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Urban Ecology and Eco-Sustainability: A Framework for Urban Sustainability of Dhaka

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Abstract

Ecological study targeting urban sustainability needs to ensure urban development in a manner that a city can achieve social and economic advances without damaging its natural environment. This paper evaluates and highlights the importance of urban ecology and eco-sustainability for sustainable use of ecosystem services within a city to ensure its urban sustainability. The study provides an ecological framework for urban sustainability of Dhaka primarily based on secondary data and information, although some information has been collected from primary sources as well. The paper illustrates that the image of Dhaka is not derived from its concrete parts like buildings, roads etc., it is much deeper and more fluid, that is, its people, pattern of spaces and activities therein, the relationship between the living and nonliving part of its environment, time, space and people. The ecological framework recognizes that the Plantation, Compensatory Greens or Garden, Green Urban Corridors, Green Urban Pockets or Vegetated Roofs, Green Roofs, Urban Landscaping, restoration of Natural Drainage System and creation of adequate water bodies are general approach to mitigate some of the losses of biomes, productivity and the biodiversity. The natural systems of Dhaka need to ensure its sustainability with the active participation of its community.

Introduction

Urban is simply a complete opposite of the natural ecosystems, which is normally void of people, built structures, and where interactions between and among organisms and between organisms and their environment occur apparently without any human interference and persuasion. On the contrary, the understanding of urbanized areas as human dominated, high density of population, buildings, traffic systems, made them appear detached from the natural ecosystems, despite the fact that bio-geophysical processes taking place in both urban and non-urban areas are essentially the same and there is no true isolation between the two (Simonaityte, 2013). Even though impermeable built surfaces and people's socio-economic activities define the cities, with learning more about the urban system it has become clear that it is the effect these two major components have on the ecological and environmental processes that makes urban ecosystems unique and effectively different from natural environments.

Urban ecosystem consists of several interlinked subsystems – social, economic, and environmental – each representing a complex system of its own and affecting all the others at different structural and functional levels (Kang and Xu, 2010). On the other hand, urban development is a major determinant of ecosystem structure and obviously affects the function of natural ecosystems through human activities such as the conversion of land and the depletion of natural resources, the discharge of emissions and waste etc. (Bolund and Hunhammar, 1999). Escort with the acceleration of urbanization

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and increasingly development of economy, a series of problems in urban ecosystem have increasingly become serious, such as heavy air pollution, ecological degradation and scarcity of various resources and so on (Savard et al., 20005). In contrast, the physical environment in urban also provides significant services to the human population in urban areas, i.e. biodiversity conservation, water supply and air refreshment and so forth (Kang and Xu, 2010). Therefore, it can be said that the linkage and feedback between the human and natural components of urban ecosystems are key attributes of the integrated ecosystem (Stewaedt and pickett, 1997).

At present, the rapid urbanization of the human population raises concerns about the sustainability of cities. Sustainable development is a broad term generally thought to include equity, and economic and environmental concerns (Andersson, 2006). As the Brundtland report states, sustainable development "... seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future" (United Nations World Commission on Environment and Development, 1987). There are two categories of sustainability in an urban area, namely, i) urban sustainability or sustainable city and ii) sustainable urban development or sustainable urbanization. The terms "urban sustainability" and "sustainable city" may be used to define the proper use of resources, the protection of the natural environment, the least possible use of non-renewable resources, and the economic growth or a community's self-confidence, individual welfare, and the satisfaction of basic human needs (Shen et al., 2011). According to the United Nations Sustainable Cities Program, a sustainable city has continuing natural resources upon which its development depends (Rasoolimanesh, 2011). A sustainable city is free from any environmental issues that may threaten its development (Whitehead, 2003). According to Whitehead (2003), "the sustainable city represents an economic space within which the social, economic and ecological contradictions of capitalism are being managed and strategically addressed". On the other hand, sustainable urbanization and sustainable urban development apply to a dynamic process geared towards achieving suitable conditions that address environmental, economic, social, and governance sustainability concerns (Shen et al., 2011). However, this paper will focus on the urban sustainability of Dhaka city in view of urban ecology and eco-sustainability.

