Evaluation of Eco-Sustainability standards of Purbachal by Ecological footprint analysis

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT FOR THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARCHITECTURE

AT

DEPARTMENT OF ARCHITECTURE

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

DHAKA, BANGLADESH

MARCH

2019

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A Dissertation Submitted

In Partial Fulfilment of the requirements for the Degree of

Master of Architecture

At

Department of Architecture

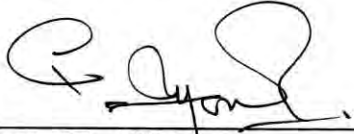Bangladesh University of Engineering and Technology

Dhaka, Bangladesh

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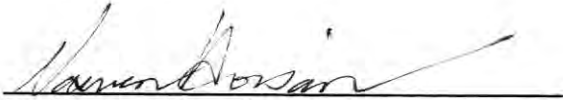
2019

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The thesis titled "EVALUATION OF ECO-SUSTAINABILITY STANDARDS OF PURBACHAL BY ECOLOGICAL FOOTPRINT ANALYSIS" Submitted by Tania Taher Lata, Roll No-100501002 P, Session- October 2005, has been accepted as satisfactory in partial fulfillment of the requirements for the Degree of MASTER OF ARCHITECTURE on this day 16th March, 2019.
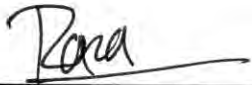
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It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Title: Evaluation of Eco-Sustainability standards of Purbachal by Ecological footprint analysis

Abstract

To provide a city with ample green, public transit, adequate services and infrastructures and to accommodate the increasing population in an affordable manner, Purbachal New Township (PNT) is designed and planned in the fringe area of Dhaka city. PNT is claimed to have been planned to be eco-sustainable and affordable (objectives 2 & 3 of PNT project is directly relevant to this claim). This study aims to evaluate PNT project in order to identify and analyze the eco-sustainability status of PNT.

Based on the literature review on worldwide eco-cities this study sets a set of checklists to assess the eco-sustainability status of PNT which are: ecological, physical, socio-cultural, technological and the bio diversity. Data from various sources are analyzed and ArcGIS Desktop 10.1 was used to analyze the context of Purbachal area. Policy and other measures are also evaluated with above checklist coupled with national standards like PRLDR, 2004 and DAP 2010 to identify the mismatch.

In the case of community facilities there is a huge scarcity of land. Low carbon emission schemes, provisions for 3R, renewable energy and blue green infrastructures were among the checklist for evaluation in Purbachal New Township.

PNT did not follow the eco-sustainable codes nor the socio-economic codes of the land. The analysis shows that PNT is not an eco-sustainable and affordable as claimed. This study observes that Land development of Purbachal area causes loss of soil ecosystem interrupting the food chain of different insects, crops, birds, lizards and other. The provision for protecting the prevailing ecosystem in the PNT plan is observed to have been grossly neglected in the present scenario The destruction of wetlands, trees, greeneries, vegetation in and around the township may endanger its terrestrial ecology, however the creation of the forest lands and water bodies, if done appropriately, may act as an opportunity to enrich bio diversity of PNT. There is an imbalance in the land use with excessive provision of commercial land.

It is recommended that based on property ownership and the economic status of local people (who are to leave their area), should receive affordable housing or plots on priority basis to ensure inclusiveness in PNT. There should be provision of low-cost housing or plots for low income groups as well. The plan of PNT could preserve the sensitive zones/areas and should take measures to protect them from any interventions that effects natural ecosystem. The forest and green area could be integrated with existing and planned water bodies (lake, river) to develop a functional blue-green network to ensure better urban environment and could enhance resilience. New tools and measures should be introduced systematically on periodic basis. The options for renewable energy, rainwater harvesting, waste recycling etc. could have been introduced and considered as an integral part of new developments subjected to periodic upgrading based on research.

Acknowledgement

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Chapter 01: Introduction

1.1 Background and Statement of the Problem

Addressing sustainable development in the process of urbanization becomes one of the most concerned issues to keep environment safe and to meet global ecosystem goals. With the increase of population, the consumption of environmental resources is also increasing. According to (Michel, 2017), "Humanity's ecological footprint[1] has exceeded the Earth's capacity and has risen to the point where 1.6 planets would be needed to provide resources sustainably". Cities already account for around 70 percent of global energy consumption and greenhouse gas emissions (Osborne, 2016). City's economic and social development is causing greater ecological footprint and environmental damage threatening to sustainable development.

Ecological environment of the city is an important part of its sustainable development and changes in the human survival and development have a huge impact in human life (Songa, 2011). It is important to organize social and economic development causing least damage on ecology and having least ecological footprint. Today's world is trying to approach towards eco-sustainable cities to save the global environment.

Efforts have been made to make cities eco-sustainable encouraging green development. Treasure island, a polluted military base is under transformation into a green neighborhood (Biello, 2008). Dongtan, China is expecting to be zero waste, energy-efficient, powered largely by sea breezes and free of vehicles running on fossil fuels (Biello, 2008). Curitiba (Brazil), Tianjin (China), Freiburg (Germany), Stockholm (Sweden) are few greenest eco-sustainable cities in the world.So eco sustainable city is an achievable goal that can be achieved in Bangladesh context also. Measures should be taken to keep balance between built environment and natural environment sharing that eco-sustainable city development is a realizable agenda Four "R" is the key to ecological development where "Reduce", "Reuse", "Recycle" and "Renewal" of available resources is the focus and in a balanced manner within the three context i.e 3-E. Three "E" is the

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[1] Ecological footprint is a standardized measure of biologically productive land and sea area necessary to supply the resources a human population consumes, and to mitigate associated waste. Ecological footprint analysis compares human impact on the ecosystem. This assessment will help to calculate and analyze the ecological footprint of Purbachal to assist in its sustainable development and the formulation of environmental strategy.

fundamental to sustainable development where Equity, environment and economy in a balanced manner is the driving force.

Dhaka is one of the most densely populated urban areas in the world and is expanding fast to accommodate its ever-increasing population. Many of the surrounding districts and Dhaka itself are also facing the urbanization pressure and turning them into complex hybrid morphology. To cope up with the situation, the government has initiated a large scale township project in the peripheral area of Dhaka, the Purbachal New Town (PNT), which claims to have responded to contemporary sustainability needs and provided with necessary supporting infrastructures. So far it is the largest planned township in Bangladesh. Soon after the foundation of this township is laid, the ecological and physical scenario began to change drastically. The township is being developed through transformation of suburban and agricultural land (Dewan, 2009). An imbalance between the demand for high density central development and the new policy for Greater Metropolitan Dhaka occurs as the city restructures towards the high density form. To assess the claim of PNT, for being an eco-sustainable development, it will be evaluated against available eco-sustainability checklists, parameters and indicators.

This study will focus on the evaluation of eco-sustainability status of Purbachal New Town Area. It studies and evaluates the changes taking place in the ecosystem of Purbachal New Town Area as per eco-sustainability checklists, parameters and indicators since it was developed as planned residential area. Based on the evaluation a set of recommendations has been formulated for the planning of future eco-sustainable cities in Bangladesh.

1.2 Aim and Objectives

The research aims to evaluate the eco-sustainability status of PNT and develop a set of strategies/recommendations for making the PNT eco-sustainable by reducing ecological footprint.

The specific objectives of this research are:

1   To develop an eco-sustainability checklist for the evaluation of new townships

2   To identify eco-sustainability gaps in the Purbachal New Town (PNT) and suggest improvements.

1.3 Major outcomes

The major outcome of the study is "A set of guiding checklist or recommendations for the planning of eco-sustainable new towns in Bangladesh".

1.4 Rationale of the Study

Dhaka, the capital city of Bangladesh is experiencing unplanned urbanization for decades. As a consequence of which, the city losing its livability and facing environmental degradation, scarcity of resources, extreme housing problem and hazardous phenomena. There are negligible considerations for eco-sustainable development in Dhaka city. Due to unplanned resource allocation and development of built environment, eco-logical footprint and its adverse effects is increasing. Dhaka is also facing hike of unplanned residential developments to accommodate increasing number of people migrated from all over the country. It is necessary to make Dhaka eco-sustainable. But there is no valid or previous source of data to assess eco-sustainability status of those residential developments. Proper indicators, parameters or standards were not developed for physical planning to ensure eco sustainable city. This research makes an attempt to develop a set of indicators that can evaluate eco-sustainability of PNT and can provide the basis for further recommendations to ensure eco-sustainability in PNT as well as other new towns in Dhaka City. This study would create scope for further research by considering the limitations of this study and will enrich the eco-sustainability measures, resource and strategy for new developments.

1.5 Scope and Limitations of the Study

This study attempts to make evidence based decisions to reduce the gaps in implementing eco-friendly schemes to develop the township and to reduce ecological footprint. This study

evaluates the eco-sustainability status of the PNT project against checklist developed in this study, as the case. Urban Design policy decision regarding eco sustainability evaluation, community participation and eco sustainable measures can be taken by going through this research. The study may also be useful by indicating areas of further research to evaluate eco-sustainability of a settlement and eco-friendly township project in the future. The study would also be able to guide further research and initiatives to conceptualize future eco-sustainable towns in Bangladesh with proper evaluation criteria (checklist, parameters and indicators) and strategies.

Major limitations of this research are the following:

- The study only considered PNT which is surrounded by many other developments and new settlements. Thus the study might not give overall picture of the eco-sustainability status of those areas and developments.
- The study used selected indicators or checklist from different ecological context due to relevance with the PNT and for the sake of availability of data and information.
- The study was conducted based on the PNT master plan whereas the actual development is yet to take place, so the evaluation might not portray the actual impacts on the ecological footprint on this area (evaluation will be based on forecasted scenario).
- The study was conducted based on mostly secondary information and proposed PNT plan, as the area is still not developed and not many people are living there at this moment.
- Time and resources (Secondary data, manpower and funding) were also major constraints to conduct this research.
- Another limitation of this study is the lack of primary data and information. Whatever data is available may not be accurate because of biasness or lack of interest of the stakeholders.
- Analysis and result is expected to be indicative of the actual scenario.

1.6 Organization of the Study

This study is comprised of five chapters. The first chapter introduces the background, the context of the study, objectives, possible outcomes, scope and limitation of the research and thus creates the foundation of the study and an outline of research design.

The Chapter two of methodology comprises of the whole methodological framework of this research including research design, research questions, criteria for evaluation, literature and field survey and the methods of analysis.

Chapter three sets a framework of the study based on literature review on related theoretical understanding in the field of eco-sustainable urban development and relevant case studies. This chapter, together with literature review helps to set evaluation criteria for eco-sustainability analysis and carry out the research.

Chapter four on data analysis represents the analytical review on present scenario of Purbachal New Township (PNT) project, the proposed plan and its eco-sustainability with the help of the checklist developed in the previous chapter. With the help of the analysis, the study tries to find the gaps in the eco-sustainability for the improvements of PNT or for future eco-sustainable developments.

Chapter five contains the summary of research outcomes and points out to the key loopholes of the project and puts forward recommendations for necessary measures that may be taken to minimize the shortcomings and improve the PNT on evidence based eco-sustainability standards.

The conclusion answers to the questions raised in the chapter one towards achieving the objectives of the study, recapitulates the whole study and highlights the main findings. Scope of the future research on eco-sustainable urban development in Bangladesh context were also be recommended in the final chapter.

Chapter 02: Methodology of Study

Methodology describes the procedures to organize and analyze the scattered ideas and views of the study. It also expresses some techniques of collecting, processing and analyzing the information. As a proper working procedure helps to accomplish the study smoothly, this study has also maintained a systematic method for the achievement of desired output. Eco foot print analysis could be both qualitative and quantitative. As the preliminary assessment shows that the PNT did not follow the basic urban design procedure for sustainability, a comparative qualitative evaluation would be sufficient to assess the eco sustainability status of PNT. The study is mainly a literature based study but both the qualitative and quantitative data are used wherever necessary. The quality of the research depends on a well-designed methodology to achieve goals and objectives.

2.1 Conceptualization

This study conceptualizes the basic terminologies which are relevant to eco-sustainability and ecosystem before starting the research. The need of eco-sustainability and eco-cities was studied in the global context of environmental degradation and reduction of environmental carrying capacity.

2.2 Research Questions

To achieve the aim of this research, objectives and research questions were set for evaluation as follows:

Table 2.1: Formulations of research questions under specific objectives

Objective	Research Question	Data Source
1. To develop an eco-sustainability checklist for the evaluation of New Towns.	• What is the relevant checklist in the global, regional and national levels to measure eco-sustainability in the study area? • What are the baselines for evaluation criteria? • Which standards are followed in	• Literature review, master plan review. • Case Studies. • Planning guidelines and

		Bangladesh for Urban land development? • How much is the deviation from the checklist in the PNT? • How planning of PNT can or will affect the eco system of PNT? • What is the status of PNT vis-a-vis eco-sustainability?	principles revision master plan revision, DAP, PRLDR etc
2. To identify eco-sustainability gaps in the PNT and suggest improvements.		• Which eco-system did exist in the study area before the initiation of the project? • Which eco-system does exist in the study area at present? • What are the changes that took place before and after the project? • Eco-sustainability deviation from the checklist? • What could be possible strategies to reduce the gap or improve the situation?	• Literature review, master plan review, Google images, field observations, Key Informant Interview (KII), Master plan review against checklist, etc

2.3 Selection of Purbachal and its Rationale

A study reveals that only 5.0 per cent of the housing demand is met in Dhaka city and now the city requires 0.12 million housing units in total (Shova, 2017). This situation has adverse effects on the environment of Dhaka city in terms of the eco-system and urban system. Environmental resources are degrading and becoming scarce because of unplanned resource allocation and lack of optimization. To place extra population and provide accessibility to services in an unplanned manner, the utilization of environmental resources is exceeding its capacity.

The tremendous pressure for accommodating the huge population demand requires establishment of new residential areas. To decentralize this pressure from Dhaka city and to create a better city environment for the city dwellers, DMDP adapted a policy to establish a series of new towns around Mega-city Dhaka. Several projects have been taken up such as "Jhilmil Residential Area", "Puurbachal New Township", "Uttara Residential Model Town", "Villa Apartments" at Banani and Gulshan etc. Among them "Purbachal New Township(PNT)" project is the first of its kind in Bangladesh, which claims to have taken measures to keep the smart city clean, green and eco-friendly (Chowdhury, 2016). As the Purbachal area was a blend of various eco-system (taking place into Balu and Sitalakhya rivers, its agricultural and undulating lands, forest, wood

lands and water bodies), developing it as a township may pose a threat to its ecosystem.PNT is located

in the flood flow zone of DMDP'95. It would be interesting to investigate, how the eco-sustainably issues were negotiated in the PNT after creating obstacle in the natural system. This study therefore selects "Purbachal New Township (PNT) Project" to assess its eco-sustainability by measuring the effects on its past (before the project) and existing eco-systems against a standard checklist.

The Purbachal New Township (PNT) is located in the three administrative districts, Dhaka, Narayanganj and Gazipur. It is about 18 km from the zero point of the capital, Dhaka and located on the North-East corner of RAJUK jurisdiction area, bounded by the rivers Sitalakhya on the east and Balu on the west.

Total area of PNT is 6077.36 acres, 150 acres of which is occupied by the approach road of the project which that lies in Badda Thana under Dhaka district. According to RAJUK's Master Plan the key PNT objectives are:

1. To reduce the pressure of population in Dhaka city by creating opportunity of residential accommodation of the city dwellers in the vicinity of the city;
2. To maintain the balance of environment by proper urbanization;
3. To create environment friendly and sustainable atmosphere;
4. To expand civic facilities by urbanization to the nearby and surrounding areas gradually;
5. Development of a new township and to expand economic facilities; and
6. To mitigate future housing demand.

The objective number 2 and 3 of PNT is directly relevant to this research i.e, "the balance of environment", "environment friendly and sustainable urbanization" would be studied to understand and evaluated PNT. For evaluation, checklist/ parameters developed in this study would be used and cross-checked with Detail Area Plan (DAP) and Private Residential Land Development Rule (PRLDR).It may be mentioned here that PNT did not follow the standard participatory approach of planning, nor it made any provision for the existing population of PNT.

2.4 Development of Framework for Study

The study began with a literature survey to develop a framework of the study and assess the current state of affair universally following a set of key policy issues and yardstick for evaluation. Literature survey was conducted under two heads:

i.   Literature review to develop a theoretical framework: which helped to develop research design, to conduct study on the PNT Project and provide guidelines to develop evaluation criteria.

ii.   Literature review on case studies: which helped to conceptualize about different eco-city projects taken worldwide, the success and failures of these projects and their salient features, would provide the basis of evaluation of eco-sustainability of PNT.

