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Ecological footprint as an indicator of national and city level
sustainability

M. N. HOQUE

PHD

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Ecological footprint as an indicator of national and city level sustainability

A case study of Bangladesh with a focus on Narayanganj

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Abstract

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Sustainability, Ecological Footprint, Indicators, Bangladesh, Narayanganj City, Bottom-up approach, Multi-dimensional, Policy.

This thesis addresses urban sustainability from an ecological footprint viewpoint to make cities inclusive, safe and livable in Bangladesh under the SDG-11 of the Agenda for Sustainable Development Goals-2030. Previous empirical studies on Bangladesh do not focus on Ecological Footprint (EF), and Narayanganj City's (NC) EF has yet been explored. Previous studies also focused on only specific dimension of sustainability. This study aims to meet these gaps by linking the existing facilities and required initiatives under all dimensions of sustainability, e.g., social, economic, environment and institutions. Both secondary and primary data were used. Secondary data were collected from the World Bank and Global Footprint Network. Primary data were collected by a survey of 500 households in NC and twenty in-depth semi-structured interviews with experienced urban experts from academics, NGOs, government, voluntary and independent urban research organizations in Bangladesh. STIRPAT model was used to analyze the secondary data, and interview data were analyzed following theoretical thematic analysis. The empirical findings suggest that Bangladesh can still afford more urbanization. However, the high EF of NC is a concern of this affordability. The interview data analysis indicates that the government can promote the current opportunities for a relatively quick result for urban sustainability without imposing any extra burden on citizens. A sustainable urban development framework (SUDF) and based on this SUDF, a set of policy recommendations is also proposed. Further research options and limitations of this study have also been identified.

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Abbreviations

AMG	Augmented Mean Group
ARDL	Autoregressive Distributed Lag
BAEC	Bangladesh Atomic Energy Commission
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCSIR	Bangladesh Council of Scientific and Industrial Research
BD	Bangladesh
BRRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engineering and Technology
CCEMG	Common Correlated Effect Means Group
CLUM	Consumption Land Use Matrix
COICOP	Classification of Individual Consumption Accounting to the Purpose
CUP-FM	Continuously Updated-fully Modified
CUP-BC	Continuously Updated-bias corrected
DOLS	Dynamic Ordinary Least Square
EF	Ecological Footprint
EFA	Ecological Footprint Accounting
EKC	Environmental Kuznets Curve
FMOLS	Fully Modified Ordinary Least Square
GoB	Government of Bangladesh
GFN	Global Footprint Network
GMM	Generalized Method of Moments
GTAP	Global Trade Analysis Project
LCB	Lower Critical Bound
MENA	Middle East and North Africa
MoEF&CC	Ministry of Environment, Forest and Climate Change
NC	Narayanganj City
NCC	Narayanganj City Corporation
NFA	National Footprint Accounting
RAJUK	Rajdhani Unnayan Kartripakkha
SREDA	Sustainable and Renewable Energy Development Authority
SUDF	Sustainable Urban Development Framework
UCB	Upper Critical Bound
UNCED	United Nations Conference on Environment and Development
UNCSD	United Nations Commission on Sustainable Development
UNDESA	United Nations Department of Economic and Social Affairs
OECD	Organization for Economic Co-operation and Development
UNDP	United Nations Development Program
WEF	World Economic Forum

Chapter one

Introduction

1.1 Research Background

This research aims to examine some of the challenges of managing urbanization and sustainability in Bangladesh from an Ecological Footprint (EF) viewpoint with an in-depth study of one of its secondary cities, namely, Narayanganj City (NC). This study is also about identifying the major driving forces of higher EF of this city and provides a series of easily achievable sustainable practices covering all dimensions of sustainable development. The sustainable urban development framework (SUDF) and related recommendations (by following the principles of “no extra burden to the citizen” and “Utilizing the existing facilities”) is also explained.