The study to present an ecological framework for urban sustainability of Dhaka is primarily based on secondary data and information. Some information has also been collected from primary sources through informal interviews of experts of different development organizations, i.e. officials of Department of Environment (DoE), Deputy Director (Planning) of RAJUK, Senior GIS Expert of DWASA, officials of National Housing Authority (NHA), Urban Planning Expert of UPPR, Slum Improvement Officer of Dhaka North City Corporation (DNCC), officials of the Bangladesh Meteorological Department (BMD), officials of Climate Change Cell, and officials of Department of Forest (DoF) to acquire relevant information, data and suggestions related to the coherent matters of the study. Varied information allied to biodiversity and ecosystem functions, the role of humans in ecosystems, landscape connectivity and resilience, open spaces, natural drainage system, climate change feature, residential vegetation and the ecological benefits of green roof in Dhaka city have been collected from various secondary sources as well.

Contextual Brief

The World Bank (2000) indicated that cities must be livable, competitive, properly governed, and bankable to achieve urban sustainability. Hence to ensure urban sustainability, cities should accomplish social and economic advances without damaging the natural environment. The environmental balance can come about by using a smart framework that combines the stated aspects in order to arrive at a city vision. The image of Dhaka is not derived from its concrete parts like buildings, roads etc., it is much deeper and more fluid, that is, its people, pattern of spaces and activities therein, the relationship between the living and nonliving part of its environment, time, space and people. Any space in an urban area outside the buildings constitutes urban open space and the design and management of these spaces are crucial to urban sustainability and image. A common notion is that ecosystem or biodiversity or eco-design is something outside the city boundaries, whereas 'green open space', 'parks', 'garden' etc. are found within (Mowla, 2005a). Population growth and urbanization creates pressure on these open spaces to be encroached upon for housing and circulation. This urbanization is not being managed properly causing unplanned encroachments contributing to deforestation, water logging, flooding, overheating, pollution of water, soil and air etc. A constant awareness of green dimensions of urban development at all stages of the design and planning process is likely to develop a smoother handling of eco-design matters. Instead of creating fleshy eco-design project areas, the enter city would be an eco-design area, perhaps more discreet, but also more useful and sustainable. Open spaces together with circulation areas in the city with their cooling effect acts like its lungs besides being used as active recreation and leisure areas for its citizens, needs conservation (Mowla, 2003).

Major problems in Dhaka city are overheating, pollution and water logging while dominant ingredients in the natural environment are open spaces, woods and water bodies and the environmental variables are temperature, relative humidity, air velocity, precipitation, soil-moisture and biomes. Other variables being almost constant for a given area it is seen that comfort and sustainability is directly linked to biomes (Mowla and Zereen, 2005). In contrast, the basic concept of ecosystem is that '*everything is related to everything else*', therefore, it is believed that a comprehensive approach of planning is needed for a stable urban system (Mowla, 2003). It is implied also that Ecological Corridors or Green Grids or Green Urban Corridors (GUC), Ecological Nodes or Green Urban Pockets (GUP) or Vegetated Roofs (VgR) and water bodies are general approach to makeup for some of the looses of the natural systems in an urban area. On the other hand, Eco-design approach does not reject high technology, but it is based on an ecological moral imperative '*take least from and dump least*' into the environment (Mowla, 2005a). Therefore, through thoughtful design and careful management of the development process and natural forces, even the largest structures can further the cause of more harmonious integration of the built and natural environment. Hence the paper aims to understand the concepts of Urban Ecology and Eco-Sustainability to provide an ecological framework for urban sustainability of Dhaka.

