in its peripheral area. Although green wedges are part of another park system proposal for the barriers of the urban green belt, the importance of land allocation for urban green space is usually neglected or easily reported in the city transition region. Moreover, the cities of Glasgow, Stockholm, Melbourne, and Copenhagen, amongst others, have accepted green wedges mechanisms. The study found some barriers like industrial development and some exclusive economic zones, where some green wedges are much more suitable in the gap of urban green belt in Chittagong city. The concept of green belt and green wedges both supports sustainable urban management in the city of Chittagong. The study also exposed that urban green belts and green wedges were declining trends in the name of development activities and lack of monitoring of the City Development Authority (CDA). Although the city planning authority proposes in the master plan for urban green infrastructure including green belts, green wedges, parks, etc. The outcomes of this research will help CDA, urban local governments, and other stakeholders to identify suitable sites for green belts and green wedges and their suitability for a sustainable urban environment in Chittagong city. Therefore, a local green indicator should be developed and included in urban planning in Chittagong city. Moreover, these findings and analysis will be of great importance to the urban planners and decision-makers for making an environmentally friendly and sustainable modern and planned future for Chittagong city.

Keywords

Greenspace; greenbelt; green wedges; urban planning and design; sustainable urban development; Chittagong city

1. Introduction

A green environment is very essential for a sustainable urban environment (Liu, 2018). Urban greening includes air (Nakamura, 1973) and noise pollution control (Bilgili & Gökyer, 2012). It generates a territory for the native environment. It delivers several valuable direct and indirect services in the city for entertaining openings to improve air quality (Heidt & Neef 2008) as well as benefits associated with reduced housing density (Panduro & Veie, 2013). The Green environment is very significant in understanding, development, and enlightenment (Jim & Tan, 2017). The city of Chittagong has experienced extreme and frequent coastal urban floods (Tanim & Goharian, 2020) caused by cyclones and storm surges (Tanim & Goharian, 2021). In planning the protection of the city, the risk assessment of cyclones and storm surges is necessary (Khan, 1997). Damage to the physical infrastructure of the country's major seaport in Chittagong and the neighboring industrial area has been colossal, and recovery took years due to the catastrophic cyclone that hit the city of Chittagong in 1991 (Khalil, 1993). In protecting the city people and reducing the damage to life and properties from the cyclone and storm surge, the city development authority, community people, and local and international donors took several initiatives such as building an embankment, green belt, etc., although these measures proved only partially effective. Besides, hill cutting and deforestation in Chittagong city are very much communal as a consequence; landslides have created a major humanitarian problem (Ahmed & Dewan, 2017). Landslides cause precious life and property damage, loss of natural scenic beauty, economic loss, etc. (Mia et al., 2015). During the rainy season, the soil erosion rate highly increased as a consequence, drainage increased rapidly, and channels and sewers were clogged with sediment (Barua & Van Ast, 2011) due to waterlogging in Chittagong city (Papry & Ahmed, 2015). High magnitude of property damage and economic loss are very much common because of waterlogging. It has become a common hazard in the highly urbanized coastal city of Chittagong (Islam & Raja, 2021).

The garden city program is an initiative scheme of urban planning. It was introduced in 1898 by Sir Ebenezer Howard in the UK for a sustainable city environment (Richert & Lapping, 1998). Garden cities were proposed to be planned, self-reliant societies surrounded by "greenbelts" (Thomas, 1963) containing proportionate areas of dwellings, commerce, and cultivation (Sundar et al., 2019). A green belt label is a planning tool (Burat, 2000) and green belt policy aims to prevent the urban municipality (Taylor et al., 1995) from keeping land eternally open. This includes investing in public transport, creating green public spaces, and improving urban planning and management through participation and integration (Hong & Guo, 2017). Currently, more than half of mankind lives in cities, by 2050 two-thirds of the world's people will live in cities. Sustainable development cannot be achieved without a major change in the way we build and manage our urban spaces. In many countries, the introduction of the green belt can be considered one of the best-known international policies that manage urban growth (Han, 2019). The green belt has ringed larger cities to keep them from spreading (Kardani-Yazd & Daneshvar, 2019). Planners are trying to steer urban growth towards sustainable land use. They must see green zone policy as a tool to promote urban growth (Dey & Greeshma, 2014). With the increasing recognition of the nature of the urban and urban service environment, the integration of an ecological, social, and economic understanding of urban services into relevant policies and sustainable urban development is still in its infancy (Chen, 2017). Although controlled and integrated urban satisfaction measures have only emerged over the last two centuries, green space has become an integral part of urban history, regardless of time and place.

Beautiful cities have a long-term landscape because they understand the city's attractions in addition to being

able to solve modern problems (Feng & Tan, 2017). Nowadays every city around the world tries to promote improving the quality of life in the city through good infrastructural progress of urban green space (Erell, 2017; Bilgili & Gökyer, 2012). In the green spaces of the city, it is believed that hot temperatures can drop, reducing the heat island effect, depending on the main planning process (Bowler et al., 2010). A green city has long been a concern in the history of urban development. The vegetation in the city is the most powerful, and nature has become an integral part of the city and its intended management (Feltynowski et al., 2018). For the city of Chittagong, it is very much essential to the development of various infrastructural expansions by enlarging the boundary of urban green space for a sustainable urban environment. This study explored the various urban green infrastructure development issues for a sustainable urban environment in Chittagong city. The background studies revealed that the green spaces. especially natural hill forests in 1989 which had 18.89% land coverage, had in 2011 been reduced to 15.93% (Hussain, et al., 2016). Moreover, coastal green belts are depleting at an alarming rate in the name of development activities, hill cutting, and soil erosion have resulted in severe drainage blockade and flash floods, as well as frequent cyclones, storms, and tidal surges, have occurred in Chittagong city.