Urban areas in general can contribute more to the national economy and act as a growth centre of a country. The worldwide population in urban area also increased dramatically from thirty per cent in 1950 to 55.3 per cent in 2018 and sixty per cent of total population will live in urban areas by 2030 (UNDESA 2018).

This rapid population change implies increased consumption and more agricultural activities, ultimately increasing energy consumption (Bi et al. 2011). These increases directly impact land use change and have indirect and inter-linked effects on Greenhouse Gas (GHG) emissions. Urban areas are responsible for over seventy-five per cent of global GHGs emissions. Climate change is also one of the indirect impacts of urbanization and accounts for eleven to sixteen per cent of global biodiversity loss (WEF 2022).

On the contrary, cities contribute eighty per cent of world GDP (WEF 2022), creating employment opportunities and acting as a sustainability multiplier (Wackernagel et al. 2006). Sustainability multiplier in the sense that introducing a sustainable practice in a city will automatically generate other sustainability practices. In this regard, Baabou et al. (2017) gave an example of mileage-based vehicle tax. On the one side, this tax reduces traffic congestion. On the other side, the reduction of traffic congestion improves the air quality, which will ultimately improve the productivity of

the people. Thus, urbanization has both positive and negative sides. Nevertheless, its sustainable planning and design can create an opportunity to promote a global sustainability transition (Pearson 2013).

Studies of sustainability also have a long history of development. However, the recent initiative for sustainable studies started with the United Nations Conference on the Human Environment in 1972. Huang et al. (2015) offered the most systematic development of this study. They claimed the United Nations Conference on the Human Environment in 1972 as the starting point of sustainability studies. Afterwards, in 1987, the Brundtland Report circulated the widely accepted definition of sustainable development (WCED 1987). Then, Rio Earth Summit adopted the necessity of sustainability indicators in 1992. In 1999, the term “sustainability science” was introduced by US National Research Council Report. The Johannesburg Earth Summit of 2002 is another crucial milestone for sustainability studies. This summit reaffirmed the importance of implementation of agenda 21, and finally, Rio+20 Earth Summit in 2012 came up with specific and practical measures for implementing sustainable practices.

According to the Brundtland Commission’s report, sustainable development is “...development that meets the needs of the present generation without compromising the ability of future generations to meet their needs”. The Rio de Janeiro (first) Earth Summit in 1992 formally accepted this definition as the basis for Agenda 21 while the Johannesburg summit of 2002 further advanced support for this. From this second earth summit, the well-known three dimensions/pillars of sustainable development- social, environment and economic- evolved to represent the summit's motto “People, Planet, Prosperity” (Chen 2018). Nowadays, it is taken as common sense, widely accepted and well-discussed in every political, business or other strategic document (Moldan et al. 2012).

Evaluating developments from a sustainability standpoint is an extensively discussed issue, especially for urban areas (Kaklauskas et al. 2018; Wang et al. 2018). Since cities are regarded as the children of urbanization process (Mumford 1961) and the originators of environmental degradation (Shen et al. 2011), urban sustainability is critical for long-term sustainable development. As a result, sustainability assessment

originated from the local level, like cities, is a more tangible, action-oriented and smaller-scale initiative (De Lannoy et al. 2001). In addition to this, Wallner et al. (1996) claimed that the local level is the starting point of any natural transition process. Therefore, before creating the whole system sustainably, it would be better to start from the local level, like cities.

UN-Habitat (2011) also argued that cities should be the starting point for any sustainability initiatives. Another reason to start with cities is that the EF of cities' inhabitants is always much higher than the earth's biocapacity. If this continues, the earth might be unable to supply the resources. As a result, an imbalance between demand and supply will arise, and it would be challenging to maintain the quality of life of people and local communities. Quality of life is also a central discussion point in the recent urban global policy dialogue. For instance, the new Urban Agenda of UN-Habitat-III in Quito, Ecuador, on 20 October 2016, sets the standards and principles for planning, construction, development, management and improvement of urban areas. Another important initiative in the global policy dialogue for urban sustainability is adopting a dedicated goal as 'Sustainable Cities and Communities' (SDG-11) in the Agenda for UN Sustainable Development Goals-2030. This goal aims to make cities inclusive, safe, resilient and sustainable (Vaidya and Chatterji 2020).