Concept of Urban Ecology and Eco-Sustainability

The terms Urban Ecology and Eco-sustainability are not synonymous. Because, Urban Ecology does not necessarily make value judgments about whether urban environments

are 'good' or 'bad'. Rather, Urban Ecology allows one to see what is happening in a community and, assist in developing ways to reach the goals that one would like to see in their community. On the other hand, any community needs go to, not just 'towards', eco-sustainability. For example, car can be driven safely or dangerously. And so can society. A society that is not ecologically sustainable is being 'driven' recklessly and that is not something we want to continue. While safety is not a 'destination' for a car, it is certainly a condition that we all want to achieve. That's way it is not good enough to just work 'towards' ecological sustainability for society as if it is not actually something we expect to happen. We have to work out how ecological sustainability can be achieved in a desirable time frame, and how it can be maintained as our society continues to evolve. The concept of Urban Ecology and Eco-Sustainability have described below:

Urban Ecology

Human ecology identifies itself with the human community, that is, with man's interrelations with other men. As the community grows larger, human ecology becomes synonyms with urban ecology. Urban Ecology can be defined in different ways. It describes urban design program or design that incorporates political, infrastructure (roads, sewers etc.) and economic considerations. Second, it refers to the areas of biology that is concerned with urban areas in terms of relationships, interactions, types, and numbers of species found within urban habitat (Mowla and Zereen, 2005). Urban Ecology is a subfield of ecology which deals with the interaction between organisms in an urban or urbanized community, and their interaction with that community. Urban ecologists study the trees, rivers, wildlife and open spaces found in cities to understand the extent of those resources and the way they are affected by pollution, over development and other pressures. Analysis of urban settings in the context of ecosystem ecology may ultimately help the urban designer to design healthier, better managed communities, by understanding what threats the urban environment brings to human life.

The Independent Community or major community or a town is self-sufficient, isolated, and adequate in population and possesses simple technology (Mowla and Zereen, 2005). Its structure is simple with a limited number of corporate and categorical units. Due to very moderate specialization, the centralization of control is very nominal. On the contrary, the Dependent Community or minor community or sector/zone is not self-sufficient, possesses a specialized population and advanced technology. Its structure consists of a large number of diverse corporate and categorical units (Hawley, 1950). The centralization of control is pronounced, although shared by government or other associational corporate units. A major community (independent community) is self-sustaining and self-regulating. It is at the level of survival and sustainability for its component species population. Therefore, a new comer in an existing community may do one of three things:

a) It may adjust to the total environment.

b) If not, it may move or migrate to another environment.

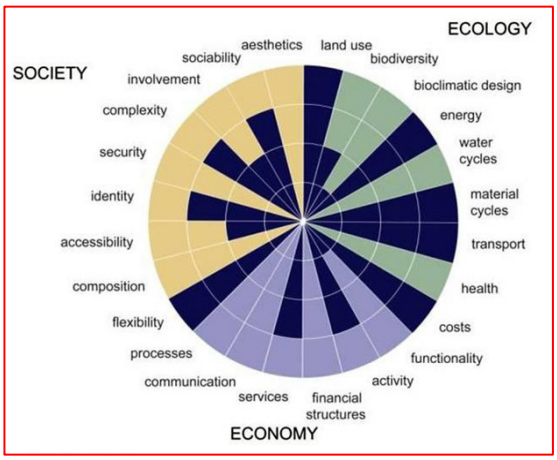
c) If neither is fulfilled then it will die.

If the new members adjust to the environment then it implies that they can cooperate with the other members in the environment for food and shelter (Gupta, 1988).

Eco-sustainability

There are three definitions of ecology that can be appropriate and relevant to matters and issues of sustainability. The first definition is the branch of biology that deals with the relationship of plants and animals to their environment and with each other. The second definition deals with the sociological aspects of humanity's relationship to their environment. And the third is definition is a relationship of harmony of all living things to their environment (CCSENET, 2016). As per Franco (2001), sustainability, from the ecological perspective, is based on three fundamental principles: "*the conservation of sustainable ecological systems of life and biodiversity; the use of renewal sources; and keeping the human actions compatible with the load capacity of ecosystems*". Thus, in order to implement those ecological sustainable concepts it is necessary substantial changes on the way of thinking, producing, consuming, etc. "*Hence, the four anthropogenic factors that most influence in sustainability are: pollution, poverty, technology, and life styles*".