Chittagong City is not only the principal city of the district of Chittagong but also the second-largest city in Bangladesh. It is situated within 22°-14' and 22°-24'-30'' N latitude and between 91°-46' and 91°-53' E longitude and on the right bank of the river Karnaphuli. Chittagong Municipality area is bounded on the west by the Bay of Bengal. It consists of twelve police stations and part of the Hathazari police station (Thana). According to BBS, the area of Chittagong City is 209.66 Sq. Km. (CCC Census, 2001). Being a major contributor to national exports and imports, Chittagong has become a thriving city with strong linkages to the domestic economy. According to the Bangladesh Bureau of Statistics (BBS), the total population of Chittagong city was 400, 9423 (Male: female, 2203377: 1806046) in 2011 (Mia et al., 2015). Amongst them, the floating population is 542,965 people. With production accounting for over 40% of national industrial output in 2012, the Chittagong Export Processing Zone (CEPZ), which employed over 150,000 employees, contributed more than 50% of Bangladesh's tax revenue earnings and Chittagong contributed 11% of Gross Domestic Product (GDP). The climate of Chittagong is very favorable for plants and animals. Heavy rainfall has contributed to the growth of diversified plants. At present, 13.26 sq. km (9.97 percent) of vegetation coverage is available within Chittagong city (Haider, 2020). Considering the national importance and research gap, the objective of this research was to investigate the existing actions for green infrastructure development in Chittagong Development Authority (CDA) as well as to compare with some similar types of cities based on physiographic conditions, economic activities, and planning issues around the world; specifically places with urban green in the green belt and wedges along with urban environmental issues and design aspects.

2. Methodology

The research methodology is a systematic way to solve research problems. This research reviewed the Chittagong Development Authority's (CDA) Master Plan from 1961 to 1981 and 1995-2015, Detailed Area Plan (DAP), and a significant number of journal articles, books, and reports, as well as field observation. A comprehensive description of each method is given below.

2.1 CDA Master plan

The Chittagong Development Authority (CDA) made two master plans for city growth in a planned way. The first one was from 1961 to 1981 for 20 years duration and the second master plan was prepared in 1997 but officially executed from 1995 to 2015. These two master plans were evaluated on how they planned regarding urban green spaces and environmental management.

2.2 CDA Detailed Area Plan

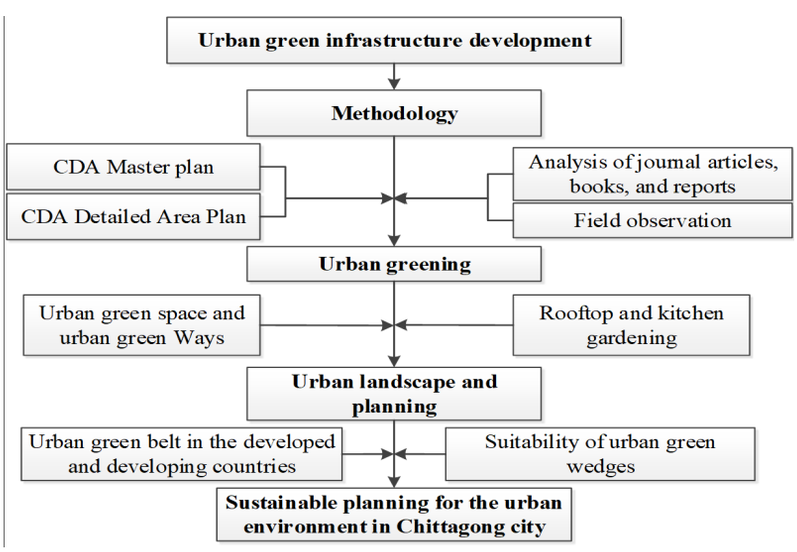
The Structural Plan (1995-2015), consists of a series of policies for twelve sectors and outlines urban areas (1995-2005) and contains a broad framework to encourage development control and coordination. The detailed area plan (DAP) contains some policy recommendations to protect and improve the environment for a sustainable, habitable, and environmentally friendly city. The DAP emphasized conserving the existing green cover of the city. The DAP, in achieving a sustainable urban environment, proposed building a green belt along the coast, front line of the river, and edge of Khals (canals), with the rest of the open areas in the process of planning an individual development framework. Moreover, the plan supports knowing about the present condition of the green spaces specifically the green belt and green wedges area of the city.

2.3 Analysis of journal articles, books, and reports

The study also reviewed a significant number of research articles published in scientific journals around the world and compared them with the condition of Chittagong city. A more in-depth investigation was conducted by using the best available comments from the published and unpublished books and reports.

2.4 Field observation

The city is the hometown of both researchers. Being a researcher on geography, regional planning, and the built environment, the development activities and trends, existing green space, and depletion issues were observed from 1993 to date in Chittagong city, Figure 1 displays the framework of the research, and figures 2 displays the location of the study area in Chittagong, Bangladesh.