Cities would be more inclusive and could provide something to everyone if everyone created them (Jacobs 1992). However, bio-productive processes (intense material consumption and waste discharged) supporting urban populations occur outside the city boundary (De Lannoy et al. 2001). So, it is reasonable that one can raise the question of how much bio-productive area is required to meet the demands of a typical city. Is the present production capacity of this bio-productive area sufficient to support cities' needs for the next century by maintaining the present needs? This fundamental question for sustainable urban development is answerable by EF (Rees 1992; Wackernagel and Rees 1997; Wackernagel et al. 1999). Against this backdrop, this research took the initiative to study the relationship between EF and urbanization of Bangladesh with an in-depth study of a city level EF measurement and proposed a sustainable urban development framework (SUDF) for Bangladesh.

1.2 Importance of the Research

UNDESA (2018) claimed that most of the world fastest growing cities are now in Asia and Africa. Among Asian countries, Bangladesh have also experienced fast rate of urbanization where, one third of population are now living in urban areas (BBS 2019) and more than half will live in urban areas by 2040 (UNFPA 2016). This rapid urbanization process might damage more natural resources and causes environmental degradation over the next few decades (Breheny 1992; Jenks et al. 1996; Haughton 1999; Williams et al. 2000; Chen 2018). It would not be possible to attain the target of limiting global warming to 1.5°C without the successful implementation of SDG-11(Sustainable Cities and Communities) in developing countries (de Coninck et al. 2018).

Historically, it is found that cities are generally confined within a specific geographical boundary, with a small population and only perform some specific activities. However, now cities are overwhelmed by the growing population, social diversity, complexity and purposefulness. Instead of this increment in the purposefulness of the city, city areas only occupy two per cent of the world's landmass (Falk 2011; Stephan et al. 2016). Which is a good thing. They are compact and therefore save a lot of land that could be used if the same population had to be accommodated at much lower density. However, urban resident consumes almost seventy-five per cent of natural resources and generates seventy per cent of the world's waste (Adams & Klobodu 2017; UNEP 2012).

These wastes are usually much more expensive to reuse (De Lannoy et al. 2001). Therefore, if we want a sustainable world, we must ensure sustainability in our urban areas. If we can ensure sustainability in the city, it might save seventy-five per cent of the world's natural resources.

While discussing sustainable cities in Asia, Caprotti and Yu (2018) claim that due to globalization and acceptance of the market economy, cities of South Asian Countries have been undergoing socio-economic transitions in the last two decades. Especially the massive expansion of population and demographic diversity in urban areas of Bangladesh has created social tensions and fragmentation. The urban infrastructure and environment are also facing severe stress. Although there is a significant

improvement in the road infrastructure of the cities, the congestion on roads, queuing of vehicles and waiting time at junctions have increased. Buildings look more impressive with their height and glazed facades, but the greenery and open spaces have dwindled considerably. Other visible environmental challenges include environmental pollution and the occurrence of uncontrollable floods. Under the pressure of the vicious combination of these infrastructural and environmental challenges, the urban landscape of Bangladesh's cities is changing from functional liveable places to monstrous concrete jungles creating both spatial and environmental problems with due consideration to the people living in them (ibid).

Despite this, if cities are well-planned and managed, they also have the capacity not to pose serious environmental problems. For instance, Curitiba city in Southern Brazil is one of the most rapidly growing cities in the world. Due to its innovation and rational development strategy, this city is known as highly livable and sustainable among planners (Rana 2011).