When we talk about sustainability, we refer to the way a community, a city, or planet deals with its resources. Unthinking and wasteful utilization of a planet's finite and valuable resources will inevitably lead to depletion. Sustainability can be seen to be a way of using resources that will prolong or even prevent depletion of our most valuable natural resources (CCSENET, 2016). On the other hand, an eco society is considered to be a society that cares for sunlight, air, water, land, greenery and other natural blessings, a society that restrains the mass consumption of resources and energy and generation of waste, which endeavors to return to natural cycle the waste that is ultimately discarded after treatment to minimize the burden on the environment (Mowla and Ahsan, 2009). There are many ways in which Eco-Sustainability can be achieved (Figure 1):



Source: Mowla, 2016.
Figure 1: Model of Eco-Sustainability.

a) ***Human Welfare***

Sustainable development must provide for a certain level of human welfare. Sustainability cannot simply mean rationing of resources. When taken with ideas of morality and judgments about acceptable levels of human welfare and conditions, eco-

sustainability can be an economic and social imperative that maintains a certain level in the human condition.

b) Living in Harmony

Ecological sustainability can also be seen as a way to live harmoniously with the environment that allows healthy and essential ecological states to be preserved. In this description of ecological sustainability human involvement is not specifically mentioned but the concern lies in how human activities impact the ecology.

c) Here Today, Gone Tomorrow

The most common and accepted definition of sustainable development states that sustainable development is development that meets the needs of the present without compromising future generations capability to meet their own needs. Therefore, there needs to be a balance of what we use and how we use it. This must be a case of justice between our generations and future generations. This means that we must consider both the people's needs and their quality of life when we think about preserving resources for future generations.

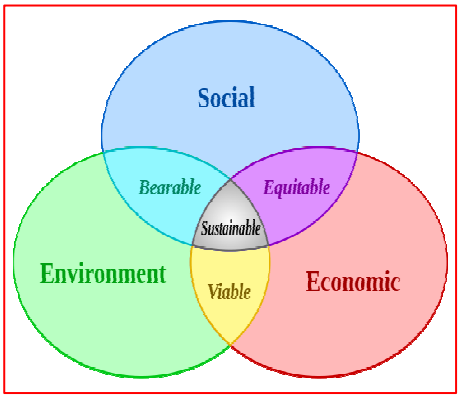
Eco-sustainability is the maintenance of life support systems (i.e. Climate system, nutrient cycling etc. to achieve a healthy geo-physiological state) and the achievement of a 'natural' extinction rate (Mowla and Ahsan, 2009). Some aspects can characterize ecological sustainability, i.e. sense of place; food production and distribution; recycle system; water supply and sewers; renewal energy integrated system; ecological restoration; and physical infrastructure (East, 2002). There are also four anthropogenic factors that most influences in sustainability are: pollution, poverty, technology and life styles. Poverty is the greatest threat to the eco-system (population view). However, the rich should also get part of the blame for use of resources, over consumption, waste generation, emissions and discharge. Similarly both poor and rich countries are responsible for environmental degradation (East, 2002).

The conventional concept of sustainable city is translated to the biological diversity preservation and the air's, ground's and life's quality, thus preserving the humanity welfare and respecting the nature. According to Jorge Samek (1999), sustainable development is only possible if resources consumption and population growth are adjusted to the ecosystem's capacity, having no sense if not linked to social equality and justice. Therefore, Eco-sustainability ensures a stable ecosystem for sustainable city development.