This literature review recapitulated the related issues of eco-sustainability in order to develop a checklist for evaluation.

2.5 Data Collection

Based on the checklist developed from different review and case study the past and present data of PNT were collected. An empirical survey in Purbachal was conducted to explore its prospects and problems.

i.   Primary Data: Primary data was collected from field visit and observation, Key Informant Interview and PNT planning document.

ii.   Secondary Data: Case study method was conducted to gather global as well as local data from Purbachal area in Dhaka city as per the yardstick / checklist evolved. Google image, maps, master plan, news articles and relevant reports were also considered as the key source for secondary data to trace back past information.

Eco-sustainability checklist was developed for the analysis and evaluation of PNT. To gather with the development checklist, the DAP and PRLDR is used for socio-economic sustainability analysis, because for sustainability, the plans must first comply with the prevailing standards.

2.6 Data Interpretation and Analysis

Data from various sources were analyzed to evaluate the eco-sustainability of PNT. Based on the data gathered existing eco-sustainability status, evaluation and planning implications were analyzed and presented in this research. Quantitative observational method of SWOT analysis and ArcGIS Desktop 10.1 for quantitative analysis of available PNT data, was used. The available images were mainly interpreted with the help of Arc GIS and field survey was done for SWOT. Google earth image of 3rd April, 2018 was used for image analysis. Prevailing standards were used for comparison and finds the deviations. Policy and other measures are evaluated to identify the gaps.

2.7 Findings and Results

Based on the findings from analysis, results are summarized and discussed to assess whether PNT is an eco-sustainable township or not, as claimed.

2.8 Research Design

Developments of an evaluation checklist, evaluation of PNT and assessing the eco-sustainability Status of PNT Results from findings helps to develop strategies that are needed to be executed to make PNT a successful eco-sustainable township project or any other similar initiative.

The flowchart (fig 2.1) summarizes the entire study. Related terms and contexts were conceptualized based on which objectives and research questions were set. After analyzing and understanding the basic structure of eco-friendly cities from literature review and case studies, the "Purbachal New Township (PNT)" has been selected for evaluation. A literature survey was carried on theoretical context and case studies were conducted to understand the eco-sustainability application in real life context. It was done to develop framework of the study and

formulate some evaluation criteria for eco-sustainability of which socio-economic sustainability is an integral part.

On the basis of evaluation checklist/criteria developed in this study, the PNT is studied with eco-sustainability principles in mind.
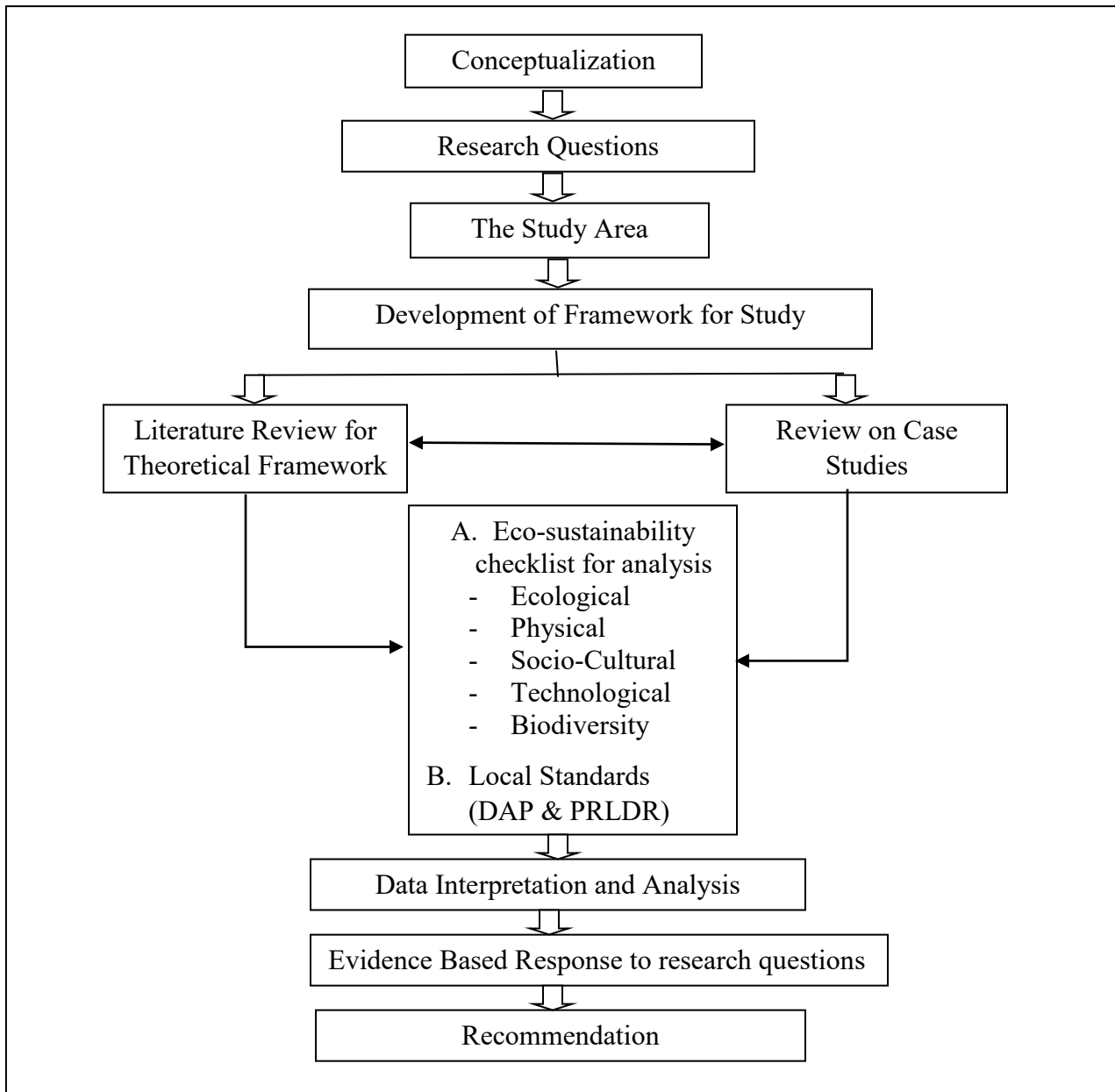
Figure 2.1: Flowchart of Research Design

Chapter 03: Literature Review and Case Studies

Cities are the engine of economic growth, but today more and more countries have realized that it would be good to alter the traditional emphasis on the pursuit of higher economic growth with scant regard for environmental protection and social harmony. Dhaka is located in central Bangladesh surrounded by Buriganga River, Turag and Shetolokhya Rivers. Due to fast urbanism, the environment quality of Dhaka has deteriorated. An ecological approach is needed in urban design to restore Dhaka city's environmental quality and to preserve land, water and woodland ecosystem. Though Bangladesh has no proper ecologically focused rules and regulation for spatial planning and designing so some case studies were conducted here for identifying basic parameters of eco-sustainable city planning and design..1 Development of Theoretical Framework

Basic terminologies used in the study require specific definitions and meaning before actual study is undertaken to avoid confusion. A theoretical framework is developed based on the following terminologies.

3.1.1 Eco-system

An ecological community is comprised of biological, physical, and chemical components in an interwoven system called an ecosystem and are considered as a unit. It is comprised of the biological community (plants, animal, fungi, bacteria i.e. all living elements) in some locale, and non-living or abiotic environment (water, light, radiation, humidity, atmosphere, soil etc.) where organisms interacts with one another and with the environment in which they occur. Ponds, forests, estuaries, grasslands all have eco-system. Everything is related to everything else in a definite pattern and system called eco-system (Mowla,2006) An eco-system consists of the two main sequences which are energy transformations and biogeochemical cycling.

Eco-system services contribute to the world's sustainability. But humans have been changing the world's ecosystems more than ever before to satisfy growing demands for food, freshwater, timber, fiber, fuel and minerals (Lin, 2012).

3.1.2 Environmental Carrying Capacity

Environmental resources are finite in comparison to the exceeding demands on these resources. The over consumption, misuse of resources over time is leading to environmental damage and an ultimate harm on economy. Environmental carrying capacity refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural social, cultural and economic environment for present and future generations. Environmental carrying capacity can be worsening by pressure of the population increase and mismanagement of resources. Pressures caused by population increase such as pollution, over-exploitation of natural resources and resulting climate change impact on the functioning of an environment, reduces the environmental carrying capacity (Mowla & Zereen,2005).

3.1.3 Ecological Footprint

Ecological footprint is a measure of human impact on Earth's ecosystem and reveals the dependence of the human economy on natural capital. The ecological footprint is defined as the biologically productive area needed to provide for everything people use: fruits and vegetables, fish, wood, fibers, absorption of carbon dioxide from fossil fuel use, and space for buildings and roads. It varies at the individual, regional, national or global scale. Both footprint and bio capacity, change every year with number of people, per person consumption, efficiency of production, and productivity of ecosystems. It measures the requirements for productive areas such as croplands, grazing lands for animal products, forested areas to produce wood products, marine areas for fisheries, built-up land for housing and infrastructure, and forested land needed to absorb carbon dioxide emissions from energy consumption. Ecological footprint can be used to measure and manage the use of resources throughout the economy and explore the sustainability of individual lifestyles, goods and services, organizations, industry sectors, neighborhoods, cities, regions and nations. It has become one of the most widely used measures of humanity's effect upon the environment and has been used to highlight both the apparent

unsustainability of current practices and the inequalities in resource consumption between and within countries (Borucke, et al., 2013).

In its most basic form, ecological footprint is calculated using the following equation:

$EF = D/Y$,   (Borucke, et al., 2013)

Where D is the annual demand of a product and Y is the annual yield of the same product. Yield is expressed in global hectares which are estimated with the help of two factors: the yield factors, which compare national average yield per hectare to world average yield 6 in the same land category; and the equivalence factors, which capture the relative productivity among the various land and sea area type.

Taking into account these factors, the formula of the Ecological Footprint becomes:

$EF = (P/YN) *YF*EQF$

Where P is the amount of a product harvested or waste emitted (equal to D above), YN is the national average yield for P, and YF and EQF are the respective yield factors and equivalence factors for the country and land use type in question. The yield factor is the ratio of national-to-world-average yields, which is calculated as the annual availability of usable products and varies by country and year. Equivalence factors translate the supply of or demand for an area of a specific land use type (e.g. world average cropland or grazing land) into units of world average biologically productive area expressed in global hectares. These factors can vary by land use type and year. (Wackernagel, Zokai, Iha, Kelly and Ortego, 2015).

However, after preliminary studies, this quantitative method of Ecological footprint analysis was found irrelevant for the present study.

3.1.4 Eco-sustainability

Eco-sustainability is where the human ecological footprint harmoniously co-exists with other life forms as opposed to carbon sink overloading resulting in environmental externalities, such as extreme climatic changes (Rose, 2013). 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" (Islam, 2016). Eco-sustainability ensures improvement of quality of life and maintenance of decent life balancing between urbanization and environmental quality. An eco-sustainable city is an ecologically healthy city that is designed to minimize ecological footprint.

According to (Mowla and Ahsan, 2009), 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.

There are many ways to achieve eco-sustainability balance within the sustainability criteria which is shown in the following model (Fig 3.1).

Figure 3.1: Model of eco-sustainability, Source: (Mowla, 2016)

3.1.5 Eco-cities

The environmental problems in cities manifest differently and the concerns of development and those of environment and social welfare demand an integrated approach for their resolution (Boyle, et al., 2003). Urban areas are causing environmental change, drastically by altering land use and using natural resources for production and human consumption, affecting biogeochemical cycles and climate through urban waste discharge. To face this challenge, the concept of eco-cities has been evolved.

The concept of eco-cities is introduced to reduce environmental impact on human lives and to live in a more nature friendly way. Eco-cities can be defined by reducing resource consumption and waste generation by considering effective and optimized use of resources, using waste as resource, maintaining and restoring environmental quality, protecting plant and animal habitats and eco-systems. An eco-city aims to achieve sustainable development within the carrying capacity of local ecosystems through changing the production mode, consumption behavior and decision instruments based on ecological economics and systems engineering (Hefa and Hu, 2009). In short, Reduce, Reuse and Renewal of available resources are the basis of an eco-city.

3.1.6 Urban Eco-system

Urban ecosystems are those in which people live at high densities, and where built structures and infrastructure cover much of the land surface (Pickett, et al., 2011). Urban ecosystems are dynamic ecosystems that have similar interactions and behaviors as natural ecosystems (Mowla and Zereen, 2005). Such as-

a. Interdependence: Urban areas act as population centers providing goods and services. Urban areas cannot exist in isolation. They require inputs from, and waste assimilation functions of other ecosystems.

b. A locale: An ecosystem should have an identifiable locale where the interdependence or interactions take place. Every urban area has its delineating location with specific geographical characteristics.

c. Community: A community of various species is a prerequisite for an eco-system. Similarly based on ethnicity, income level, social status, livelihood people live in a group or community in urban areas.

d. Competition: Based on adaptive quality species are always under competition for their survival in an eco-system. In an urban area people also compete with one another over economic and social issues, sometimes for higher qualification and one wins over others.

e. Dominance: In an eco-system species dominate over others depending on prevailing situations. People with higher social status, power, qualifications dominate others in urban areas.

f. Symbiosis: Symbiotic relationships in an eco-system are a special type of interaction between species which are essential for survival and they provide a balance that can only be achieved by working together. In urban areas this happens by working for others or working together. -

The urban ecosystem contains three spheres: the natural environment, the built environment and the socio-economic environment where human activity influences natural environment (air, water, plant) and natural environment influences human decisions (where and how to build green spaces, houses.). According to (Zellner, Theis, Karunanithi, Garmestani, and Cabezas, 2008), "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" (Fig: 3.2).
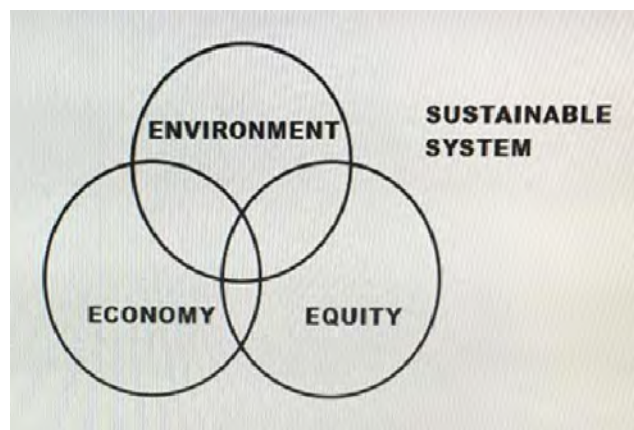
Figure 3.2: Urban Sustainability Model-3E , Source: (Adams, 2006)

In urban ecosystem, the core of mainstream sustainability thinking has become the idea of three dimensions, environmental, social and economic sustainability (Adams, 2006). A balanced blend of sustainable environment, social equity and sustainable economy i.e. '3E' can ensure a sustainable urban ecosystem(fig 3.1). In order to develop policies and programs to ensure sustainable development and the equitable allocation of resources, each system within the urban ecosystem needs to be recognized. Unhealthy urban ecosystems can lead to local and wider environmental degradation, social problems, economic decline, human health problems and further disconnection from nature.

3.1.7 Ecological Urban Design

Cities are the engine of economic growth, but today more and more countries have realized that it would be good to alter the traditional emphasis on the pursuit of higher economic growth with scant regard for environmental protection and social harmony (Mathad, 2013). The bio-capacity of the earth (including both extraction and absorptive capacity for waste and emissions) has already been exceeded by around 50% (Szilagyi, Mocan, Verniquet, Churican and Rochat, 2018). With the increasing population and their increasing ecological footprint, it is necessary to synthesize the built and natural environment.

Eco-design approach revolves around plantation or natural inter-relationship of elements, constituting our living environment (Mowla, 2005). Incorporating ecological design into urban design can reduce ecological footprint and provide a healthier and safer environment to live. It is tested that comfort and sustainability is directly connected to biomes and dominant natural ingredients are open spaces, trees and water bodies (Mowla, 2013). So, in ecological design natural forests, water bodies, habitats, open spaces should be preserved as-

- Vegetation can reduce temperature and heat island effects and create cooling effects. Green roofs, green terrace, green walls help surface cooling. Plants have significance for providing shade to building and spaces, cut off solar radiation, cool the air by 'evapotranspiration' and filter the pollutants from air (Mowla, 2012). They also reduce noise pollution and purify air quality.