Note: CDA –Chittagong Development Authority

Figure 1 Framework of the research

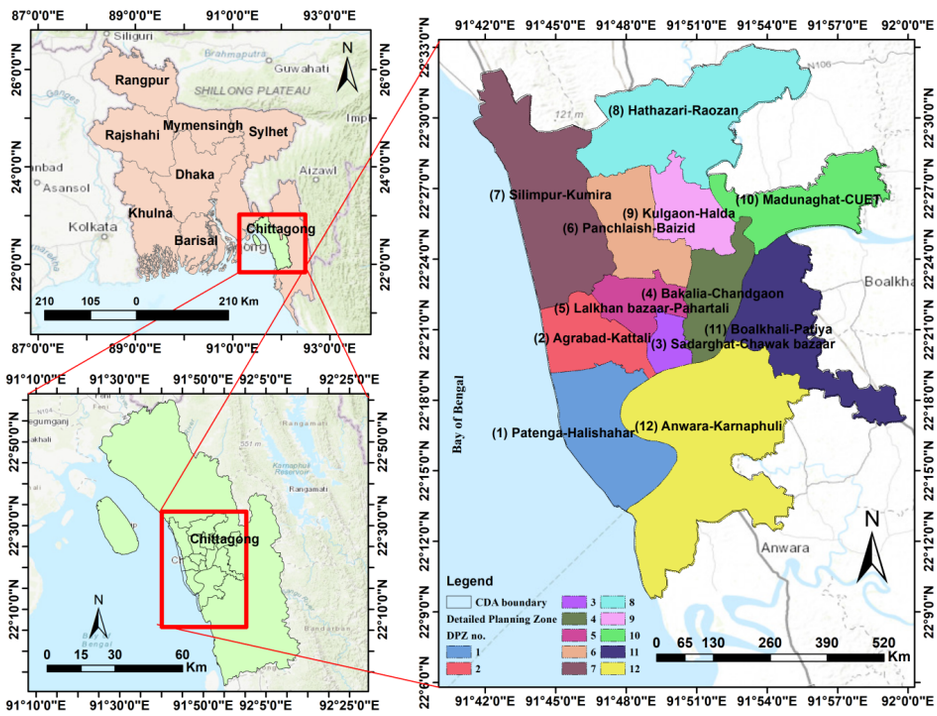


Figure 2 Location of the study area

3. Urban Greening

Urban greening is very important for sustainable urban environmental management. Urban geographers, environmentalists, urban planners, and architects have proposed a green web system of green segments, grounds, and green passages at the city level. This green network benefits to limit future urban extension (Li et al., 2005), expanding city green quality (Wachsmuth et al., 2016), and oblige as habitats and migration ways for nature. Urban greening includes a joint effort to improve public health, adjust climate change, and the effects of organic farming in large urban areas which also affects trees (Niemelä et al., 2010; Lyytimäki & Sipilä, 2009). However, the evidence for the cooling effects of green spaces is mainly based on observational studies of a small number of green spaces (Bowler et al., 2010). Moreover, Werner and Kelcey (2017) described three methods for representing different scales, i.e. urban area, urban indicators, and green spaces. These three perspectives provide a better understanding of the relationship between urban green and biodiversity and provide an optimal governance platform for enhancing biodiversity in urban areas. Urban greening helps to control air and noise pollution (Wolch et al., 2014), soaks up rainwater that may otherwise create flooding, and creates a habitat for local wildlife. By employing urban greening, these infrastructures contribute more to the environment and the people using them (King & Shackleton, 2020). The green infrastructures of the natural environment section identified ‘in preparing plans to meet development need to minimize pollution and other adverse effects on the local and natural environment (Upton, 2019). Thus, strategies must assign terrestrial with the least environmental or feature value’ for the formation, safety, and supervision of systems of biodiversity and green infrastructure. The green wedge designation is significant locally with multifunctional green space identity, providing a green lung into urban areas and a recreational resource, promoting physical activity and public health (Wolch et al., 2014). Several types of natural and manmade urban greening activities are observed in Chittagong city but the quantity and volume of urban greening are not increasing significantly considering the requirement, given efforts and investment. Therefore, several scholars recommended the development of

urban green infrastructure that will be an appropriate way to plan for sustainable urban expansion in Chittagong city, anchoring the environment and urban conditions (Islam et al., 2020).

3.1 Urban Greenspace

The history of urban planning and green space began in Europe and America (Clark, 2006; Loughran, 2020) in the early 1800s. Urban green spaces in city zones vary in coverage from the high maintenance urban park to natural areas and barrier spaces between noisy infrastructure and other land use. From such a degree of heterogeneity in the type of green spaces, it follows that the benefits produced by different green space provisions vary greatly. Wang (2009) described most of the problems related to urban landscaping arise due to ignorance of the features of the urban landscape and the determinants of the urban planning system. Moreover, urban areas may have rich vegetation (Sukopp & Werner, 1983) that contributes significantly to biodiversity (Bretzel et al., 2016), but habitat loss and isolation (Pardini et al., 2017) from urban sprawl threaten biodiversity and require boundary building. The connection provided by the urban green space provides habitats and corridors that help conserve biodiversity. Urban green networks can simplify and improve complex landscapes, understand the importance of individual green spaces, and guide urban planning (Kong et al., 2010). Additionally, green areas produce the social benefits of urban spaces, including recreation, as well as adjust aesthetic pleasures and physical health from time to time and create social links, and improve educational opportunities. Analysis of current processes specifies that the green zone is measured by only one of the preselected elites. On the other hand, Jansson (2014) proposed that green spaces provide various characteristics in compact cities for the effective improvement of urban areas and also mentioned the contribution of ecosystem services and the need for descriptions of valuable green space qualities including properties and potentials. Besides, Taylor and Hochuli (2017) have determined an initial concern in the influence that biodiversity and ecosystem have on life in urban spaces.

Furthermore, the coming century will see a substantial majority of the world's population live in urban areas. The World Health Organization (WHO) and the United Nations (UN) have developed policy frameworks and directions that encourage the enlarged provision of city green space for the health of the population. Green spaces are generally required to be preserved as a regular environment type (Miller et al., 2015). To accumulates and review the evidence linking health, well-being, and green space using a life course approach (Douglas et al., 2017). Wolch et al. (2014), explained that the cities in the US and China have developed innovative ways to create new green spaces. Green spaces in urban settings can help to address public health concerns related to obesity, cardiovascular effects, mental health, and well-being. In determining the efficiency of urban green space interpolations to enhance healthy urban environments, the WHO regional office for Europe assessed environmental health impact involvement for well-being and equity (WHO, 2017). In Europe, it is estimated that nearly three-quarters of the population are living in urban settings by 2020. Urban living limits access to the natural environment and can increase contact with certain environmental threats, such as air and noise pollution. These issues must be addressed for municipalities to deliver quality and sustainable living environments (WHO, 2017). While cities around the world are struggling to keep a standard amount of open space, the WHO suggested a standard of nine square meters per capita; whereas the cumulative existing open space in Chittagong is only 0.18 square meters per person (Jafrin & Beza, 2018). Furthermore, Jafrin and Hossain (2019) designated that when the first regional plan in Chittagong was formulated, it proposed 26 new parks and other open spaces to meet the needs of the city's population. The planned accumulated zone to

deliver for these spaces contained 2935 acres of land, which was mostly scattered around the city in small parcels. This manuscript is of particular importance because it noted for the first time, the city's lack of community parks, playgrounds, and small children's composition parts (Jashimuddin & Alamgir, 2005). Table 1 shows the geographical dimensions, perception, and forest coverage for different Asian cities.