The Ecological Framework for Urban Sustainability of Dhaka

For sustainable living in Dhaka, the city environment needs to be in a state of equilibrium. The utility value of biodiversity which provides equilibrium into a city can be divided into four categories: goods, services, information, and psycho-spiritual uses. First of all, biodiversity can be seen as a *good* (or a resource) that can be consumed or useful by humans, and therefore should be protected. The second category is the wide variety of *services* offered to us by a healthy ecosystem. Green plants, for example, replenish the oxygen in the atmosphere and remove carbon dioxide. Fungal and microbial life-forms in the soil decompose dead organic material and play a vital role in recycling plant nutrients. A third category is the *information* obtainable from the natural

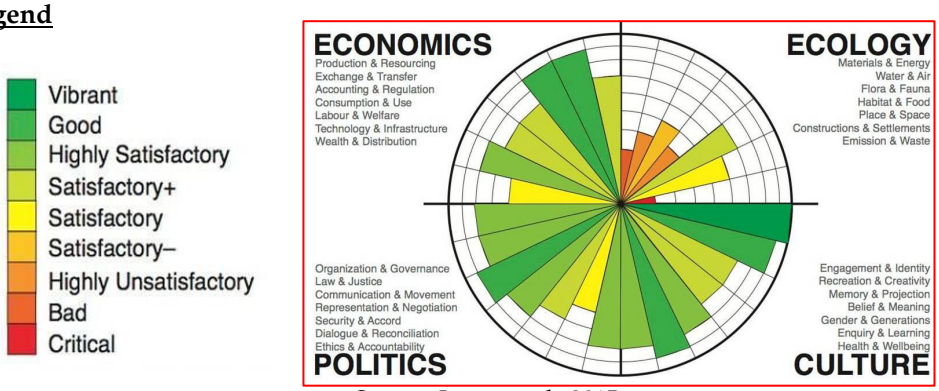
world. Each species is a vast library of desirable characteristics encoded in isolatable genes and transferable, by means of gene splicing, to edible or medical resources (Farhana et al., 2004). Finally, there must be in place support and a respectful environment so that *spirituality* may manifest itself on the different ways, shapes, philosophies and practices, thus satisfying everyone living at the eco-society. The sustainable development makes evident, when applied alone and on short scale, its oppositions to globalization. Sustainability is beyond environmental, technological and economical factors, covering additionally cultural, spiritual and political dimensions that require participation of every member on the decision making process, so that the necessary changes to support sustainability implementation can happen (East, 2002). Figure 2 shows an interactive model of sustainability.



Source: Adams, 2006.

Figure 2: The Interactive Model of Sustainability.

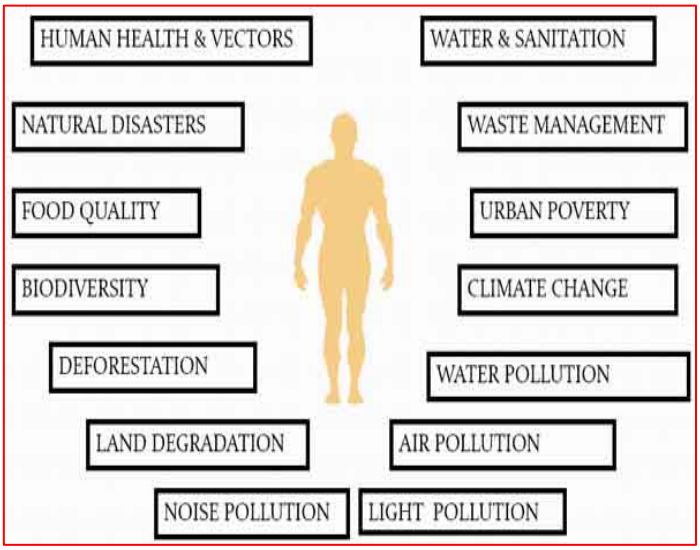
On the other hand, sustainable city invokes those issues concerning human societies and human activities, which can be specified in terms of human vs. human and human vs. environmental relations. Such relations place human beings at the center stage and are concerned with social, political, economic, and environmental sustainability within an integrated framework (Mowla, 2016) as can be seen in Figure 3:



Source: James et al., 2015.

Figure 3: Circles of Sustainability.