- Open and green spaces are an important element of built environment, which provides vibrancy and sustainability to a city (Mowla, 2005). Preserving open spaces and developing as green spaces or urban green pockets, helps to build recreational centers and perform as habitats for different birds, animals, insects and other species.

- The ecosystem of water bodies, rivers, canals and topography maintains the water circulation and drainage facilities. Some flora and fauna purifies ground water and works as water treatment system.

- Incorporating natural water bodies and vegetation in urban design preserves safe and secured habitat of flora, fauna, animal and other species. Thus, biodiversity is maintained.

Eco-friendly design also assists in achieving environmental sustainability of cities through reduction of greenhouse gas emissions, utilization of renewable energy, and green transportation, maintains high air and water quality standards and an above average ratio of green space per person. Well thought-out distribution of green has greater potential to recompense the deteriorating natural green and combat urban heat island effect, alleviate storm water pressure on sewerage system, reduce energy consumption and purify the air (Mowla, 2013).

3.1.8 An Overview on Environmental Degradation of Dhaka City

Mega city Dhaka, which is the capital of Bangladesh, is facing environmental degradation overtime. Dhaka, in the geographical basis located in central Bangladesh surrounded by Buriganga River and it undergoes humid monsoon weather throughout the year, but the temperature of this area has risen since the independence of the country. Since 1971 the average annual temperature of Dhaka is increasing. This change is taking place due to global warming and the increasing number of population is another reason for this change. During the time of independence Dhaka city was less populated. But in 2015 the number had been boosted. For giving space to this massive population, Dhaka is undergoing massive urbanization process which is cutting down trees from the city and filling up water bodies.

About 15 million people living in about 340 sq km area of Dhaka city and 5 lakh people migrate to Dhaka every year requiring 1 lakh housing unit demand (Ara, 2014). This population pressure

accelerating urbanization of Dhaka city which is unplanned in most of the cases. This is also creating pressure on available natural resources which is creating ecological imbalance and environmental degradation. Unmanaged urbanization causes encroachment contributing to deforestation, water logging, flooding, overheating, pollution of water, soil and air (Mowla and Zereen, 2005).

To be environment friendly and have sustainable ecosystem, a certain amount of green spaces (trees, vegetation, forestlands, gardens), blue infrastructures (water bodies, canals and lakes) are needed. Until 2004 Bangladesh had 9% forest cover whereas 25% is minimum requirement for a healthy ecosystem (Mowla, 1984). Sustainable environment requires 75% open space of urban area. In a dense country like Bangladesh 25% is the lower margin assuming surrounding hills and oceans to compensate the deficit (Mowla, 1984). Against 25% acceptable urban green Dhaka has less than 15% (Nurunnabi, 2002). In Dhaka, 60% of land surface is covered by roads and buildings and as the city totally served by storm water drain, flood frequency has increased by a factor 6 compared to pre-urbanization periods (Khalequzzaman, 2006).

Of the total land area the city has only an average of 14.5% open space (17% in north and central part and 12% in old town) left whereas any city requires 25% for fresh environment and to maintain a sustainable land ecosystem (Daily Star, 2004). Dhaka city regularly generates about 4000 tons of solid waste, of which less than 50% is disposed in the landfill site and a significant part of the remaining waste goes into the water bodies (Edu Carnival). These are polluting water bodies of Dhaka city.

Haphazard planning, excessive pressure on available resources, uncontrolled pollution, and deterioration of ecosystems are degrading the environment and making Dhaka city unlivable. An ecological approach is needed in urban design to restore Dhaka city's environmental quality and to preserve land, water and woodland ecosystem. Bangladesh does not have any ecologically focused rules and regulation for spatial planning and designing (Mowla, 2012).

3.1.9 Quantifiable Guidelines to Evaluate Eco-sustainability of Townships

To evaluate eco-sustainability of a township the following criteria should be analyzed:

Ecological Parameter

i.   **Cultivable lands and grazing lands:** It indicates after developing the township how much area left for cultivation and grazing. These lands are source of bio-production.

ii. **Fishing lands:** It indicates whether due to the built environment the habitat of fishes and their eco-system become changed or not.

iii. **Canal network/Water Body:** This will keep balance in water circulation system and drainage system.

iv. **Open spaces and forest lands:** It will evaluate whether there is enough vegetation or forests to absorb CO_2 or not.

v.   **Habitat loss:** It will measure the loss of habitat because of change of land area for forests, cultivable lands, rivers and vegetation. Moreover, the change of topography can cause loss of habitat too.

vi. **Impact on river:** As in this township there will industrial park, the impact of these parks on rivers or water bodies should be measured. Apart from that impact of human generated wastes, drainage system should be measured too.

vii. **Footprint of working people:** In this township there will be mobilization of working people who will commute from outside of this township and this will result in significant change on transportation and fuel. This should be measured.

Biodiversity Parameter

viii. **Woodland eco-system loss:** As there was squatter forest in Purbachal, the change of this forest area should be evaluated to measure the woodland eco-system loss.

Socio-economic Parameter

ix. **Energy saving approaches:** To reduce ecological footprint energy saving schemes (walking strips, renewable energy, natural solutions for utility, green transports etc.) should be introduced in the township and this will be evaluated.

3.1.10 Key Parameters found from the Literature Review

Literature review on the theoretical framework develops concept on ecology, ecosystem, urban ecosystem, environmental capacity, ecological footprint, eco-sustainability, eco-cities. The literature review shows the possible evaluation criteria to measure eco-sustainability of city. These guides to set evaluation criteria that can be used in this research work. Some parameters of eco-sustainable city are found from the literature review. These parameters are:

Table 3.1: Eco-sustainability Parameters from Literature Review

Parameter	Checklist
Ecological	Cultivable lands, Fishing lands, Forest lands and Vegetation, Footprint of working people, Habitat loss
Environmental	Temperature, Heat, Rainfall and Humidity
Biodiversity	Woodland ecosystem, Ecosystem of flood plains and fisheries, Terrestrial ecology, River ecosystem.
Physical	Soil, Hydrology, Topography, Land uses and built forms, Canal networks, Drainage systems
Socio-Economic	Accessibility, Utility services, Affordability, Economic activities, Activity patterns and Land values, Public participation, Social interaction, Social balance, Equal accessibility.

3.2 Case Studies: Application of Eco-City Concept

3.2.1 An urban metabolism and ecological footprint assessment of Metro Vancouver, Canada

Moore, Kissinger and Rees, (2013) assesses ecological footprint and urban metabolism of Metro Vancouver, which contains some of Canada's most fertile agricultural land; the delta of one of Canada's largest rivers, the Fraser; forested mountains; and coastal shores with crab, salmon, and other fin-fish fisheries. Metro Vancouver remains characteristic of a high-consuming, first-world, urban region. Based on this context determining sustainability of cities grows importance. This research presents a detailed, integrated urban metabolism of residential consumption and ecological footprint analysis of the Vancouver metropolitan region for the year 2006 with a goal to demonstrate the application of a bottom-up ecological footprint analysis using an urban metabolism framework at a metropolitan, regional scale. This study prepared a structure of

components that would assess urban metabolism and ecological footprint which is shown in the figure (Fig: 3.3).

This study shows that the largest components to the ecological footprint are food followed by transportation fuels which is the largest source of carbon dioxide emissions. Buildings account for the largest electricity flow and constitute the third largest component of the ecological footprint. Finally, it recommends to take an initiative to reduce overall energy and materials consumption by changes in urban morphology and management practice and high income consumers to reduce their personal consumption, is emerging in the urban sustainability literature.

Figure 3.3: Component Structure of the integrated urban metabolism and ecological footprint

Figure 3.3: Regional Ecosystem Distribution of Metro Vancouver Area, Canada; Source: (Metro Vancouver, 2015)

Salient features of Metro Vancouver

▪ Ninety-three percent of the electricity used in Vancouver is generated using sustainable resources such as hydroelectric power.

According to Vancouver's Greenest City Action Plan, 2020 Vancouver is set to-

▪ Bring their community-based greenhouse gas emissions down to 5% below 1990 levels, even as the population has grown by more than 27%.

▪ It is intended to all new buildings be carbon neutral, and cut energy by 20 per cent from 2007 by 2020.

▪ Cut per capita water consumption by 33 per cent from 2006 levels.

▪ Reduce waste going to landfills or incinerators by half from 2008 levels.

▪ Make the majority (over 50%) of trips by foot, bicycle, and public transit and reduce average distance driven per resident by 20% from 2007 levels.

Table 3.2: Parameters to evaluate urban metabolism and ecological footprint assessment of Metro Vancouver, Canada

Parameters	Checklist
Environmental	community-based greenhouse gas emissions down ,temperature, heat, rainfall and humidity
Ecological	land, air and water, agricultural land, coastal shores
Physical	waste going to landfills , new buildings be carbon neutral
Socio-cultural	Make the majority (over 50%) of trips by foot, bicycle, and public transit and reduce average distance driven per resident.
Technological	construction techniques for eco-friendly buildings, proper management of waste affecting the air and water quality.
Economic	activity patterns and land values.

3.2.2 Planning for sustainability in China's urban development: Status and challenges for Dongtan eco-city project

Nowadays cities are planned based on the aim to achieve sustainable development and designed to be ecologically friendly guided by principles like carbon neutrality and self-sufficiency. (Hefa and Hu, 2009) introduces the development of the Dongtan eco-city project on Chongming Island,

Shanghai and describes how it addresses issues including energy, water, waste, transportation, ecosystem, and social and economic development in its design. This research was carried out when this eco-city was in planning and design phase and expected to be an exemplar of eco-friendly city for China.

Ten principles had been proposed to create an eco-city which is as follows:

a) revise land-use priorities to create compact, diverse, green, and safe mixed-use communities around public transportation facilities;

b) revise transportation priorities to discourage driving and to emphasize ''access by proximity'';

c) restore damaged urban environments;

d) create affordable, safe, convenient, and economically mixed housing;

e) nurture social justice and create improved opportunities for the underprivileged people;

f) support local agriculture, urban greening, and community gardening;

g) promote recycling and resource conservation while reducing pollution and hazardous wastes;

h) support ecologically sound economic activity while discouraging pollution, waste, and the use and production of hazardous materials;

i) promote simple lifestyles and discourage excessive consumption of material goods;

j) Increase public awareness of the local environment and bioregion through educational and outreach activities.
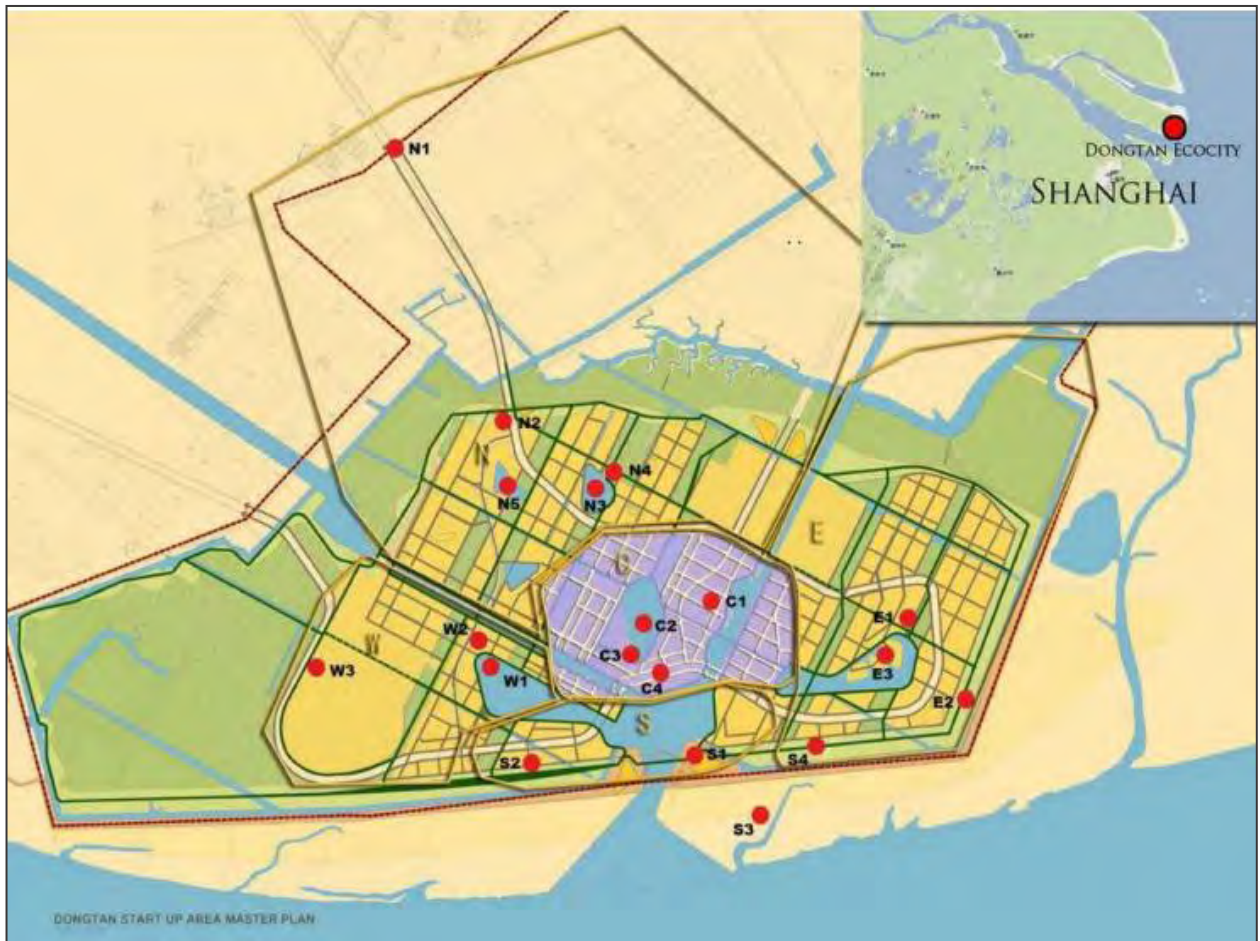
Figure 3.5: Master Plan of Dongtan Eco-city, China; Source: (Qiang, 2009)

Salient Features of Dongtan eco-city project

- **Target:** According to its master plan Dongtan eco-city would have a 60% smaller ecological footprint than conventional Chinese cities, a 66% reduction in energy demand, 40% energy from bio-energy, 100% renewable energy in buildings and on-site transportation, reduction of waste to landfills by 83%, and almost no CO_2 emissions.

- **Wetlands:** It will protect and enhance the wetlands adjacent to Dongtan in several ways: by returning agricultural land to a wetland state, by creating a wide 'buffer zone' (3.5 km across at its narrowest point) between the city and mudflats, by building on less than 40%

of the Dongtan site and by preventing pollutants (light, sound, emissions and water discharges) from reaching the wetlands.

- **Building:** Its well-insulated buildings, outfitted with energy-efficient equipment, will use 66% less energy than buildings usually do and will emit 350,000 fewer tones of CO_2 annually.

- **Waste:** The city will collect 100% of waste (including sewage), using 90% of the waste as a source of energy, irrigation and composting. Some of the processed waste will serve as fertilizer in the city's organic farms. Dongtan will not have a landfill.

- **Energy:** Dongtan will produce all of its own electricity and heat. Buildings and vehicles will run on renewable energy sourced from the wind (via a wind farm and micro wind turbines on buildings) and sun (via photovoltaic cells). A combined heat and power plant will run on rice husks discarded by local rice mills. Treating municipal solid waste and sewage will generate biogas, another energy source.

- **Transportation and Accessibility:** All housing should be within a seven-minute walk of public transport. Businesses, schools, hospitals and the like should also be easily accessible. Accessibility will reduce travel distances, thereby lowering CO_2 emissions by 400,000t annually. Transportation options within the city will include cycling, walking, hydrogen fuel-cell buses and solar-powered water taxis. The boats will use a network of canals and lakes.

Table 3.3: Parameters to evaluate eco-friendliness of Dongtan eco-city project

Parameters	Checklist
Environmental	Air Pollution, Climate Change, Livestock–Fishery
Ecological	Reduce Ecological footprint by reduction in energy demand, energy from bio-energy.
Physical	land uses and well-insulated buildings, Cultivable land
Technological	Production of renewable energy for building and vehicle, using 90% of the waste as a source of energy.

Economic	Activity patterns and land values, transportation and accessibility to reduce travel distance.
Political	Environmental management tools, policy instruments, decision making, people empowerment and private-public participation

3.2.3 Application of a system of urban indicators for the Greater Thessaloniki Area, Greece

This study was carried out to use some indicators which are important tool for assessing the progress achieved towards sustainable development. The context of this study was to protect and restore environment that requires mitigation efforts and responses to environmental degradation should be closely monitored and quantified so that relevant problems could be encountered. This research work aimed to develop and utilize a system of indicators as a dynamic tool for the management of environmental, social and economic information to evaluate sustainability in urban areas. The study area of this research work was in Thessaloniki area, the second-largest city in Greece and the capital of Macedonia, the nation's largest region. Thessaloniki is considered one of the most polluted cities within Europe.