Table 1 Different Asian cities' geographical dimensions, perception, and forest coverage

City indicators	Chiang Mai, Thailand	Tehran city, Iran	Kathmandu, Nepal	Bandarban, Bangladesh	Chittagong city, Bangladesh
Geographical dimensions	Middle position in the Ping and Kawila river	Near the Mount Tochal	The northwestern part of the Kathmandu valley to the north of the Bagmati river.	Near the Sangu river	Karnafuli river on the southern bank and the Bay of Bengal on the city's western side.
City area	40.22 sq. km	730 sq. km	49.45 sq.km	51.8 sq. km	168 sq. km
City perception	Northern capital and major trading routes	Capital of Iran and business hub	Capital and the city of Temples	District city and exotic tourist attractions spot in Bangladesh	The coastal port city and the financial hub of Bangladesh
Forest land coverage	The city of Chiang Mai has 50.62% of forest land coverage	The total green space within Tehran stretches over 12,600 hectares covering over 20 % of the city's area	Most of the area is less suitable with 78.87% of the area in its current state and the remaining 9.47% of the area is not suitable for the development of greenery	In 2018 in the Sadar Upazila areas, the forest coverage areas are 69.41%	Hill with a vegetation coverage area of 2517 hectares and 15.93% land coverage in 2014

Note: Sadar Upazila- An administrative area in Bangladesh; Drawn from-Sangawongse (2006); IRNA (2021); Pokhrel (2019); Mamnun & Hossen (2020); Hussain (2016).

Along with Chittagong city, four more hilly cities from South and Southeast Asian countries, considering the geographical condition and green spaces were reviewed. It was found that the city of Chiang Mai has 50.62% forest cover and is one of the major functional trading centers in Thailand. Moreover, near mount Tochal, the city of Tehran functioned as the capital and business center of Iran, where it has almost 20% vegetation coverage although the city area is so large. Kathmandu, Nepal, is 4.47% and 7.19% respectively high and moderately suitable for the urban greenery, and as a result, large sections of the general people cannot access the open space. In contrast, Bandarban Sadar Upazilla has almost 69.41% greenery though Chiang Mai, Kathmandu, and Bandarban have almost the same land area. On the other hand, the city of Chittagong is facing various urban greenery contextual issues because it has only 15.93% of green spaces although naturally organized various vegetation coverage were in the hills in the past.

Moreover, vegetation and agriculture remained the major land cover classes in Chittagong city; however, their areas of extent were declining at a rate of 3.75 and 0.86 % per annum, respectively (Hassan & Nazem 2016). Urban structures (20.83%), water bodies (5.96%), bare lands, and other lands (16.67%) coverage also significantly changed due to the increasing urban infrastructures (58.93%) leading to rapidly decreasing vegetation and the vegetation coverage was 20.24% in 1989 (Gazi et al. 2020). Also, the hill with vegetation coverage area was 18.89% in 1989 and in 2014 it decreased to 5.93% (Hussein, et al. 2016).

3.2 Urban Green Ways

Greenways are the systems of planned, designed, and managed lands (Ahern, 2002) for several purposes including environmental, recreational, visual, and economic purposes (Baschak & Brown, 1995). The 'green' in 'greenway' originated from 'greenbelt' and the 'way' from 'parkway' (Little, 1995). This approach of urban greening supports the practice of 'greenway' to designate the rectilinear community exposed space in whichever countryside or urban region. Moreover, Ahern (1995) proposed three essential welfares of greenways: co-occurrence of resources (Büchs et al. 2009); the characteristic aids of landscape connectivity (Ndubisi et al. 1995); and the conception of compatible, or numerous habits in greenways for landscape/greenway arrangement is proposed constructed on a substitute future situation method (Rottle, 2006). An inspection of greenway planning in the USA was directed which found that greenways are progressively united with comprehensive landscape planning in the USA, and greenways are often commenced to provide trail and recreational use (Bin-yi & Chang, 2001) but evolve to support multipurpose/multi-functional planning for urban management. It is important to protect public safety while providing the necessary public support for the successful integration of the natural green line into urban infrastructure (Luymes & Tamminga, 1995). According to Salici (2013), greenways were devised by inspiring urban analysts and the greenways were enjoyable links. However, they do require to be directed, for relaxation or commuter practice, and have as prerequisite, good eco-friendly ability in the sense of having well-designed surroundings free from traffic noise, air pollution, and ugliness. Also, Haaland and Van (2015) revealed the route aims to compensate for the negative effects of urban sprawl on inefficient land use and related environmental problems through reliable and compact buildings.

In this regard, Roy and Hoque (2016) opined about the administrative capital of the largest city of Bangladesh, Dhaka where its green resources declining rate was very rapid. They identified various issues for the reasons for the loss of green resources in Dhaka city including the transformation of existing green areas or open spaces for other land use purposes, unplanned development and unsuitable planning, a quick increase in urban population, and lack of maintenance actions for protecting the prevailing green space. On the contrary, two indicators, namely accessibility, and quantity need to be reviewed and focused on as they represent dimensions of the existing open space shortage currently being addressed in the city's planning proposals and little material is found on the level of satisfaction of safety and security of parks and playgrounds in Chittagong city (Hassan, 2008), although urban green space delivers a healthy atmosphere to city residents as well as ecological reliability.