Cities play a vital role in the social and economic development of countries. Efficient and productive cities are essential for national economic growth, and equally strong urban economies are essential for generating the resources needed for public and private investments in infrastructure, education and health, improved living conditions, and Poverty alleviation. However, urban environmental problems are a serious threat to the full realization of the socio-economic contribution which cities can make. Environmental degradation brings with it enormous costs, resulting in significant inefficiencies in the use of local resources. It also compounds inequities, and threatens the sustainability of development. Yet environmental degradation is not inevitable and is often caused by inappropriate urban development policies and ineffective planning and management. Therefore, urban sustainable systems are composed of various closed cycles to prevent any leakage of materials to get out of the cycles and end up in pollution (Mowla, 2016). An ecological framework for urban sustainability of Dhaka is shown in Figure 4.



Source: Mowla, 2016.

Figure 4: Closed Cycles to prevent leakage of Materials.

Urban Green for Sustainability of Dhaka

Eco-design or green urban planning or so on are terms that revolves around plantation or natural inter-relationship of elements constituting our living environment in an urban area. The amount of forest cover in Bangladesh was reduced from 15.6% in 1973 to 13.4% in 1997, and eventually to 9% in 2004 (Mowla, 2004). A minimum of 25% forest cover is suggested for a healthy ecosystem and as about 150 m^2 leaf surface is needed to meet the yearly oxygen requirement of each person and to absorbs the carbon-di-oxide from the air produced by him (Mowla, 1984). In Dhaka, the situation is more precarious. Therefore, planting programs may help reduce urban temperature, emission, pollution etc. and make city greener, cleaner and ecologically more sustainable.

Selection of Plants for Environmental Sustainability

Plants play a significant role in moderating the built environment by providing shape to buildings and spaces, intercept solar radiation, cool the air by "evapotranspiration" and filter the pollutants from air (Mowla, 1984 & 2005b). Geo-climate of a place should dictate the selection of plants in the built-environment (PWD, 2003). In Dhaka city, dust and smoke in the air is a big problem - *Mandar* and *Neem* are dust and smoke hardy tree respectively. There are certain hardy local plants such as *Korobi*, *Kolke* and *Acacia* which can withstand pollutants such as sulphur-di-oxide from auto-emissions, and deposition of physical pollutants such as dust and other particulate matter.

Compensatory Greens or Garden for Urban Sustainability

Green Urban Corridors, Green Urban Pockets or Vegetated Roofs have the potentials to combat urban heat island effect, alleviate storm water pressure on the sewerage system, reduce energy consumption, and purify the air. Newly created road or corridor green space or urban pockets can supply green habitat and nesting areas for displaced birds, butterflies and other wildlife. For parks and green pockets of the city – *Neem Arjun*, *Tetul*, *Chattim*, *Albizia*, *Raintree*, *Sharnachapa*, *Bokul*, *Nageshar*, *Ashok*, *Hijal*, *Tamal*, *Polash*, *Daruchini*, *Tejpata*, *Korpur*, *Mehgoni*, *Krishnachura*, *Radhachura*, *Shetchandan*, *Bashak* etc. may be planted (PWD, 2003).

Green Roofs for Urban Sustainability of Dhaka

Rapid population growth of Dhaka city has created shortage in land for human habitation and shortage of ground level green. The green roof construction would help to sustain urban future by bring back nature into the city. The air and noise pollution in the city can be decreased by roof greening. Extensive green roofs are built when the primary design is for an ecological roof with limited human access. On the other hand, intensive green roofs look like traditional roof gardens because a much wider variety of plant materials is encouraged in this approach. Practice of intensive green roofs are rare in Dhaka city. Green roof and roof gardening seen may be categorized in to four types according to their usage and appearance in the city; namely a) extensive green roofs; b) extensive with some intensive plantation; c) plants in fixed and designed plots; and d) plants in moveable plots (Hossain, 2009). Vegetated Roof can help reduce global warming, lower the urban heat island effect, improve air quality, reduce ambient air temperatures, filter air, bind dust particles, and reduce glare (Mowla, 2010). Most of the roof tops of Dhaka are flat which are quite appropriate for greening.