This study led to 88 indicators included in a framework of 13 discrete thematic areas, namely: a. Economy–Population, b. Land and Urban Planning, c. Energy, d. Transportation, e. Agriculture–Livestock–Fishery, f. Industry, g. Tourism, h. Air Pollution–Climate Change, i. Water Resources and Sea Environment, j. Solid Waste, k. Biodiversity, l. Health, m. Education–Research and Technology.

This research work found the system widely accepted and characterized as accurate, reliable, bias-free, and scientifically robust, generally allowing for monitoring of the most important thematic areas for all local stakeholders. But for another area these indicators could be altered.

Table 3.4: Parameters to evaluate eco-friendliness of Greater Thessaloniki Area, Greece

Parameters	Checklist
Environmental	Air Pollution, Climate Change, Livestock–Fishery

Ecological	land, urban planning, Water Resources and Sea Environment
Physical	land uses and built forms, Cultivable land
Technological	Education–Research and Technology.
Economic	Activity patterns and land values
Political	Environmental management tools, policy instruments, decision making, people empowerment and private-public participation

3.2.4 'Planning for Eco-Friendly Cities: A Case study of Gulbarga City', India

(Mathad, 2013) carried out this research with an aim to examine as to whether the city of Gulbarga is an eco-friendly city and, if it is so, then to assess the city with some definite criteria which would help us to label it 'eco-friendly' in conclusive terms. If on the other hand the city is not an eco-friendly one, analyze the reasons why it is not so and characterize it such that the planning means can be examined by which it may be made an eco-friendly. The study area was Gulbarga is one of the cities in Karnataka, India which is known by 'Sun-city'. The objectives of this research work were:

a) To examine the natural settings and assess its influence on the design, layouts and built form, which make for and enhance eco friendliness.

b) To examine and assess the existing and changing land use patterns and the felt needs of the people influencing eco-friendliness.

c) To assess critically areas of importance such as public realms, historical precincts, and visible natural landscapes that require further reshaping/landscaping for enhancing sustainability; and

d) To make considerable recommendations for better designs, layouts and built forms and to

inform policy frameworks to improve the quality of urban life by incorporating eco-friendly aspects in the preparation of development plans.
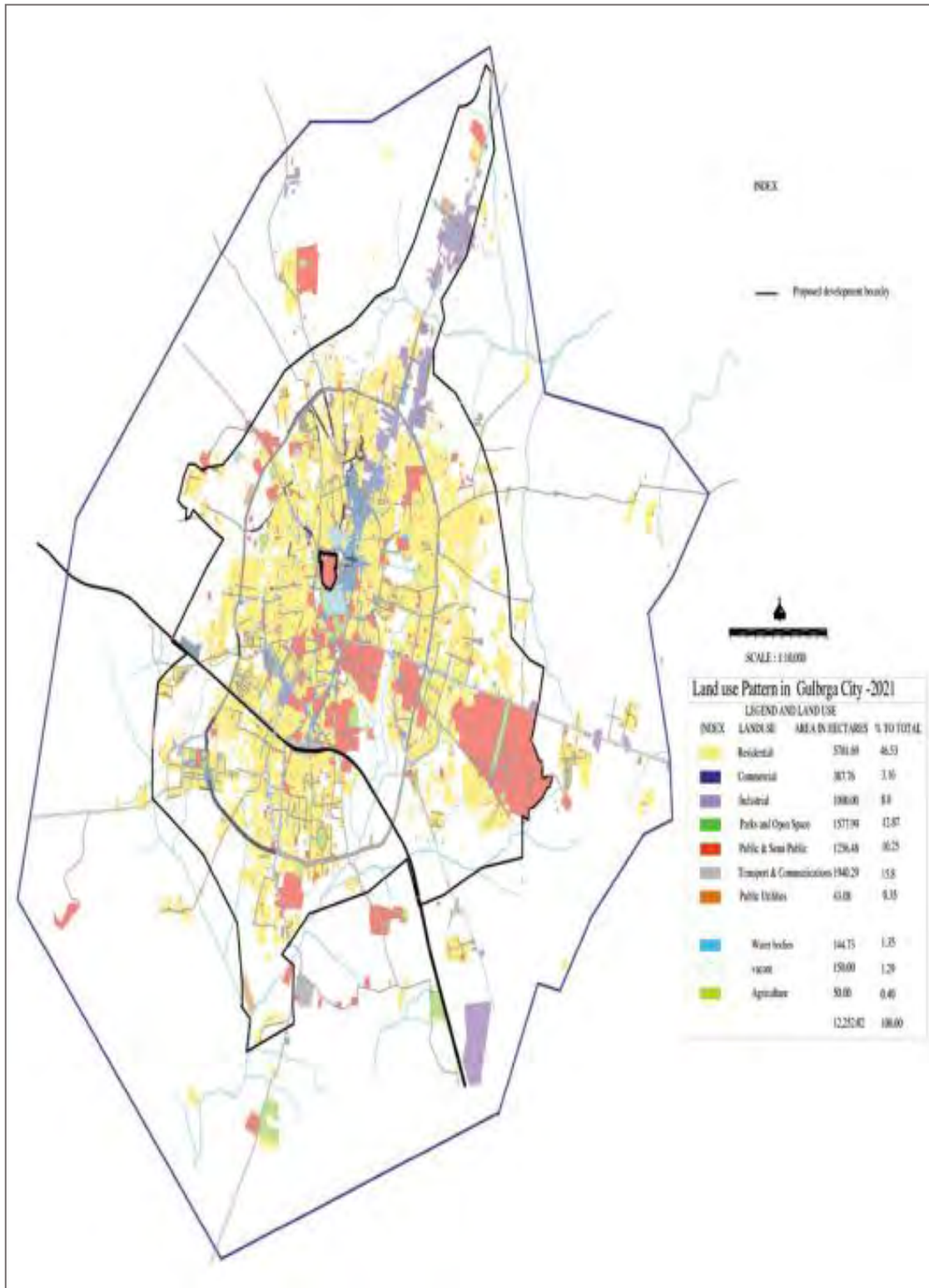
Figure 3.6: Proposed Landuse Map of Gulbarga City, India (of 2021); Source: (Mathad, 2013)

Besides these, a set of key but generic indicators (5 of socio-demographics, awareness, source and knowledge, want, eco-friendliness, sustainability, likings and community contribution) along with 50 perceptual variables in regard to climate (3), water (7), topography (3), green infrastructures (3), landscaping (12), quality of environment and resources (6), waste management (2), land uses (5), transport network (2) and built forms and buildings (7) had been added to a questionnaire for interviews with the residents in order to capture their revealed perceptions on the nature of Gulbarga city and its socio-cultural and ecological characteristics.

Salient Features of Gulbarga City:

- **Topography:** The topography of the city contributes a lot towards achieving sustainability through rainwater harvesting and maximizing the use of the sun and the wind energy for building Gulbarga as an eco-friendly city.

- **Water:** The extent of land covered with water bodies is mere 0.54 percent of the total geographical area of the city (6,868 ha) which is very low for any comfort.

- **Green Areas and Landscaping:** These are limited in extent and not widely scattered within the city. Green and open areas account only for 6.56 percent of total land uses.

- **Buildings:** Most recent buildings, because of the materials used, are not compatible with climate, especially during summer because of the large expanse of glass and other heat absorbing materials like steel and cement plaster.

- **Open Spaces:** Gulbarga has a very small extent of open spaces compared to built-up area and that it would be difficult to achieve comfortable levels of open spaces in the city while the available open spaces are eroding fast.

- **Circulation Patterns:** The circulation pattern of the city has shown that the streets are of sufficient width for the current levels of traffic, except for a few locations (central areas) which lacks completely in streetscapes.

The research had concluded that Gulbarga city is not eco-friendly and there are certainly possibilities for improvement to achieve eco-friendliness with certain modern planning strategies, such as creating blue and green network besides using the concept of 3-R.

The key parameters that were set are:

Table 3.5: Parameters to evaluate eco-friendliness of Gulbarga

Parameters	Checklist
Environmental	temperature, heat, rainfall and humidity
Ecological	land, vegetation, air and water
Physical	land uses and built forms
Socio-cultural	good access to resources through transport, well-designed public spaces and cultural and recreational spaces
Technological	construction techniques for eco-friendly buildings, proper management of waste affecting the air and water quality
Economic	activity patterns and land values
Psychological	the felt needs of the people in their city
Political	environmental management tools, policy instruments, decision making, people empowerment and private-public participation

3.2.5 Evaluation of Ecological Urban District in Malmo- Sweden

This study aims to identify the role that architects play in environmental justice and ecosystem support. The study area was Bo01 in Malmo, Sweden which was an industrial harbor and newly designed to serve residential and some commercial purpose. The goals of developing it as an ecological urban district were (Mowla & Ahsan,2009):

a. Be a local, national and international leading example in sustainable urban development.
b. 100% locally produced renewable energy from sun, wind and water.

The evaluation criteria were set to evaluate eco-system in the built environment to evaluate the quality and success of a development from an ecosystem support standpoint. The criteria were a)

waste, b) health, c) transport, d) integration with local ecosystem, and e) global impacts. And for evaluating environmental justice in a built environment, the criteria were a) social justice, b) substantive justice, c) procedural justice, d) distributive justice, and e) corrective justice(Mowla & Ahsan,2009).

Salient Features of the Project:

Table 3.6: Features of Malmo-Sweden

Energy Saving	100% locally renewable energy - Zero energy balance - Recycling energy from sewerage and waste - Minimization of energy use
Traffic Reduction	- Prioritizing bicycle and pedestrian traffic over car - Reduced traffic space - Restriction in car traffic in low speed zones - Encouraging public transport and car pooling
Sanitation and drainage	- Introducing 'Cradle to Cradle' approach to manage waste through recycling and reusing. - Implementing neighborhood source separation of waste to promote waste recovery - Recovery of energy and nutrients form waste and transforming waste into biogas - Production of agricultural products from waste - Waste water treatment and local rainwater management
Socio-Economic	It is planned to take measures for public participation, social interaction, social balance, equal accessibility and affordability
Biodiversity	- System for green space factors - Green points for bird and bat nesting, and courtyards for

	Swedish wild flowers
	▪ Recovery for biotopes
	▪ Park and gardens, green roofs which will perform as habitats for natural lives
Building Materials	▪ Environmentally benign, recyclable and recycled materials were used and encouraged.

After analyzing these features it research recommended some pivotal actions such as- ensuring gender equality in public participation, encouraging communication at all level, managing accountability for environmental justice, equitable sharing of all benefits, developing and expanding land and water conservation, introducing eco tax, introducing walkable districts and mixed use activities (Mowla & Ahsan,2009).

Figure 3.7: Malmo, as Visualized with Vector Data; Source: (Nilsson, 2017)

3.2.6 Key Parameters identified from Case Studies

This study aims to identifying the role that architects play in environmental justice and ecosystem support. Study on different eco-cities shows that conserving green spaces and water bodies, generating electricity using sustainable/renewable resources, using green technology, cutting water consumption and waste, greener public transportation and walking, recycling, reusing and recovering waste, enhancing public cohesion can reduce ecological footprint and make a city eco-sustainable. The case studies show the possible evaluation parameters to measure eco-sustainability of city which are combined in the Table 3.4.

Table 3.7: Eco-sustainability Parameters from Case Studies

Parameter	Checklist
Ecological	Cultivable lands, Fishing lands, Forest lands and Vegetation
Environmental	Temperature, Heat, Rainfall and Humidity
Biodiversity	Woodland ecosystem, Ecosystem of flood plains and fisheries, Terrestrial ecology,River ecosystem.
Technological	Renewable energy, Green transport and utility, Environmental management tools, Zero energy balance, Recycling energy.
Physical	Soil, Hydrology, Topography, Land uses and built forms, Canal networks, Drainage systems
Socio-cultural	Accessibility, Utility services, Affordability, Economic activities
Economic	Activity patterns and Land values
Socio-Economic	Public participation, Social interaction, Social balance, Equal accessibility.
Psychological	The felt needs of the people in their city
Political	Environmental management tools, Policy instruments, Decision making, People empowerment and Private-public participation

3.3 Development of Eco-sustainability Checklist for Evaluation

Literature review on the theoretical framework develops concept on ecology, ecosystem, urban ecosystem, environmental capacity, ecological footprint, eco-sustainability, eco-cities. This chapter provides overview about 3E i.e. economic and environmental sustainability and social

equity and 4R i.e. reuse, reduce, renew and recycle; which can be blended in urban design to build an eco-sustainable city.

Study on different eco-cities shows that conserving green spaces and water bodies, encouraging greener public transportation and walking, generating electricity using sustainable/renewable resources, using green technology, cutting water consumption and waste, recycling, reusing and recovering waste, enhancing public cohesion can reduce ecological footprint and make a city eco-sustainable. The case studies show the possible evaluation criteria to measure eco-sustainability of city and salient features of eco-cities. These guides to set evaluation criteria that can be used in this research work.

From literature review five criteria/parameters were determined broadly which are Ecological, Physical, Socio-Cultural, Technological and Biodiversity i.e. creating green-blue-grey network. After setting these criteria some indicators are also selected which are explained in next chapter. A field survey was conducted to assess the outcome and data were analyzed according to these criteria. Based on the findings the PNT project was evaluated based on its eco-sustainability and necessary measures were recommended.

3.4 Setting the Checklist

To reduce environmental degradation and ecological footprint a city needs to be developed as eco-sustainable city. It is necessary to measure the eco-sustainability of its existing built environments and its future development. Based on the literature review five parameters of evaluation are identified and a set of checklist are determined on the basis of related features that existed in the study area before initiating the project. Though an eco-sustainable city has various types of parameter which differs from city to city but mainly these five parameter are common in most cases in various forms. So, these five parameters of eco-sustainable city are chosen to present the minimum standards for eco-sustainable qualification.

Table 3.8: Eco-sustainability criteria check list

Eco-sustainability component	Eco-sustainability Parameters	Checklist
Environment	Ecological	Cultivable lands, fishing lands, forest lands and vegetation
	Biodiversity	Woodland ecosystem, ecosystem of flood plains and fisheries, terrestrial ecology, river ecosystem.
Economy	Physical	Soil and hydrology (Topography, land uses and built forms, canal networks, drainage systems)
	Technological	Renewable energy, green transport and utility, environmental management tools
Equity	Socio-cultural	Accessibility, utility services, affordability, economic activities

Chapter 04: Analysis and Parametric Evaluation

This chapter demonstrates the scenario of Purbachal New Town before and after the initiation of the project and the evaluation of proposed plan based on the selected five indicators which are Ecological, Physical, Socio-cultural, Technological and Biodiversity. The objective of designing this township was to build up an eco-friendly city with the blend of urban and natural ecosystem. This township is designed to accommodate 1.5 million people within 2025. It is claimed that the natural flow of water bodies is used to maintain the drainage network and the existing forest is also preserved to conserve its eco-system. An urban ecosystem is proposed to be develop in this area with vibrant economy and enhancing the mobility. Roads and utility services are provided in this area for better accessibility and livability. Basically, this chapter will evaluate PNT objectives 2 and 3 which includes balance of environment; environment friendly and sustainable environment.

4.1 Setting up the Parametric Checklist for Evaluation of PNT

Based on literature review five broad criteria are set based on which ecological footprint can be shown in Table 4.10.