3.3 Rooftop and kitchen gardening

A roof garden is a concept that has been around since there were roofs. City dwellers have been putting plants on roofs and escape stairs for several generations. Green roofs, roofs covered with soil and plants, have also been around for years (Baudoin et al., 2017). It seems that no matter how much land a gardener has, we always seem to be looking for more space, and roof gardens of all kinds are gaining popularity (Barreca, 2016) in both residential and commercial locations (Datta, 2020). With the speed of urbanization, the built-up area increases (Li & Zeng, 2004). This also increases the supply of roof space. Growing food on roofs can provide a solution to increased food demand (Astee & Kishnani, 2010) and can also contribute to a sustainable and vibrant city. Almost a third of the buildings (36.4%) include rooftop gardening, which depends on the aesthetic sense and moral values of individuals in the city of Dhaka (Islam et al., 2019). Fresh and safe local food can be produced from rooftop gardens (Safayet et al., 2017). Rooftop gardening is an important element in making cities more sustainable and livable, although it is not the overall solution for cities with food security issues

(Chowdhury et al., 2020). Urban rooftop gardening is a practical way of sustainable urban planning in Chittagong that integrates the environment and urbanity into sustainable urban development (Islam et al., 2020). On the other hand, kitchen gardening is an innovative idea to provide immediate help to residents by producing fresh vegetables that they produce themselves (Mohsin et al., 2017). Another study revealed that for households geared toward urban green infrastructural development only 7.46 % have plants on their premises but 27.91 % have a garden on the rooftop in Chittagong city (Islam et al., 2020). The field observation and literature review revealed that rooftop and kitchen gardening has immense potential in Chittagong city. More than two-thirds of the roofs of the buildings currently vacant could very easily introduce rooftop gardens that will also contribute to urban greening and sustainable urban development in Chittagong city. Additionally, a vast amount of barren public and private land is also found in the city where during the entire year kitchen gardening could be performed to contribute to producing fresh vegetables and fruits.

4. Urban Landscape and planning for the sustainable urban environment in Chittagong city

Currently, landscape planning is an essential element in sustainable urban development. It is valuable for environmental amenities and green urban areas. It delivers community and inner services that are very significant for modern cities and the well-being of urban natives. The rapid growth of urban population and development made it part and parcel to make the city livable and environmentally friendly. Urban local government and development authorities are taking several initiatives such as green infrastructure, urban green belt, and landscape planning, amongst others, for the sustainable urban environment of Chittagong city. The subsequent sections discuss green infrastructure, urban landscape planning, sustainable planning for the urban environment, an urban green belt in developed and developing countries; urban green belt and its alternative; and the suitability of urban green wedges.

4.1 Green Infrastructure

Continued degradation and dilapidation of green spaces in urban and rural areas can have an impact on the environment as well as human health and well-being (Tzoulas et al., 2007). Green infrastructure redesigned and built primarily with hybrid or design networks to expand and integrate green spaces could provide a friendly environment (Ahern, 2007). Green infrastructure contributes a lot to health planning solutions, climate change, revitalization, or sustainability of the environment, (Mell, 2008). Amati and Taylor (2010) found the recent policy changes in the UK and Canada and showed how green belts are being conceived more broadly to include the concept of green infrastructure. This is a procedure not simply for preservation but contributes to incremental revision of the green belt (Mace et al., 2016). It can easily contribute to the development of urban green but its application in urban areas is limited by many solutions. Also, green roofs transform the negative aspects of an empty landscape into beautiful greenery, as well as provide a new opportunity for a better range of service environments (Jim, 2017). Competition for space and the environment often limits the construction of urban farms in many parts of the city (Lin et al., 2017). Finally, sustainable management should be based on ecological principles to restore natural processes and factors and promote the natural recovery of degraded areas. Protection strategies can focus on maintaining large forest areas, expanding existing areas, connecting small woodlands with habitat corridors, and connecting with adjacent natural areas. A new forest can be proactively created on suitable green, brown, and grey fields (Jim, 2017). Ensuring the quality of the

environment is very important for the city. The loss of ecologically significant areas or vegetation is also observed in this plan. Policies for identifying and protecting ecological priorities extend to forest areas and protected coastal areas. In addition, the study expanded knowledge about the city's environment and its structure (CDA Master Plan, 2015). Table 2 displays the various types of urban green infrastructure and their functions.

Table 2 Types and functions of urban green infrastructure

Green infrastructure	Function
Urban greenways	Greenways are a general term for the representation of a common highway along a strip of developed land, connecting open and green spaces and providing growth in urban consistency. Greenways are often built on unused railways, canal trails, utilities, or similar passages or abandoned industrial sites.
Rooftop and kitchen gardening	A private eco-friendly venture that provides a chance to be close to nature in addition to the practice of cultivating food in the house area or rooftop.
Urban green belt	The main purpose of the green belt is to protect the land from urban sprawl and preserve designated areas for forestry and agriculture as well as provide a habitat for wildlife.
Urban green wedges	The green wedge plays a vital role as a new element in the design of park systems, the aim of which is to limit the spread of built-up areas beyond the prescribed boundaries of settlement and allocated localities.

Drawn from Lovely (2020); Baudoin et al., (2017); Ramesh, et al., (2014); and Oliveira (2014).

4.2 Urban Landscape planning

The dynamics of land-use change in urban-rural areas and their interactions with the natural environment and ecosystem function frequently reshape the urban landscapes (Verburg et al., 2000). In addition, land-use conflicts are of particular concern for landscape planners in metropolitan areas. It contributes to the conclusion by presenting the typology of land-use conflicts for a peri-urban area in a country. Von der Dunk et al. (2011) identified six significant types of peri-urban land use exemptions as "noise", "burns", "health risks", "conservation", "protection of the past" and "loss of change". With growing awareness of human interaction with nature, planning and design experts are now making more careful efforts to implement green spaces in established environments. The fields of urban planning, public health, and park planning explain in detail the role of urban greening in the well-being of populations (Vogt et al., 2017). The ecological network is based on the concept of network, space, and landscape integration. The uses of landscape ecology and remote sensing technology for biodiversity conservation and analysis are essential to explain how tools can be developed for environmental networks and their functions in biodiversity management (Hamid & Tan, 2017). In Chittagong city, it contradicts the regional plan to reduce green coverage from 46.20 to 32.56%. Therefore, in achieving consistent and sustainable buffer zone management practices, effective coordination of land management is very much significant (Al Mamun & Kim, 2020).