Introduction to urban agriculture in rooftop will greatly contribute to food security by increasing the supply of food as well as exploiting the rural migrating farmer's skills as urban farmers. In the contemporary high-density urban Dhaka, the neighborhood livability, street life, social interactions between neighbors and level of outdoor activities is not visible due to scarce ground level green (Hossain, 2009). A safe, accessible green on rooftop can provide much needed recreational space for all age group to relax and enjoy. For senior citizens access to the green roof would be less prone to stress, disease and social content. In Rooftop green decorative, flower plantation can enhances the beauty of the town. It is an easy and effective strategy for beautifying the built environment and increasing investment opportunity (Mowla, 2010). Therefore, the higher initial investment for green roof construction will be offset by economic advantages of roof

greening in the long run. Examples of green practices can be seen in Figures 5-8.

Source: Hossain, 2009.

Figure 5: Extensive Green Roofs.

Source: Hossain, 2009.

Figure 6: Extensive with some Intensive Plantation.

Source: Hossain, 2009.

Figure 7: Plants in fixed and designed Plots

Source: Hossain, 2009

Figure 8: Plants in moveable Plots

Urban Water bodies for Sustainability of Dhaka

Restoration of natural drainage system and creation of adequate water bodies is needed for a sustainable ecosystem in Dhaka. *Ipil-ipil*, water *lily*, *lotus* are aquatic species of plant that may be recommended in the city water bodies, because these plants have extensive root system with rapid growth rate and very good capacity for nutrient absorption (Mowla, 2008). This will protect the water bodies from eutrophication. Besides this *Ipil-ipil* is a good fish feed. Among the fish varieties, *Rui*, *Silver Curp*, *Grass Curp* eats upper level food and purifies water. *Sarputi* and *Rajputi* are environment friendly species because they eat wastage in water like rotten leaves, insects and organic materials.

Urban Landscape for Sustainability of Dhaka

Dhaka city was once known for its serenity, beautiful parks, clean roads and lush greenery have now been converted into brick and concrete jungle (Mowla, 2011). Considering the pressure of urbanization and existing pace of development, it has been almost impossible to create the standard required amount of public spaces in the city. Even the Detailed Area Plan (DAP) has failed to set aside the adequate amount of space (Nilufar, 2009). In the old part of city, there is only 5% open space while in New Dhaka 12 % of land is green and open. The total amount of open spaces in greater Dhaka is about 17% to 18% and the total stock of public open spaces is hardly over 5000 acres (Mowla, 2011). But in the developed countries, in order to create a balanced and sustainable urban environment, up to about 75% of urban area is retained for open spaces. Ideally this should be about 40-50% but in a compact or dense situation like Dhaka city is recommended lower margin is about 25% of urban space (Mowla, 2011). Hence like any other sustainable city, Dhaka needs a huge stoke of open spaces for urban services or utilities and circulation besides space needed for different public functions and recreational activities. It is known that for a healthy city we need a right balance and proportion of open and built-up spaces.

On the other hand, our developers have made the word "development" synonymous with destruction of environment but it is not so. There will be needed for constructions or cutting of trees for development activities but that should be done in a planned manner with planned replenishment of the nature to keep the biomass in a balanced state. Appropriate balance of living and nonliving parts of the environment need to be promoted to maintain a sustainable ecosystem, because a stable urban morphology is always alive and careful landscape planning and design has a role to play in it (Mowla, 2011).

Conclusion

The above studies have shown that Urban Ecology deals with the interaction between organisms in an urban community, and their interaction with that community; while Eco-sustainability ensures a stable ecosystem to provide Urban Sustainability or Sustainable City. On the other hand, a sustainable city is free from any environmental issues that may intimidate its advancement. In contrast, planning and design, sympathetic to many forces of nature and human activity pattern, result in a sustainable development. Therefore, the ecological framework for urban sustainability of Dhaka have explored the protection processes of its natural environment, the proper uses of its resources and the least possible uses of non-renewable resources, the economic growth or its community's self-confidence, individual welfare, and the satisfaction of basic human needs of its citizens.

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