Table 4.10: Checklist for Evaluation Criteria from Literature Review and Case Studies

Eco sustainability component	Eco sustainability Parameter	Indicators
Environment	Ecological	Cultivable lands, grazing lands, fishing lands, forest lands, vegetation, impact on air and water quality, Blue and Green Network.
	Biodiversity	Habitat loss, woodland ecosystem loss, Blue and Green Network.
Economy	Physical	Topography, land uses and built forms, open spaces, canal networks, drainage systems, well-designed public spaces and cultural and recreational spaces
	Technological	Construction techniques for eco-friendly buildings, energy saving approaches (walking strips, renewable energy, natural solution for green transport and utility), proper management of waste affecting the air and water quality

Equity	Socio-cultural	Footprint of working people, accessibility, public participation, social interaction, affordability, economic activities, environmental management tools, policy instruments, decision making, people empowerment

This specific evaluation will consider a set of indicators which are relevant to PNT area (as of now) because the project is yet to be completed. Also some of the indicators are not applicable for local context. It would be more feasible to use the indicators mentioned above if the project had been completed. By considering all these reasons the project will use the partial set of indicators and conduct the evaluation based on them and they are organized as per selected parameters as identified before:

Table 4.11: Selected indicators for evaluation

Parameters	Indicators for evaluation
Ecological	% of land available for agriculture % of land available for fishing (water body) % of land available for forest and vegetation cover - Level of pollution (air, water, sound) - Presence of blue-green network (including area)
Physical	% of people living per acre (gross residential density) % of land with infrastructure (built form) % of land available for mixed use (drawing-check the plan)

	• Provision/availability of densification strategy • Connectedness with surrounding networks/areas
Socio Cultural	• Provision of affordable plots/housing for displaced people (previous residents) • % of land available for commercial use • % of land available for key urban services and facilities • Provision of public transport. • Provision of participatory planning
Technological	• Provision of renewable (eg solar, wind etc) energy • Provision rain water harvesting • Provision of waste recycling • Provision for waste water treatment • Provision for technology and innovation
Biodiversity	• Strategy for environmental protection/resilience • Provision for bio-diversity conservation • Habitat loss per hectare (flora and fauna) • Change of river/natural drainage system (% of land) • Existence of natural drainage system

Source: Developed by author based on literature survey and case studies

For the sake of evaluation and for consistency, the research has considered only five major indicators for each parameter. The next section will rank each indicators based on available data and information found during the study.

4.2 Context Analysis

Eco sustainable settlement design starts with through documentation of existing situation. Development takes care of the natural systems. Conservation of natural and man-made elements (that provides character and identity to the place) are ensured as far as possible.

Planning and design definitely brings about some changes in the natural eco-system. If pre design inventory of eco-sustainable elements is recorded, the planning and post-planning phases have a scope to replenish the eco-system loses by designed means. No pre-design inventory was available in RAJUK. However, Pre design scenario is compiled from various published sources for this study.

For the evaluation of eco-sustainability of PNT, the parameters developed in the chapter-3 would be used and for socio-economic assessment of PNT, local standards of DAP and PRLDR would be used.

4.2.1 Ecological Parameter

Based on the existing ecological features of the Purbachal area before initiating PNT project, some indicators are set such as agricultural lands, lands for pisciculture and vegetation and forest lands. These three indicators show the change in the land areas and how the ecosystem of water bodies, forestlands and cultivable lands is being transformed.

   a. **Cultivable lands:**

   i. Pre-project situation: Before initiating Purbachal new township Project, the Purbachal area was a hilly area where homestead vegetables were cultivated. Around 43.5% of the land area was cultivable and there were a few agricultural lands too.

Table 4.1: Cultivable Lands in Purbachal Area before the Project

Type of Land use	Area (Acres of 6077.36 acres)	Percentage (of 100%)
Cultivable Land	2645.46	43.530
Agricultural Low Land	172.33	2.836
Built up Land (Residential & Roads)	3259.57	53.634

ii.   Present scenario: According to present residents of Purbachal area, the soil of this area is fertile and they used to cultivate here and sell those in nearby Bazars. Now the cultivable and agricultural low lands have been converted into flat lands and prepared to develop residential plots and roads. But still some of the residents continue cultivating vegetables. When these plots will be developed for commercial and residential purpose, there will be no scope for such cultivation.

Figure 4.1: Cultivable Lands of PNT, Photo Taken on 23 July, 2018

iii.   Proposed plan of the project: In the proposed plan of PNT area, there is no provision for conserving cultivable lands and agricultural low lands. There are only 215.89 acres of vegetation and forest land in PNT area which is only 3.55 percentage of total land.

b. Lands for fishing

i.   Pre-project situation: There were several canals and water bodies in Purbachal area where fish were cultivated and there was a food chain among fishes, flora, fauna and other

aquatic habitats in these water bodies. The edges of water bodies are rich in nutrients from inundated soils and decaying vegetation, and also rich in food in the form of dead insects. And these water bodies were habitat for carp, catfish, shrimp and other fishes and different insects.

i.   Present scenario: At present the water bodies are filled with sand for development and it is affecting the aquatic habitats and their ecosystem. But still people are continuing fishing in some canals and Balu river.

ii. Proposed plan of the project: Though the present scenario is different, in the proposed plan, it is expected to develop 7.58% water bodies which are about 5% more than the pre-project scenario. Some new locations are proposed as water bodies in the new planning of PNT and these can be used as fishing lands and a place for aquatic habitats.

Figure 4.2: Fishing in existing Canals in Purbachal Area, Photo Taken on 23 July, 2018

Figure 4.3: Water Bodies in PNT area, Source: DAP 2010

c. Forest Land and Vegetation

i. Pre-project situation: There was a big privately-owned commercial forest area with some concentrated and scattered SHAAL forest pockets in Purbachal Area. There were also homestead vegetation with canopy coverage and usually consists of Fire and Fruit trees, winter vegetables, weeds and reeds, bamboo grooves, herbs and shrubs etc.

Table 4.3: Percentage of Vegetation and Forest Land before the Project

Type of Land use	Area (Acres)	Percentage
Forest and Vegetation Land Before the Project		
Forest (Privately Owned Commercial Forest of Gozari Trees)	191.50	3.151
Homestead Vegetation	2073.65	34.121
Proposed Vegetation and Forest Land Area		
Forest	215.89	3.55

ii. Present scenario: At present about 34% lands for homestead vegetation are converted to build area and residential plots. The lands that were cultivated were the habitat of different insects and there existed a food chain among the insect of soil and swamp, trees and other flora and fauna. Diverting these lands in built area modified the ecosystem that existed. The forest area is still reserved. In the pristine nature of Purbachal, there stood a privately owned commercial forest of GOZARI trees (SHAALBON) on 191.50 acres of land which is not any preserved forest of the Department of Forest. An overwhelming part, almost in entirety, of this forest belonged to Gazipur while a trace of 0.76 acre had been in Narayanganj. There were also traces of scattered forest pockets (at 20 locations) on a total of approximately 43 acres. Therefore, the core forest area is 148.50 acres. During the planning process, maximum emphasis was put on preserving the entire forest area intact.

Figure 4.4 : Purbachal New Town Area on 2006

Figure 4.5: Purbachal New Town Area on 2018

Figure4.6: Reserved Forest Area in PNT, Photo Taken on 23 July 2018

iii. Proposed plan of the project: In the proposed plan, there is a provision for preserving the forest area. The forest is a habitat for different types of animals such as lizards, geckoes, all species of common birds such as martins, herons, kites, house sparrow, ravens and crows, mice, rats and other rodents, jackal, mongoose and monkeys. Preserving this area will help to conserve the ecosystem of the forest and the woodland habitats will not be destroyed. But total vegetation of the area will be reduced about 34% than the previous situation as other lands are being converted into built environment.

4.2.2 Physical Parameter

Topography, land use, canal networks and drainage system are used as physical indicators. These indicators will show the change of Purbachal area due to PNT project.

a. Topography

i. Pre-project situation: The Purbachal area consisted of undulated with scores of hillocks, medium high lands and pockets of low-lying areas where one-crop was cultivated a year. During the rest of the year this area remained dry except narrow furrows which act as surface drains during rains. In the high lands and hilly areas there were scattered homesteads and small villages. On the neighboring slopes, winter vegetables were produced.

ii. Present scenario and proposed plan: The area is converted to a flat land by cutting and filling. The land area is developed for the proposed roads, residential plots and other. Some plots are still 4-5 feet higher than the flat lands.

iii. Old topography (ie. contour) is not used in the proposed PNT, thereby effecting natural drainage / runoff context.

Figure 4.7: Hilly lands in PNT, Photo Taken on July 23, 2018

b. Land uses and built forms

i. Pre-project land use: The dominant land use was cultivable lands, homestead vegetation, agricultural low lands, and forest and homestead area. The detailed land use statistics are given below:

Table 4.4: Pre-project land use statistics of PNT (EIA, 2004)

SL. No.	Land use Category	Area (Acres)	Percentage
1	Cultivable Land	2645.46	43.530
2	Homestead Vegetation	2073.65	34.121
3	Agricultural Low Land	172.33	2.836
4	Forest (Privately Owned Commercial Forest of Gozari Trees)	191.50	3.151
5	Homestead Area	770.10	12.672
6	Water Body (Ditch, Pond and Swamp)	148.12	2.437
7	Khal	10.36	0.170
8	Road (Katcha)	28.64	0.471
9	Road (Semi-Pucca)	0.17	0.003
10	Road (Pucca)	19.50	0.312
11	Bazar/Growth Center	10.22	0.168
12	Playground	6.98	0.115
13	Graveyard	0.33	0.005
Total		**6077.36**	**100.00**

ii. **Present land use situation:** Present land use pattern was analyzed in ArcGIS Desktop 10.1 using the Google earth image of Purbachal New Township area of 3rd April, 2018 through image classification. This image analysis defined areas of vegetation, water bodies, barren lands and built up areas and shows that 33.6% land cover is homestead vegetation and forests, 6.80% lands are water bodies, 11.53% lands are barren lands and 48.05% is built up area.

Homestead vegetable	33.6%
Forest	6.80%
Water Bodies	11.53%
Barren Land	48.05%
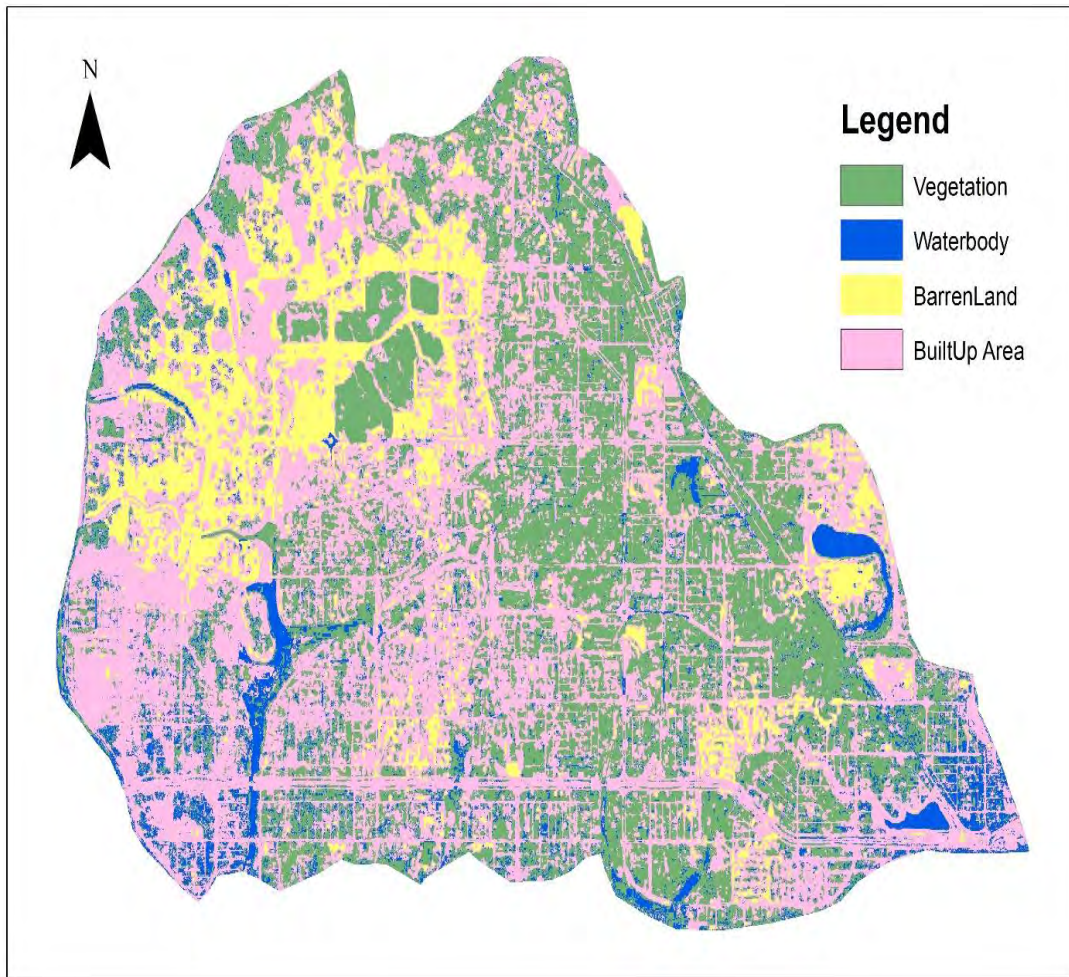
Figure 4.8: Land use of PNT at Present,
Source: Developed By Author based on DAP by RAJUK.

iii. Proposed landuse: The PNT has been planned and designed for a gross population density of 165 persons per acre and will preserve existing Gozaria forest, lakes/canals, service roads, pedestrian/ walkways along either sides of lakes/canals, space for fire service stations, law or order forces, play-lots for kids and playgrounds for the juvenile/adult, greeneries and open spaces etc. Besides adequate lands for residential blocks, urban utility facilities, a National Sports Complex as well as an Executive Golf Course and a green belt around the project area are provisioned. The overall land use pattern is shown in Table-11.

Table 4.5: Proposed Land use Statistics of PNT(Ref: Annual Report, RAJUK 2014-15)

SL. No.	Type of Landuse	Area (Acres)	Percentage
1	Community Organization (Community Centers & Convention Centers)	50.37	0.83
2	Commercial (Market/Katcha Bazar/Corner Shop, Commercial Plots)	214.84	3.54
3	Education (Nursery, Primary & Secondary Schools, Colleges & Universities)	270.40	4.45
4	Forest	215.89	3.55
5	Health (Clinics & Hospitals)	38.07	0.63
6	Higher/Research Institutional	61.37	1.01
7	Industrial Parks	69.30	1.14
8	Lake/Canal	460.94	7.58
9	Officiating Accommodation (Administrative & Diplomatic)	141.86	2.33
10	Other Essential Services (Fire Service, Police, RAB)	47.07	0.77
11	Physical Infrastructure (Central Eidgah, Crematorium, Filling Station, Graveyard, Slaughter House, Central Bus Terminal)	54.52	0.90
12	Recreation (Eco Park, Park, Playground, Play-lot)	220.27	3.62
13	Road (All types plus pedestrian, plaza, walkways)	1614.34	26.56
14	Residential Area (Plots, High-rise Blocks)	2359.94	38.83
15	Social Infrastructure (BMA,IVVB, other clubs)	35.66	0.59
16	Sport Facilities	99.83	1.64
17	Urban Utility Facilities	119.22	1.96
Total		**6077.36**	**100.00**

Table 4.6: Comparison of Pre-project landuse and Proposed Landuse Statistics of PNT

SL. No.	Land use Category	Area (Acres) Pre-project Scenario	Percentage Pre-project Scenario	Area (Acres) Post planning Scenario	Percentage Post planning Scenario
1	Forest and Vegetation	5082.94	83.638	215.89	3.55
2	Homestead Area/ Residential Area	770.10	12.672	2359.94	38.83
3	Water Body (Khal,	158.48	2.607	460.94	7.58

	Lake,Ditch, Pond and Swamp)				
4	Road Network	48.31	0.786	1614.34	26.56
5	Commercial Area	10.22	0.168	214.84	3.54
6	Recreational Area	6.98	0.115	389.40	6.40
7	Physical Infrastructure	0.33	0.005	448.70	7.38
8	Educcational Institution and Health Facilities	0	0	369.84	6.16
Total		**6077.36**	**100.00**	**6077.36**	**100.00**

The Land use plan of the Purbachal New Town Project is finalized and approved by the Authority. Of the total area, 2359.94 acres would be used for residential, 663.54 acres for commercial and physical infrastrucres, 331.77 acres for institutional purposes. About 45% of the total area has been proposed to be reserved for lakes, parks, roads and other open spaces. The huge amount of cultivated land and forest land has decreased to make space for the residential plot. No specific homestead vegetation unit is defined by the authority. There was a big privately-owned commercial forest area with some concentrated and scattered SHAAL forest pockets in the Purbachal Area. At present about 34% lands for homestead vegetation are converted to build area and residential plots. No social forestry or home stead vegetation criteria has been set in the plan to compensate for the bio diversity or open area loss.Proposed water bodies or forest were also not aligned with the natural setting.

Detail Land use of Purbachal Area

Legend

	Administrative
	Commercial
	Community Organization
	Education
	Forest and Eco-Park
	Health
	Industrial Park
	Institutional
	Pedestrian
	Physical Infrastructure
	Play-Ground/Play-Lot
	Police
	Research and Institutional
	Residential Block
	Residential Plot
	Road
	Social Infrastructure
	Sports Facilities
	Urban Green
	Urban Utility Facilities
	Water-Body
	Unclassified

Fig 4.9: Detailed Land use of Purbachal Area.
Source: Annual report,RAJUK 2014-2015

According to Private Residential Land Development Rules 2004 (PRLDR,2004), standards for different land use pattern are guided. According to RAJUK, PNT is designed to fulfil the demand of projected 1.5 million people of 2025. In the following table, space for different urban facilities is calculated for 1.5 million people.