4.3 Sustainable planning for the urban environment

The significance of sustainability and resilience is due to modern urban planners and certain designers who argued that modern life uses many natural resources that pollute or destroy ecosystems and increase social inequality and create and cause urban islands. This is why many urban planners support sustainable

city development programs, especially green city initiatives. There have been several programs implemented in various countries around the world to protect and preserve the environmental systems (Brunner & Kaminski, 2012). Due to the rapid development of the social economy, Chinese people experienced the positive effects of urbanization. They also face several challenges and threats such as severe air pollution, water pollution, waste pollution, soil deformation, floods, and other disasters. China adopted several green programs to save and protect the urban environment due to rapid urbanization in improving the development and ensuring a good ecological environment (Xu & Yang, 2013).

It is important to evaluate and monitor the environmental protection plan after the implementation of the city plan. Another example of green alleys infrastructure development through green programs is seen in seven US cities which was very much noticeable, particularly its sustainable design. Exploring the Green Agenda in Los Angeles shows how a stronger commitment to sustainable development by taking into account the goals of environmental protection, economic development, and social justice, can be updated as part of green efforts (Newell et al., 2013).

Another example from a third-world country like India, a local green indicator should be developed, which should be included in urban planning. The projected green indicator will be revised taking into account the real situation in Gulbarga, India. The study results showed the possibility of an alternative green cover when the green indicator is always low emphasizing that urban planning replaces all green features (Anguluri & Narayanan, 2017).

According to Wantai and Calthorpe (2012), for city structure and management, it is very much important to maintain seven principles for a sustainable urban environment such as preserving the natural ecologies, agrarian landscapes, and cultural heritage, which are the first and foremost criteria, and these will be connected to a street network with a focus on appropriate density and transit capacity with designed walkable streets and human-scale neighborhoods. It is scientifically evident that a greening environment or greening infrastructure is very much important for a better living environment and sustainable city growth. In this connection, Chittagong City Development Authority and urban local government took initiatives through their Master plan and detailed Area plan first from 1961 to 1981 and second from 1995 to 2015. In the detailed area plan, CDA specifically identified twelve zones and proposed building a green belt in Chittagong city along with coastal areas, riverbanks, canal sides, etc., although the rate of success was insignificant and in some demarked zones it showed zero percent of implementation.

On the contrary, field observation reviewed the individual locations of the city and found a very significant change in the urban environment in Chittagong city. Specifically, in the areas of DPZ 1 (Patenga-Halisahar), DPZ 2 (Agrabad-Kattali), and DPZ 7 (Salimpur-Kumira) coastal green belt rate decreased significantly due to various infrastructural developments such as the building of a new highway, rapid growth of the informal settlement, and unplanned industrialization, etc. In the DPZ 6 (Panchliash-Baizid) region, the construction of the Baizid outer ring road is one of the major reasons for the depletion of vegetation coverage in the hilly area. Moreover, in the DPZ 12 (Anwara-Karnaphuli) and DPZ 8 (Hathazari-Raozan) areas, the city extension rate was found to be high because of various development infrastructures, unplanned urbanization, and consequently, the vegetation coverage is decreasing day by day at an alarming rate. Therefore, greenways, green belts, green infrastructure, green wedges, and green corners are needed to further investigation in Chittagong city.

4.4 Urban green belt in the developed and developing countries

The green belts in many countries can be seen as one of the most internationally recognized attempts to control urban growth (Kardani-Yazd et al., 2019). Green belts have encircled large cities to keep them from expanding (Amati 2016). Green belts had a significant impact on urban economic development and urban eco-function and achieved higher efficiency in the use of services by ecological services lowering the air temperature (Horaginamani et al., 2012) and also increasing the relative humidity when the canopy density reaches more than one-third of the city area (Chun-yang et al., 2011). Moreover, green belts can help to reduce the deadly effects of cyclones and storm surges and could act as a shield. Many experts opined a green belt of sea mangroves is recommended in Chittagong city, stretching from the riverbank to the low-water line. Except on the coast of Karnaphuli, there should be a buffer zone (green zone) in the Salimpur-Kumira area. In the city of Chittagong, which stretches along the banks of the Halda River, a narrow strip of 100 meters is designated as an ecological zone. Considering the existing spectacular riverside view of the Karnaphuli and enhancing the physical environment quality of the city on the bank of the river, establishing a green belt is an essential initiative. In the riverbank area, a forest would be rich in biodiversity and used as a wildlife reserve and sanctuaries. In addition, in the Madunaghat to Chittagong University of Engineering and Technology (CUET) area (DPZ-10), a 100-meter wide green belt is proposed along the Karnafuli waterfront. Furthermore, in the Anowara to Karnafuli region, the green belt also implied that all major khals (natural drainage) should be a buffer zone for the green belt, up to 30 meters wide on both sides (DAP-2015).

In comparing the green concept practice, seven cities and their urban planning and development were reviewed including Chittagong city. We know green belt initiatives were firstly adopted in 1935 in London for a reserve supply of public green spaces beside the new settlement planning in the city fringe area. After that, a green revolution was seen in Ottawa to protect urban heritage with functional planning which delineates the rural-urban fringe. On the other hand, the cities of Boise and Victoria-Gasteiz developed a green belt focused on ecologically-based recreation and aesthetic appraisal in their peripheral areas. However, in Asian cities like Seoul and Beijing green belts were used to prevent urban sprawl and also significant land use planning. In the city of Chittagong, coastal green belts were naturally developed with their aesthetic value but in recent decades, the belt depleted day by day in the name of development issues especially coastal embankment and Asian highway construction along the Patenga seaside area. Table 3 shows the green belt perception among the various comparison cities.