Table 4.7: Space requirement for different urban facilities in PNT for 1.5 million people

SL. No.	Type of Land use	Area (Acre) for 1,00,000 population (PRLDR, 2004)	Area (Acre) Required for 1.5 million	Proposed Area (Acre)	Percentage of Area
1	Community Organization (Community Centers & Convention Centers)	4	60	50.37	1.49
2	Commercial (Market/Katcha Bazar/Corner Shop, Commercial Plots)	4	60	214.84	6.34
3	Education (Nursery, Primary & Secondary Schools, Colleges & Universities)	34	510	270.40	7.97
4	Health (Clinics & Hospitals)	4	60	38.07	1.12
5	Community Facilities (Central Eidgah, Crematorium, Filling Station, Graveyard, Slaughter House, Central Bus Terminal, BMA,IVVB, Sport Facilities, other clubs), Other Essential Services (Fire Service, Police, RAB)	100	1500	237.08	6.99
6	Recreation (Eco Park, Park, Playground, Play-lot)	20	300	220.27	6.5
7	Residential Area (Plots, High-rise Blocks)	185.71	2785.65	2359.94	69.59
	Total Area	351.71	5275.65	3390.97	100

The table shows that there is insufficiency in lands needed for 1.5 million population of PNT which is projected for 2025. PNT project needs more 425.71-acre area to satisfy the PRLDR, 2004. It will fail to provide sufficient space for community organizations and gathering places, educational facilities, recreational facilities, health facilities and even residential plot. People will rely on facilities outside PNT area which will create extra pressure on neighborhood areas. It concludes that PNT will fail to be eco-sustainable city and will be a crowded township in 2025 similar to existing Dhaka. Moreover, PNT will not be able to absorb some of the pressure of

Dhaka (as mentioned in the PNT objective) on the contrary; it will exert more pressure on old infrastructures.

c. Canal Networks and Drainage System

In the proposed plan of Purbachal New Township 7.58% area is designed for lakes and canal development which is more than the previous situation (about 2.5% area were water bodies). To resolve water stagnation, increase water retention capacity and improve sewerage system, 100-foot-wide canals along both sides of Purbachal link road from Kuril to the River Balu is under construction.

This canal network of Purbachal will facilitate in meeting water demands of Nikunja, Baridhara, Joarsahara, DOHS, Cantonment, Hazrat Shahjalal International Airport, Kalachandpur and nearby areas too.

Figure 4.10: Drainage network alongside the road, Photo Taken on July 23, 2018   Figure 4.11: Canal network of PNT, Photo Taken on July 23, 2018   Figure4.12: Existing khal in PNT, Photo Taken on July 23, 2018

A drainage network is developed in Purbachal area alongside of each road and these control the water flow and lead it to the existing Khals and open spaces. At present in this area there is few water logging problems due to the existing terrain of lands where buildings are not developed still. But in future development process it will cause water logging as the open spaces that leads the water to the canals will be developed. Still there are few water logging scenarios in some roads and water does not stand on roads for long as the adjacent plots are lower than the roads. But this scenario will change if those lands are developed in same height of the roads.

4.2.3 Socio-cultural Parameter

Socio-cultural indicators demonstrate the mobility and availability of urban amenities which will make the urban ecosystem vibrant. In this regard, three indicators are set which will discuss the road facilities, plot distribution and utility facilities such as gas, electricity, water supply, sewer system.

a. Accessibility

i. Pre-project situation

The rural Purbachal area had no organized transportation networks because of scattered settlements of people and low economic activity. Vegetables were transported though boats and vessels to nearest economic centers. The main roadway there was the Dhaka bypass road. There were some narrow pucca roads connecting to growth centers and rest of them were Katcha roads.

ii. Situation after Initiating the Project

Based on some criteria the transportation network of PNT area had been designed which are: topography, soil and rock condition, danger signals, slopes, landscape families, surrounding land use, higher level plan provision, linkage between activities, environmental factors, distance between activities and stakeholder wish. In this project road transportation system has been developed.

The southern RHD regional road was designed to have 250 feet width and expected to have uninterrupted traffic flow. The eastern RHD regional road would be of 160 feet width. The 45.72 m to 91.44 m wide project regional road will reduce traffic load of RHD regional roads and will connect Primary and Secondary roads. The width of primary and secondary roads would vary from 30.48 m to 48.77 m and 16.46 m to 30.48 m respectively. The width of access roads would vary from 9.14 m to 20.12 m. This transportation system also has tertiary and cul de sac road networks to connect apartment buildings.

According to RAJUK's Revised Traffic Demand Assessment Report, it is projected that total 3,67,950 flats of this township area will own 2,94,360 vehicles and 80% of the flat owner will have one car. This project area will generate 8,60,254 vehicular movements daily in average.
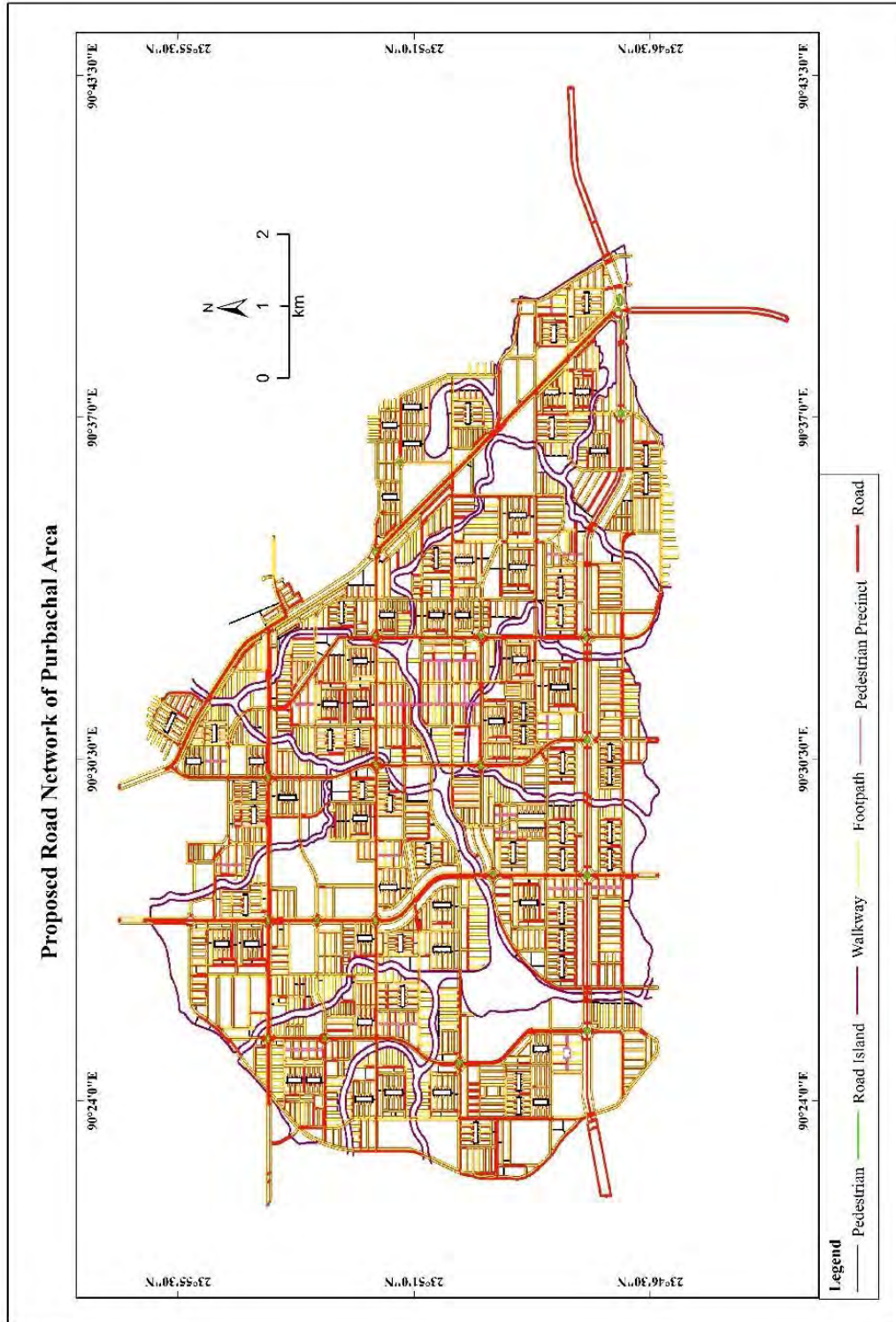
Fig 4.13: Proposed Road Network of Purbachal Area by DAP 2010

| Figure 4.14: Secondary roads of PNT, Photo Taken on July 23, 2018 | Figure 4.15: Access road of PNT, Photo Taken on July 23, 2018 | Figure 4.16: Waster logging on roads, Photo Taken on July 23, 2018 |

During the field visit it is observed that the road networks were not developed properly though it is expected to be handed over within 2018. Some of the constructed roads are already damaged which needs renovation. Future traffic pattern and volume has not been considered in the road network planning. There is no specific public parking arrangement.

b. Utility Services

i. Pre-project situation

The Purbachal area was being a purely rural area and the power supply came from Palli Bidyut Samiti of the Rural Electrification Board through their poles and transformers located beside the roads. Water was collected from local source. And because of availability of wide open spaces, wastes were left there for decomposition, disintegration and gradual absorption by soil.

ii. Situation after initiating the project

Utility service of this project area has been designed based on the population project of 2025. It was projected by RAJUK that by 2025, the population of PNT area will be about 1.5 million. The utility services special water supply system and sewerage system is being developed in two

phases where phase I is based on the population estimation of 2015 and phase II is based on population estimation of 2025.

Table 4.8: utility Services of Purbachal New Township Area, Source RAJUK

Services	Land Allocated (Acre)
Electrification (Partially green using solar energy)	5.40
Water Supply	
Sewerage System	2.42
Drainage System	
Gas Distribution	2.79
Telecom	2.03

These services are not green. Because green options for water supply, sewerage, drainage and gas distribution were not used.

Water system has been designed according to the projected water demand. Total water requirement is estimated about 188 lpcd. And total water demand for the year 2025 would be about 282 MLD. 80% of the water demand will be met from surface water source and 20% will be extracted from ground water source.

In Purbachal New Township area, Separate system (one sewer for the sanitary sewage and other for the storm water drainage) has been designed with effective sewer network and sewage treatment plant. The effluent of sewage treatment plant and storm water drainage will be discharged to nearby Balu River. By 2025, the estimated sewage flow is 268 Million Litre per Day (MLD). Sewerage treatment plant was proposed to be constructed in two phase (Capacity of 134 MLD in Phase I and the rest in Phase II). It was expected to end by 2015. But at present the construction work is not finished.

Though in the proposed plan it is expected to provide the utility services within 2015 implementing the phase I and rests will be provided within 2025. But still residents of PNT area use water from deep tube-well and pumping machine and electricity from Rural Electrification Board. No sewerage system has been developed. And no spaces or bins are delineated for waste disposal. Due to these situations plot owners cannot shift there and develop their plots.

Figure 4.17: Waste disposal situation in PNT, Photo Taken on July 23, 2018

c. **Affordability**

The Purbachal New Township area is divided into 30 sectors, of which 35,592 residential plots have been designed. It is about 38.83% of the total area. 42% of total plots has been handed over already. 3.54% land area are for commercial development.

Table 4.9: Residential Plot Distribution of Purbachal New Township Project

Category	Plot Size (Decimal)	No. of Plots	Total Area (Acres)	Plot % in Terms of Total Number	Percentage in Terms of Total Project Area
Category-I	4.96	10012	498.77	40.02	8.21
Category-II	8.26	10361	859.79	41.42	14.15
Category-III	12.40	2616	326.34	10.47	5.37
Category-IV	16.53	2025	336.65	8.09	5.57
Grand Total		25016	3637.10	100.00	33.30

According to (Morshed, 2013), about 63% of the total land plots are reserved for selected groups: government job holders 40%, employees and officials of semi-government bodies 15%,and officials of the RAJUK including the ministry concerned 2.5%.Only 22% of the total land plots are for wage earners and other categories of employees. This scenario concludes that this project will hardly meet the actual housing need of Dhaka City. Moreover, the land price of this project area is considered as high value to wage earners. The distance from working place also affects their affordability.

4.2.4 Technological Parameter

Technological indicators show the features that are adopted to make the PNT eco-friendly and energy efficiency.

a. Walking strips and Green Transport

A city-wide accessibility through eco-mobility was a main goal of the master plan and a tool for an adequate design of the Blue-Green network. Proximity plays a key role in this strategy and so the network was planned based on walkable and bikable distances. Enabling walkability and cycling improves public health. A larger network of cycling routes and public transportation has been suggested for ensure green network. At present in PNT there is some delineated walking strips, but this project has no provision for green transport system. Green transportation is a low-carbon and environmental travelling mode. The active promotion of green transportation is not only good for intensive use of road resources, the ease of traffic congestion, the decrease of energy consumption and the improvement of air quality, but also, as a return to healthy and leisure lifestyles, good for the improvement of citizen health. It is developed as an eco-friendly city, but its road network system doesn't promote any non-motorized schemes.

b. Renewable energy

In the proposed plan of PNT project, there is no provision for renewable energy which could reduce energy consumption and promote natural energy sources.

c. Environmental Management Tools

To ensure safer environment and control pollution, RAJUK sets some environmental regulations for Purbachal New Township project as follows:

➢ Environmental Conservation Acts 1995 and Environmental Conversation Rules, 1997
➢ National 3R (Reduce, Reuse, Recycle) Strategy for Waste Management, 2010
➢ Local Government (City Local Authority) Act, 2009
➢ Medical Waste Management Rules, 2008

These regulations are followed to minimize potentials for pollution, to obtain environmental clearance certificate, waste treatment and management and to provide residents a decent living environs.

As this project has potentials for environmental impacts an Environmental Impact Assessment study had been carried out and an Environmental Management Plan has been prepared by RAJUK. A robust system has been planned for waste disposal of different types of wastes. Effectivity of these plans and regulations can be measured when the whole project will function.

Seismological considerations are missing in the layout of PNT in terms of land allocation and or for post disaster management.

4.2.5 Biodiversity Parameter

a. River Ecosystem

The two rivers in the PNT area the Balu and the Shitalakhya are already polluted so that fishes and other aquatic animals cannot survive in these waters. These rivers supported a fish fauna that

included carp, catfish, loach, shrimp and a variety of invertebrates and insects. Both the rivers have factories and industries along their banks with the former having much more and as such heavily polluted. Thus fishes become extinct in the Balu. The Shitalakhya is less polluted but under threat of becoming heavily polluted in near future. The ecology of these rivers is already deteriorated.

The Balu, the Shitalakhya and the channels and low-lying areas of Purbachal provide a variety of aquatic habitats. The two rivers degraded into channels of little ecological value as the water is frequently polluted and heavily during lean season. These areas are often characterized by dense growths of the water hyacinth, *Echicornica*, crassipes, which out-competes other plants through its burgeoning growth, although species such as water chestnut and lotus can still be seen in places.

In the proposed plan there is no provision for cleaning the water channels and preventing pollution, thus conserving this ecology. Moreover, in this plan the sewage and drainage system is supposed to flow into Balu river. If the sewage is not treated the Balu river will be severely polluted.

b. Ecosystem of Flood Plains and Fisheries

Floodplains are natural lowlands alongside rivers which are important ecologically as adults of many species migrate into these areas to breed. These lands are rich in nutrients from inundated soils and decaying vegetation, and also rich in food in the form of dead insects. Floodplains of Balu and Shitalakhya have been kept out of the planning for Purbachal. Only narrow strips along the rivers have been included in the project. Due to liquid wastes from industries fishes die in Balu river and become extinct.

c. Terrestrial Ecology

Green networks includes connecting natural, semi-natural and man-made open spaces, promote physical activity and recreation, improve accessibility within settlements and to surrounding

countryside and enhance biodiversity and the quality of the environment. The Purbachal Township was green with trees and vegetation that still beautify and make the environment congenial to terrestrial ecology specific to this area. The forests stand there and will continue so doing under a plan that integrates development with nature. The encroachment of wetlands, trees, greeneries, vegetation in and around the township endangers its terrestrial ecology. The terrestrial fauna is diverse and consists of animals such as lizards, geckoes, all species of common birds like martins, herons, kites, house sparrow, ravens and crows, mice, rats and other rodents, jackal, mongoose and monkeys. Development of these area make them extinct. Planning authorities should try to stop habitats being fragmented or isolated further as well as find ways to restore links already broken. Integrated habitat networks can be used with green networks to maintain and enhance local biodiversity. If green network is not well-managed, the accelerating process of urbanization can have a serious impact across the urban-rural continuum and on the surrounding ecosystems. It causes fragmentation between cities and their surroundings, peri-urban, and rural areas. It also damages ecosystems through the degradation of urban ecosystem services and disruption of ecological processes. Planning authorities should assess current and future open space needs, and plan how to protect open spaces to help meet those needs.

d. Woodland Ecosystem

Pressure on land to provide food, income and accommodation for burgeoning population leads to encroachment into protected areas causing severe habitat degradation in many areas. Considering this the original green areas of Purbachal have been planned to preserve as forests, eco-parks, parks, urban green, sports complexes and golf courses. It is expected to retain individual tree and vegetation based biodiversity to a great extent. But lack of monitoring can worsen the situation.