Table 3 Green belt perception among the various comparison cities

City name	London	Ottawa	Seoul	Boise	Beijing	Vitoria-Gasteiz	Chittagong
Date of urban green belt plan	1935	1956	1963	1968	1994	1990	(1995-2015)
Area (km^2)	5138.6	55	700	48 km	240	300	Specific data not available
Context	A reserve supply of public open spaces	Additional land for urban purposes and also the city's heritage	Satellite towns along the corridor between Seoul and Incheon in Korea.	Accessibility, safety, and aesthetic appearance were benefits associated with the pathway	Prevent the sprawl of urban areas	Strategically linked by eco-recreational corridors	Control natural tidal inundation and flood management
Green belt development name	Metropolitan green belt, London, UK	Ottawa green belt, Ontario, Canada	Seoul Green belt, South Korea	Boise green belt, Idaho, USA	Green Belt in Beijing, China	Vitoria-Gasteiz Green belt, Spain	Coastal/ mangrove greenbelt, Chittagong, Bangladesh
Response to the urban environment	A reserve supply of public open spaces and amusing areas besides launching a green belt or band of open space.	Including farms, forests, and wetlands and protecting the rural land bordering the Capital from haphazard urban sprawl.	Prevent industrial concentration in addition to reserving the land for environmental purposes and expansion of Seoul into neighboring cities, etc.	Recreational and alternate transportation trail along the banks of the Boise River through Boise, Idaho, United States.	The exploitation of land, building green spaces in the exploitation process, and cultivating green spaces through the green industry	Cultivated 210 organic farming plots, 97 km of cycle lanes	Protected by embankment from saline water, protection against cyclone and storm surges as well as erosion to the green walkway
Planning approach	Comprehensive urban environment planning	Land use functional planning	Government strategy to create new larger cities outside the green belt	Ecological approach	Agro-based residential approach	Ecological landscape	Naturally grown
Current status	New settlement-based approach and also the corridors/wedges policy recommendation	Connectivity of urban areas between the rural and natural environment	Significant impact on land-use planning in the southern part of the Han River	Take an active stewardship role in maintaining the health and ecological integrity of the Boise River Greenbelt	The first green belt could not contain the expansion of the city	Connecting element between the Green Belt parks located south and east of the city	A major portion of the green belt in the coastal area (south-west) is decreased

Drawn from- Green belt-politics (2020); Taylor et al. (1995); Yokohari et al. (2008); Han et al.(2017); Line (1996); City of Boise (2021); Miller, S. R. (2021). Yimin (2021);Yang & Jinxing (2007); Orive & Lema (2012); Aguado et al. (2013); CDA Detailed Area Plan (1995-2015).

4.5 Urban green belt and its alternative

Linking municipality areas and rural side areas in the periphery for urban growth led by positive management of the open space and green wedges strategy are alternative benefits of the green belt (DCLG, 2001). Yang and Jinxing (2007) think about the new dimension of Beijing city in China. Their study results show that the first green area was unable to stop the expansion of the city. Underestimation of urban growth and the lack of key stakeholders in the planning process are the two main reasons for its failure. However, linear green spaces can be placed more flexibly than green belts, and they can be used both to improve the ecological network and to stop the unnecessary urban network (Amati, 2016). Another comparative study revealed that some cities are suitable for green belts such as London which has the most famous and original green belt and some cities are appropriate for green wedges such as Stockholm because of their geographical positions (Kong, 2012). For agricultural and recreational purposes the Greater London regional committee established the greenbelt strategy in 1935, whereas Stockholm accepted the green wedge concept because of urban poly-centric expansion flexibility in its periphery region with the existing transport network system. However, the value of the 'green belt' as the most prominent model of green space planning is being widely questioned and an array of alternative models are being proposed. The green wedges, considered here as canals of green that run from the land to the center, not only go back to urban planning but also have a deeper history in the 20th century than many suspects (De Oliveira, 2017).

4.6 Suitability of Urban green wedges

Green wedges are an urban control mechanism planned to restrict the spread of constructed development exterior prescribed settlement borders and assigned sites. It includes the open areas around, and parts of settlements distinction between the settlement and build-up areas, and also for providing recreational opportunities. Moreover, the green wedges were seen as the dominating part of the green structure, while the green belt was seen as more of a complementary structure and a way of strengthening the connections between green areas that were at risk of being destroyed (Orveland, 2019). As a green belt cannot assure natural green spaces which are within walking distance of most people, in contrast, green wedges appear to offer people better access to natural green spaces while living close to inner-city facilities (Žlender & Thompson, 2017). Green wedges were introduced as channels with a green surface from the landscape to the center of a city. Moreover, the goal of the green wedges was to provide a healthy urban green space with deep connections to the country network (Lemes de Oliveira, 2014). In reducing the vulnerability due to flooding, CDA recommended in the city of Chittagong develop a green corridor along the inland side of the coastal embankment for native species other than mangroves. In the Patenga–Halisahar (DPZ-1) and Agrabad-Kattali (DPZ-2) planning zones there will be a maximum of 300 meters in width which can be reduced based on existing obstacles (DAP-2015).