4.3 Eco Sustainability of Purbachal New Town Area

4.3.1 Evaluation of PNT as per selected indicators

The research makes an attempt to evaluate the eco sustainability status through personal judgment based on experience, field level findings and available data. A before-after comparison

method has been used to show the change of different parameters which portrays the factors that affected the eco-sustainability status of PNT. This comparison has also been supported by a ranking method of relevant indicators that can be considered as a measure of eco-sustainability for a planned city extension/neighborhood.

Table 4.12: Land use analysis and before after comparison

Land use category	Pre-plan phase		Post-plan phase	
	Area (Acre)	%	Area (Acre)	%
Cultivable Land	2645.46	43.530	nil	nil
Homestead Vegetation	2073.65	34.121	No set standard	nil
Forest	191.50	3.151	215.89	3.55
Residential/ Homestead Area	770.10	12.672	2501.8	41.16
Water Body (Ditch, Pond and Swamp) including agricultural low land	330.81	5.44	460.94	7.58
Road (Katcha, semi-pucca and pucca))	48.31	.786	1614.34	26.56
Commercial activities (bazar and growth centers)	10.22	0.168	214.84	3.54
Public space (playground)	6.98	0.115	320.10	5.26
Urban basic services and facilities	0.33 *graveyeard	0.005	676.68	11.14
Industrial			69.30	1.14
Total	6077.36	100	6077.36	100
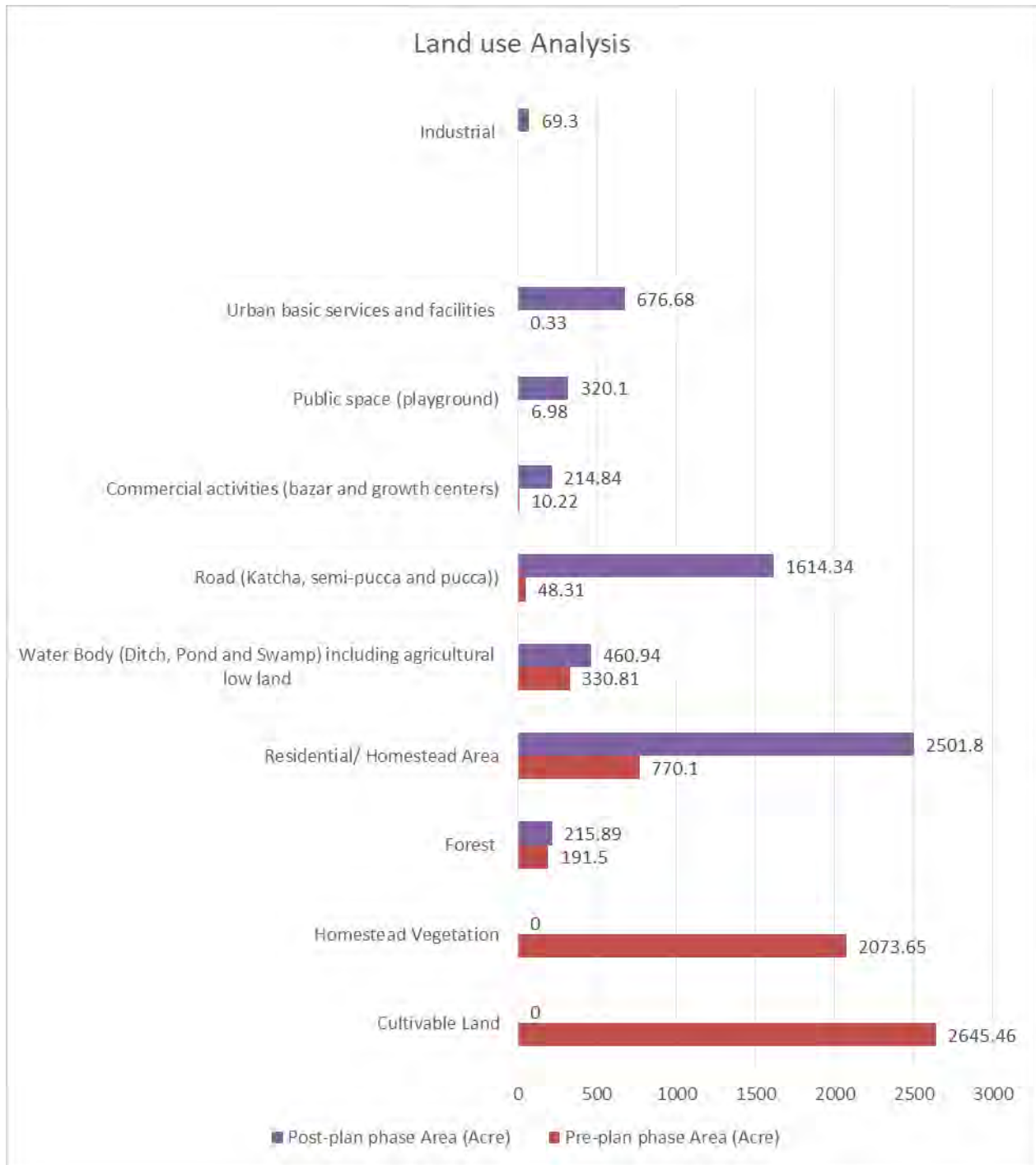
Figure 4.18: Land use analysis and comparison of pre-plan phase and post plan phase planning.(based on Table 4.12)

Source: Developed by Author based on Table 4.12, 2019

The above table shows that because of the project, the most affected areas are agricultural land and natural green areas. A huge amount of areas will be developed as built form that will affect the natural ecosystems existed in PNT area for many years.

The following table explains the ranking of different indicators that have been used as a measure of eco-sustainability in urban settings. The ranking decision has been made based on personal judgment which was influenced by available data and information gathered during the study. The ranking scores indicate different level of satisfaction in terms of eco-sustainability scenario in PNT i.e 1-very dissatisfactory, 2-disasatifcatory, 3-moderately satisfactory, 4- satisfactory, 5-very satisfactory. Ranking has been made against five indicators under each parameter and total 25 indicators has been considered under five parameters. So the maximum value of the indicators can be 125 and minimum can be 25. For this research the PNT will be considered as an eco-sustainable if the total value of the indicators is 100 as 4 depicts satisfactory against each indicator. The area will be considered as moderately satisfactory if the sum of score is 75 as 3 depicts moderately satisfactory against each indicator.

Table 4.13: Scoring of relevant indicators

Parameters on Eco-Sustainability	Indicators	Scoring of indicators					Remarks
		1	2	3	4	5	
Ecological	% of land available for agriculture	x					14
	% of land available for fishing (water body)				x		
	% of land available for forest and vegetation cover				x		
	Level of pollution (air, water, sound)			x			
	Presence of blue-green network (including area)		x				
Physical	%of people living per acre (gross					x	16

Category	Indicator						Total
	residential density)						
	% of land with infrastructure (built form)					x	
	% of land available for mixed use (drawing-check the plan)		x				
	Provision/availability of densification strategy		x				
	Connectedness (public transport) with surrounding networks/areas		x				
Socio-cultural	Provision of affordable plots/housing for displaced people (previous residents)	x					**13**
	% of land available for commercial use				x		
	% of land available for key urban services and facilities				x		
	Provision of public transport			x			
	Provision of participatory planning	x					
Tchnological	Provision of renewable (eg solar, wind etc) energy	x					**8**
	Provision rain water harvesting	x					
	Provision of waste recycling		x				
	Provision for waste water treatment			x			
	Provision for technology diffusion	x					
Biodiversity	Strategy for environmental		x				**11**

	protection/resilience						
	Provision for bio-diversity conservation	x					
	Habitat loss per hectare (flora and fauna)			x			
	Change of river/natural drainage system (% of land)			x			
	Existence of natural drainage system		x				
Total score							**62**

The total score of the indicators is 62 which is between dissatisfactory and the moderately satisfactory status according to ranking method as has been used above for this study.
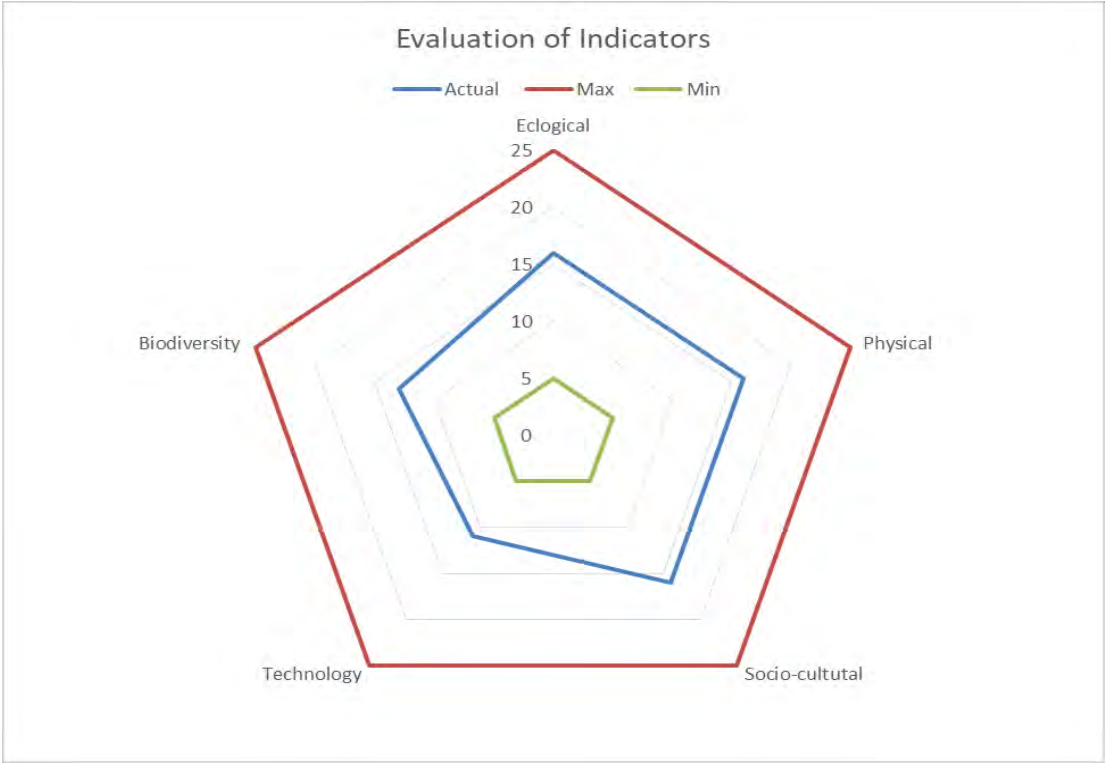
Figure 4.19: Evaluation of Indicators

4.3.2 Evaluation of PNT in respect to Global Sustainability Features

PNT project is evaluated as follows according to the characteristics of an eco-city provided by Low Carbon Green Growth Roadmap for Asia and the Pacific:

Table 4.14: Evaluation of PNT against Global Sustainability Features

Features of Eco-cities	Examples	Status of PNT
Powered by renewable energy to various scales	Masdar, United Arab Emirates; Dezhou solar city, China	No provision for using renewable energy (solar system, wind mill)
Aiming to be free from carbon emission by improving energy efficiency as well as by replacing fossil fuel with renewable energy sources	China's low-carbon cities project	Low carbon emission schemes are not proposed in the PNT.
Incorporating intensive greening as part of the urban environment	Ginza, Japan's commercial district.	PNT reserved the natural forest land which covers only 3.55% of the total area.
Using resources sustainably in both production and consumption practices	China's circular economy and eco industrial parks in the Republic of Korea	PNT has already proposed a sewer system which may affect and pollute the Balu river. Moreover, People are leaving wastes in open spaces which can be reused, recycled and recovered. PNT did not delineated any 3R policy
Using information technology as part of improving environmental sustainability	Yokohama, Japan	No provision has been found to promote green energy, green transport, green building.

The features shown above in the table are used efficiently in the eco-cities all over the world, but these features are absent in PNT. Low carbon emission schemes, provisions for 3R, renewable energy and green infrastructure are absent in Purbachal New Township. Green and blue urban node and corridor is not used in the settlement layout in conformity with the natural setting.

4.4 Planning Implication

This section summarizes planning implications for the development of PNT based on the facts and findings through this research effort.

4.4.1 Evaluation of PNT with Respect to Social Sustainability

A comparison has been made between the proposed land use of PNT and the landuse standard of Bangladesh according to Private Residential Land Development Rule, 2004 to evaluate whether PNT can provide sufficient facilities to projected 1.5 million people in 2025. PRLDR has been formulated to ensure socio-economic sustainability.

Table 4.15: Evaluation of PNT for Social Sustainability for targeted 1.5 million people

Category	Standards of DAP Area (Acre)	Standard of PRLDR, 2004 Area (Acre)	Landuse of PNT Area (Acre)	Remarks
Community Organization (Community Centers & Convention Centers)	72	60	50.37	10.37 acres is required to satisfy PRLDR, 2004.
Commercial (Market/Katcha Bazar/Corner Shop, Commercial Plots)	60	60	214.84	Commercial lands are sufficient enough.

Education (Nursery, Primary & Secondary Schools, Colleges & Universities)	410	510	270.40	To facilitate 1.5 million people, more lands of 239.4 acres are required.
Health (Clinics & Hospitals)	60	60	38.07	21.5 acres lands for health facilities are required.
Community Facilities (Central Eidgah, Crematorium, Filling Station, Graveyard, Slaughter House, Central Bus Terminal, BMA,IVVB, Sport Facilities, other clubs), Other Essential Services (Fire Service, Police, RAB)	500	1500	237.08	To serve residents of PNT with its own facilities, more 1262.92 acres of lands are required.
Recreation (Eco Park, Park, Playground, Play-lot)	240	300	220.27	In PNT 79.73 acre lands are needed to satisfy PRLDR, 2004.
Residential Area (Plots, High-rise Blocks)	6000	4285.71. (350 person/acre)	2359.94	425.71 acres land is needed to accommodate 1.5 million people according to PRLDR, 2004.

The above table shows that in Purbachal New Township only commercial land is sufficient enough but land for community organization, education, health, community facilities, recreation and residential area is not enough according to the standard of both DAP and PRLDR. In the case of community facilities there is a huge deficit of land. On the other hand land for commercial usage, it is more than the standard. That will create an imbalance situation .More

importantly land for educational facilities is almost half of the requirement. So residents of PNT may have to depend on the neighborhood for urban facilities, in other words they will put pressure on surrounding settlements, therefore, will not be sustainable socially.

4.4.2 Transformation of Purbachal New Town Area Scenario

This research found that the impacts of the PNT project is significantly notable on ecological, physical, socio-cultural and bio-diversity related matters in Greater Purbachal area.

From the findings stated above a short summary of planning implications has been stated in the following table that will help to understand how it will impact the area after completion of the project

Table 4.16: Transformation of Purbachal New Town Area

Indicators	Scenario before Development Plan	Current Scenario	Projected Scenario after Completion	Remarks
Ecological	i. There were 46.39% agricultural lands existed in Purbachal area where different vegetables and crops were cultivated. These lands supported productions that contributed to the local economy. An ecosystem was existed in these lands.	i. As the construction work has not been initiated, some lands are still used for cultivation. The ecosystems of those lands which are developed as road network, are lost.	i. After completion of the project, there will be no agricultural lands.	i. Loss of soil ecosystem ii. Interruption in food chain of different insects, crops, birds, lizards and other. iii.No specific space for social vegetation.

	ii. 2.61% of the total land area were water bodies where fishes were cultivated. An ecosystem existed among fishes, flora and faunas of these water bodies.	ii. Water bodies are still used for fishing.	ii. After land development, there will be 7.58% water bodies which is about 5% more than before.	ii. Water bodies can be developed as a habitat with rich biodiversity.
	iii. Vegetation cover was over 37.27% lands of the total area in which there was a forest of 34.12% area.	iii. The forest land is still preserved and it is rich with like martins, herons, kites, house sparrow, ravens and crows, mice, rats and other rodents, jackal, mongoose and monkeys.	iii. Reserving this forest area is proposed in PNT.	iii. This forest area may conserve the woodland ecosystem and will remain as the habitat of these animals.