The debate on urban development and open spaces for modern cities contextual issues specifically for the integration of traffic systems in Britain was accepted in the park system proposal in 1910. After that in 1930 Sweden, Stockholm city conventionally benefited from the recreation, biodiversity, and health-related issues by recognizing 22,249 km of green wedges. In Australia, the green wedges concept was employed in 1971 to protect native vegetation coverage in the urban growth boundary area in Melbourne city, as a result, the city neighborhood was ecologically improved. Returning to the compact city model and decentralization of the regional green spatial planning, Glasgow city (Britain) developed attractive urban forests and green spaces in 1999. The Chittagong City Development Authority defined urban green wedges in their master plan

from 1995-2015, in which green wedges were demarked in the Halda and Karnafuli riverside areas as well various ecological zones which contribute to protecting from salinity intrusion and tidal inundation. However, field observation found green wedges were declining gradually due to unplanned urbanization and lack of monitoring by the CDA in the city buffer zone, and illegal political intervention in implementing the master plan of urban greening. Table 4 shows the green wedges perception among the various comparison cities around the world.

Table 4 Green wedges perception among the various comparison cities around the world

City name	Glasgow	Copenhagen	London	Stockholm	Melbourne	Victoria	Chittagong
Date of plan	1999	2006	1910	1930	1971	1994	(1995-2015)
Area (km^2) of the city	Glasgow green wedges, Scotland	The green structure in greater Copenhagen green wedges, Denmark	Park system planning: the idea of green wedges in Britain	Stockholm wedges, Sweden. 22,249 km	Melbourne green wedge, Australia	Nillumbik green wedges Victoria, Australia	Halda and Karnafuli river-based green wedges, Chittagong, Bangladesh
Context	Return to the compact city or decentralized structure of the city region	Four green wedges and three green rings are located between the urban fingers.	Debate on urban development and open spaces for modern cities.	Continues almost in the city, more and more green spaces in the city	Green wedges are the non-urban areas of metropolitan Melbourne that lie outside the Urban Growth Boundary	Natural environment Green wedges are preserved and grown for current and future generations	Ecological zone (recommendation)
Development issues	Urban development issues for the urbanization and decentralization and to manage the processes of green wedges.	The city's fingers are separated by green defined as green wedges, which primarily serve the city's recreational purpose.	Indicates a green state in a soul-like form of Park systems in history. The green wedges have appeared as a basic typology of green.	A sustainable urban region with a healthy and sound population is dependent on green areas close to residential areas	Green wedges adapted while helping to meet current challenges, such as quality urban green spaces, and the pursuit of sustainable urban development	It includes Kinglake National Park and land used for agriculture, conservation, tourism, and rural living.	Protected from flood (tidal inundation) and storm.
Response to the urban environment	Metropolises and settlements that require new design today.	A multifunctional recreational landscape with high value for citizens.	Transmission lines to expansion zones and access to the network's exterior and interior.	Variety of benefits including recreation, biodiversity, health, and culture	Parks and conservation with native vegetation cover and also for airport buffers etc.	Highly valued locally and regionally for its biodiversity, natural beauty, rural living and open spaces etc.	The buffer zone of the green belt, protected from saline water intrusion, vegetation coverage area
Planning approach	Regional green structure and spatial planning	Regional and municipal planning policy	Park system planning approach.	Implemented at a larger scale of urban green networks	Eco-friendly urban development based	Sustainability and the precautionary principle-based	Structural recommendation.
Current status and future planning	Conurbation approach for improved access to attractive urban forests and green spaces.	Future green structure enlargement.	Precedents concerning the green wedge idea and history of park systems and integration into traffic systems.	Regional Development Plan for the Stockholm, RUFS 2010	To enhance attractiveness and prosperity for the good of residents, companies and visitors.	State green wedge policies contained in Plan Melbourne 2017-2050	Vegetation coverage rate declining in the area of both wedges

Drawn from- Frey (2000), Åkerlund (2011); Caspersen & Olafsson (2010); Lemes de Oliveira (2014); Xiu (2017); Thatcher (2015); De Oliveira (2019); Melbourne (2030 Thatcher, A. (2019); Detailed Area Plan (1995-2015).

5. Conclusion

Green spaces generate a good environment and aesthetic values for the urban neighborhood. Urban greening helps combat air and noise pollution, absorbs rainwater that could otherwise lead to flooding, and creates a habitat for native wildlife. In recent decades, the urban planner also planned differently for the increasing growth of city development by green wedges. It's also the alternative for a sustainable urban environment in developing and developed countries. The city of Chittagong has recently been enlarged on the northwestern side from Salimpur to Kumira, and Hathazari to Raozan, and lightly on the south-eastern side from Anwara to Karnaphuli River. Urbanization without greening the city can have many social and physical consequences for its inhabitants. The study identified the green index of smart urban design as well as urban natural ecologies and its green environmental strategy network development concerning landscape planning and design. It was also discovered that urban green belts and greenways are very much essential for the sustainability of urban settlements. It is also known that planning of the effective green belt and wedges development is a very concerning issue for the development and control of the over urbanization in Chittagong city by protecting the embankment from salinity intrusion and conserving ecological zones to the walkway which is essential for the city's structure. The study also exposed that urban green belts and green wedges were declining trends due to development activities, lack of monitoring by the CDA, and illegal political intervention in implementing the plan. As the city planning authority proposes the development of urban green infrastructure including green belts, green wedges, parks, etc., the outcomes of this research will help the CDA, urban local governments, etc., to identify suitable sites for green belts and green wedges and their appropriateness for a sustainable urban environment in Chittagong city. Therefore, a local green indicator should be developed and included in urban planning in Chittagong city.

Author Contribution

Conceptualization, S. M. Hasan and M. A. Haider; Methodology, S. M. Hasan and M. A. Haider; Validation, S. M. Hasan and M. A. Haider; Formal analysis, S. M. Hasan and M. A. Haider; Investigation, S. M. Hasan and M. A. Haider; Resources, S. M. Hasan and M. A. Haider; Data Curation, S. M. Hasan and M. A. Haider; Writing - Original Draft, S. M. Hasan; Writing-Review and Editing, M.A. Haider; Visualization, S. M. Hasan and M. A. Haider; Supervision, M. A. Haider; Project administration S. M. Hasan and M. A. Haider; Funding acquisition, S. M. Hasan. All authors have read and agreed to the published version of the manuscript.

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