Physical	i. Purbachal area consisted of undulated lands with scores of hillocks, medium high lands. ii. Major landuse was 34.53 % forest lands and 46.39% was cultivable lands. Rests were water bodies, roads, residential areas.	i. Most of the lands are flattened. ii. 33.6% land cover is homestead vegetation and forests, 6.80% lands are water bodies,11.53% lands are barren lands and 48.05% is built up area	i. This area will not have its natural topography. ii. Major landuse will be residential area and urban amenities and utility services.	i. Draining logged water through natural topography will not remain. ii. An ecologically rich area will transform into a residential area. iii.If the natural drainage system is not use properly water logging creates a great problem in future.
	iii. 2.61% land covers were canals and water bodies. Natural canal networks worked as drainage system.	iii. 100-foot-wide canals along both sides of Purbachal link road from Kuril to the River Balu is under construction. Drainage networks are built up alongside of each roads. Already water stands on roads and low lands due	iii. There will be 7.58% water bodies with improved drainage network through canals.	iii. Lack of proper interlinkage of these canals as well as lower terrain of developed lands than water level of canals and lakes may cause water logging.

		to heavy rain.		
Socio-cultural	i. This area did not have an improved road network and boats were used for transportation.	i. An improved road network including regional highway, primary road, secondary road, tertiary and access road has been developed. People will commute through motorized and non-motorized vehicle. At present few trips are generated from PNT as it is not fully developed yet.	i. This project area will generate 8,60,254 vehicular movements daily in average.	i. It will have a great effect on its neighborhood transportation system and contribute to creating more traffic jam on the regional high way. ii. There are no specific cycling route. For the eco-mobility it ensure the walkability and cycling option in the township area. iii.Mass-transit of green modes have been introduced.
	ii. Power supply came from Palli Bidyut Samiti of the Rural Electrification Board. Water was collected from tube-wells. Wastes were thrown in any open spaces.	ii. Still residents of PNT use electricity from Palli Bidyut Samiti of the Rural Electrification Board and use water from tube-wells and motors. Wastes are still	ii. The total area will be electrified under DESCO and PGCB. Total water demand for the year 2025 would be about 282 MLD and 80% of it will be fulfilled by surface water	ii. No provision for renewable energy, 3R schemes. Discharged effluents of sewer system may pollute the Balu river.

		dumped in open spaces.	sources and rests will be extracted from ground water sources. There will be effective sewer network and sewage treatment plant which will be discharged in Balu river.	
	iii. Before PNT project the land value of Purbachal area was lower than present.	iii. 42% of total plots has been handed over already. But due to lack of access to utility services people are not willing to move to PNT area.	iii. Only 22% of the total land plots will be for wage earners and rests will be for selected groups (govt. and semi-govt. officials, RAJUK officials).	iii. This project may not help to support housing problem of Dhaka city.
Technology	i. Balu and Shitalakhya river and low lands helps to pass the excessive rain water.	i. As the construction work has been initiated, natural drainage system is not working.	i. After completion of the project, there will be no low lands for drainage of the total area.	i. A robust system has been planned for waste disposal. ii. Environmental management plan may develop the situation.

			ii. No provision for renewable energy and rain water harvesting. iii. Its road network system doesn't promote any non-motorized scheme.	
Bio-diversity	i. Balu and Shitalakhya river supported a fish fauna that included carp, catfish, loach, shrimp and a variety of invertebrates and insects. ii. The Purbachal Township was green with trees and vegetation.	i. The two rivers the Balu and the Shitalakhya are heavily polluted so that fishes and other aquatic animals cannot survive in these waters. ii. The forest area still consists of animals such as lizards, geckoes, all species of common birds like martins, herons, kites, house sparrow, ravens and crows, mice, rats and other rodents, jackal, mongoose and monkeys. But development of this area makes them extinct.	i. There is no provision for restoring river ecosystem in PNT. ii. A plan that integrates development with nature will be introduced.	i. This ecosystem loss will affect the urban ecosystem weakening the local economy and livelihood. ii. The erasure of wetlands, trees, greeneries, vegetation in and around the township endangers its terrestrial ecology. Conserving the forest lands will enrich bio diversity of PNT. iii. Blue-green network planning seeks to protect the ecological and hydrological values of the urban landscape and to provide resilient measures to address climate change.

The above table shows that in Purbachal area, a variety of ecosystem existed such as soil ecosystem, river ecosystem, woodland ecosystem .Land development of Purbachal area causes loss of soil ecosystem interrupting the food chain of different insects, crops, birds, lizards and other. More water bodies are developed. Forest lands are preserved in the proposed PNT project

which can preserve the bio diversity of woodlands. Absence of provision for protecting the ecosystem that was existed previously, is observed in present scenario.

Previously lands of Purbachal area were mostly cultivated lands but now these are developed as residential and commercial lands. There was no improved drainage network and logged water flew to rivers and water bodies due to natural topography. Due to PNT project an improved drainage system is developed which is connected to canals and Balu river But lack of proper interlinkage of the canals as well as lower terrain of developed lands than water level of canals and lakes may cause water logging.

At present an improved road network has been developed in Purbachal area which increased the accessibility of the residents of this area.Previously most of the roads were katcha road and boat was the main means of commuting. The developed road network has a great effect on its neighborhood transportation system and contributes in creating more traffic jam on the regional high way. PNT project provides water supply system, electricity under DESCO and PGCB, and tele-communication which were absent before the project. There is no provision for renewable energy, 3R schemes. The sewer system is designed to discharge the effluents of sewer to Balu river. It may pollute the river if the sewers are not treated properly. Due to higher land value and reserved plots for govt. and other officials, this project may not help to support housing problem of Dhaka city.

Developing the area for residential purpose and providing necessary facilities causes transformation of wetlands and cultivated lands into built environment. The erasure of wetlands, trees, greeneries, vegetation in and around the township may endanger its terrestrial ecology. Conserving the forest lands may act as an opportunity to enrich bio diversity of PNT.

Chapter 05: Recommendation and Conclusion

5.1 Recommendation

Before development, Purbachal area was predominantly a rural area with agricultural economy. The land was acquired by RAJUK and local residents were displaced. There was no resettlement plan either for those displaced people, who were mainly farmers and rural poor. In the proposed PNT plan there is no provision for low income housing or affordable plots that the local people could afford.

Therefore, the plan should consider the provision of low cost plot so that local people or the most vulnerable and displaced groups can afford sustainable mix of plots which will also ensure social mix. Such provision of social mix has been also highlighted in the "sustainable planning principles" of UN-Habitat discussed in chapter-3.

Table 5.1: Eco-sustainability standards

Sustainability components	Eco-sustainability Parameters	Evaluation checklist
Environment	Ecology	Cultivable lands, Fishing lands, forest lands and vegetation.
	Biodiversity	Woodland eco system, eco system of flood plains and fisheries, terrestrial ecology, river eco system.
Economy	Physical	Soil and hydrology
	Technological	Renewable energy. green transport and utility, environmental management tools.
Equity	Socio-cultural	Accessibility, utility services, affordability, economic activities

Recommendation for Ecological parameter

The previous land use of PNT consisted a variety of ecological sensitive zone including lakes, rivers, water bodies with a diverse species of flora and fauna. The plan did not preserve those sensitive zones/areas and should take measures to protect them from any sort of developments that will obstruct the natural flow of surface runoff those drains, rivers and canals.

The present scenario of PNT shows that the surrounding areas have been occupied for large scale residential developments which are very alarming for the natural eco-system. In one sense PNT worked as a catalyst for other residential developments. For example, the size of "Jolshiri residential project" is twice as big as PNT which had been also developed on the agricultural land adjacent to PNT. There are so many other residential development projects which are putting huge pressure on the natural ecosystem of that area as well as for the surrounding areas/regions. By considering the issue of urban food security and rapid loss of agricultural land, the authority should take measures to protect agricultural land inside and outside of PNT area.

Recommendation for Biodiversity parameter

In the proposed plan, the amount of natural forest and vegetation cover has been reduced. So, it is advisable that some original forest areas should be preserved to ensure natural ecosystem, per capita green space and reduce urban heat island effect. The forest and green area should be integrated with existing and planned water bodies (lake-river) to develop a functional blue-green network to ensure better urban environment that can enhance resilience of the PNT. Due to the development of PNT, a huge variety of flora and fauna will be affected. Therefore, the plan should consider specific guidelines to protect the bio-diversity in PNT area. The plan should also consider issues environmental management, protection and disaster management to improve the eco-sustainability status of PNT.

Recommendation for Physical parameter

Dhaka is one of the most densely populated cities in the World and It has been reported that around 3000 people are coming to Dhaka for better livelihoods and other factors which is making the city denser than ever. If the trend continues, Dhaka will lose its' livability within next

few decades. So, densification should be the key priority for both city infill and city extension. Therefore, as a "planned city extension" PNT should have a densification strategy by considering the population growth rate of Dhaka. Such plan would guide how to PNT would accommodate additional people in future by following the basic planning principles (i.e plan at scale and plan in advance) promoted by the UN in the New Urban Agenda discussed in chapter-3.

Green options are not used in the service provision and infrastructure development. The plan mentions different services and facilities, but it is not clear how they will be interlinked and connected. There should be a functional mechanism to ensure all those facilities are properly interlinked, well-connected so that citizens can receive best service through an integrated approach and can also ensure service delivery efficiency. Ideally the plan should introduce service delivery plan and will update periodically based on users' satisfaction survey.

According to UN-Habitat's Sustainable Planning Principles, in a sustainable city extension 30%-40% floor space should be allocated for commercial/economic use. This principle will make sure the city is providing livelihoods and proper job opportunities to its' residents. The PNT plan do not have such consideration. Thus, there should be proper strategy for commercial and economic activities that can ensure vibrant and financial opportunities for the residents of PNT.

Better connectivity can ensure better urban life. It is important to analyze how this area will be connected with surrounding transport and other service networks. So proper strategy and measures should be taken to ensure better connectivity in PNT which is not considered in the current plan.

Recommendation for Technological parameter

The present PNT plan does not have any policy or guidelines for pollution control. Once the development is complete as per plan, pollutions will occur in different forms. Therefore, the plan should consider a pollution control strategy with proper measures and actions to reduce different forms of pollution i.e. air, water and sound pollution. New tools and measures should be introduced systematically on periodic basis as well.

The current plan does not discuss about any specific mobility plan i.e walking, cycling, public transport etc. The plan should propose or should take necessary measures for better mobility of the residents with special considerations for bike lane and safe sidewalks that can promote accessibility to different spaces within PNT area. At the same time the area should have better public transport, transport hub that can be easily accessible by the residents from their home.

The current PNT plan proposes some parks and green areas for the residents but it does not have any specific plan for public spaces. According to UN-Habitat's Sustainable Planning Principles, in a sustainable city 40-50 percent spaces should be allocated for public spaces (30-35% for street and 15-20% other public spaces i.e parks, garden, open spaces). A specific plan or strategy should be incorporated in the PNT plan for public spaces which is an integral part of eco-sustainability.

By considering the issue of new technologies and innovation, the plan of PNT should consider the opportunities for new innovation and technologies that can improve and support the eco-sustainability of this area. New tools, measures and skills should be tested on regular basis that can improve the life of the citizens in PNT. The options for renewable energy, rainwater harvesting, waste recycling etc should be introduced and considered as a part of new innovation subjected to periodic upgrading based on research.

Recommendation for Socio-cultural parameter

A functional coordination mechanism and governance structure should be tailored which will be the engine of PNT project implementation process. The plan should focus on that properly so that the governance structure can assign clear roles and responsibilities to different actors who will jointly work to improve eco-sustainability of PNT. Participatory planning and regular consultation process should be considered by the implementing authority for long term sustainability as well.

By considering the rapid changes the land use pattern, disasters, natural course of actions and human behavior change there should be an option to review and update the plan on periodic basis to accommodate those changes and needs which will also impact on the eco-sustainability of

PNT. Such revisions and updating process should also consider new eco-sustainability indicators and parameters relevant for PNT.

Evaluation against five indicators of eco-sustainability (sec 3.4) i.e. Ecological, Physical, Socio-cultural, Technological and bio-diversity, the PNT shows grossly sub-standard planning and development approach, that will shortly result in situation prevailing in the existing part of Dhaka.PNT fails to achieve the objectives set for the project ,particularly the objective 2 and 3 of PNT(sec 2.3).

5.2 Study Outcome

First objective of this thesis was to develop an eco-sustainability checklist for the evaluation of new township. In this regard, this study sets some evaluation criteria and evaluates the eco-sustainability of Purbachal New Township Project. This research fixes five parameters which are shown in Table 5.1.

To reduce environmental degradation and ecological footprint, Dhaka needs to be developed as eco-sustainable city. It is necessary to measure the eco-sustainability of its existing built environments and its future development as well. But it is an irony that there is no national standard for eco-sustainable cities in Bangladesh and there are no specific indicators for evaluation. Hopefully, this checklist will fill up this gap.

Second objective of this study was to identify eco-sustainability gaps in the PNT and suggests improvements. This study shows that PNT fails to be an eco-sustainable city. This project fails to preserve the existing ecosystem or propose a new balanced ecosystem through design guidelines. Though more water bodies are developed and forest lands are preserved in the proposed PNT project, there is absence of provision for protecting the ecosystem that existed previously. The new water bodies and forest could have been overlaid with existing setting. Thus, proposed PNT project will not be ecologically sustainable. It transforms the cultivated lands into residential and commercial lands which affects the agro-based local economy. Alternative vegetation scheme could have been proposed. In the PNT project a drainage system is proposed, which lacks proper links of the canals as well as lower terrain of developed lands. Uncoordinated water level of canals and lakes may cause water logging. The developed road network will have an effect on its neighborhood transportation system and will contribute in creating more traffic jam on the

regional high ways. There is no unbuilt provision for renewable energy, 4R schemes and green transport system. Green options for utilities and infrastructure were grossly neglected in the PNT. The sewer system is designed to discharge the effluents of sewer to Balu river. It will pollute the surface and underground water if the sewers are not treated properly. Due to higher land value and reserved plots for government and other officials, this project will not help to support increasing housing problem of Dhaka city. The destruction of wetlands, trees, greeneries, vegetation in and around the township may endanger its terrestrial ecology. These scenarios prove that the dwellers of PNT will not have a reduced ecological footprint or the loss of greeneries and bio-diversity will damage its natural ecosystem. Based on the finding this research proposes some recommendation that can make PNT project eco-sustainable such as- provision of affordable housing for displaced persons, zoning ecological sensitive areas, limiting unplanned and rapid development in this area, provision of land to accommodate future provision/densification strategy, securing agriculture land for urban food security, taking pollution control mitigation measures, integrating blue green network, harmonization between facilities, promoting mixed use to reduce service cost, pollution to improve social cohesion, securing sufficient amount of public spaces(open spaces, streets), ensuring public participation (development, implement, management, maintenance and monitoring or evaluation), provision of alternative power supply, rain water harvesting and management, waste recycling management and treatment, incorporating policy guidelines for biodiversity and natural ecosystem conservation. This research works on the specific five parameters, but some other criteria may also be defined for evaluation. Those can be introduced in further research works in future. This research can be helpful in further eco-city planning or assessing the eco-sustainability of similar developments projects in Dhaka as well as other cities in Bangladesh.(ref: 5.1)

In short, right balance of land use (commercial, residential and recreational), utilities and infrastructure needs to be introduced following the natural landuse standards and international eco-sustainability standards respectively. PNT needs to be viewed in the context of Dhaka. The checklist/parameters developed and suggested in this research may be used for revising the PNT and also for any new township development for their eco-sustainability.

5.3 Scope for Future Research

This study intends to be useful to make any evidence based decisions to reduce the gaps in implementing eco-friendly schemes to develop the township development and to reduce ecological footprint. This study evaluates the eco-sustainability status of the PNT project as the case. The developed eco-sustainability checklist for the evaluation PNT may be used for the future study. Any policy regarding eco-sustainability and community participation measures can be taken as indicated in this research. This study sets a minimum standard for eco-sustainable city, which may be further refined. Quantifiable ecological footprint analysis may be the next agenda.

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