Therefore, sustainable urbanization in developing countries is significant for the well-being of all human beings. Urban sustainability assessment is now a rapidly growing subfield of sustainability assessment (Cohen 2017). However, identifying the appropriate measures of urban sustainability is a significant challenge (Ciegis et al. 2009) because there is a lack of conformity and risk in interpreting urban sustainability assessment (Waas et al. 2014). It is found that there are quite several ways to assess urban sustainability. Those can be a multi-dimensional, indicator based or life cycle assessment technique. Most studies take indicator-based assessment methods, especially at the urban scale (Cohen 2017).

While searching for a suitable urban sustainability indicator, the extensive literature review suggests that EF can capture all human activity that creates pressure on the environment. It also represents a person's consumption limit according to the earth's regenerating capacity. Living below the regenerating capacity would not compromise future generations' needs, ensuring sustainable development (Youmatter 2020). As a result, this study is important for the sustainability study of the urban area of Bangladesh as it took an indicator-based city sustainability assessment approach by taking "EF" as an indicator for sustainability.

The following section will present this study's research questions and objectives in this context.

1.3 Research Question and Research Objectives

Given the above discussion, the following research question is addressed by this research:

“To what extent can we extend the ecological footprint analysis to draw inferences about the sustainability of urban development in Bangladesh? What are the policy implications of this?”

This study feels to answer the above question by achieving the following objectives:

Objective 1: To empirically examine the relationship between EF and Urbanization of Bangladesh.

Objective 2: To explore the sustainability of an urban area in Bangladesh using EF as the methodology; and

Objective 3: Based on this, to develop a Sustainable Urban Development Framework (SUDF) to encourage more sustainable practices for sustainable urban development in Bangladesh.

1.4 Research Approach and Methods

In order to achieve the above objectives, this research took mixed method research, where both primary and secondary data were used. The following sections will give a brief overview of the methodology used.

1.4.1 Objective 1: To empirically examine the relationship between EF and urbanization of Bangladesh.

Given the above discussion in the research background, this study uses EF as an indicator for urban sustainability to achieve this objective. The rationale for using this indicator is that EF represents sustainability's environment and social dimension (Huang et al. 2015). If EF increases or decreases with the increase of urbanization, we might be able to conclude that the urban development of Bangladesh is unsustainable or sustainable respectively.

EF can cover the broader impact of human activities on nature, especially soil, air and water (Al-Mulali and Ozturk 2015; Charfeddine and Mrabet 2017; Uddin et al.

2017; Solarin et al. 2018; Danish et al. 2019). Nathaniel et al. (2019) use EF to study the relationship between EF and urbanization in South Africa. Similarly, Solarin et al. (2021) for Nigeria, Hassan et al. (2019) for Pakistan, Wang and Dong (2019) for 14 Sub-Saharan Africa Countries, Al-Mulali and Ozturk (2015) for the Middle East and North African region, Al-mulali et al. (2016) for 58 developed and developing countries, Solarin and Mulali (2018) for 20 countries, studies the relationship between EF and urbanization. To the best of my knowledge, no studies have been found whose examine the link between EF and urbanization in Bangladesh.

STIRPAT model (The Stochastic Impacts by Regression on Population, Affluence, and Technology) developed by Dietz and Rosa (1994) and further explored by York and Rosa (2003), Rosa et al. (2004) and Dietz et al. (2007) is used to explore the relationship between EF and urbanization in Bangladesh. This model is the reformulation of Ehrlich and Holdren (1971) $I = PAT$ where the population (P), affluence (A) and technology (T) are the influencing factors of the environment (I) (Yousaf 2018). Real GDP can proxy affluence, while urbanization can be utilized to proxy population. Technology represents all factors other than population and affluence (Suh 2009). In this backdrop, this study will use the following model:

$$I_t = \gamma_0 P_t^{\beta_1} A_t^{\beta_2} T_t^{\beta_3} \mu_t$$

Where “ I ” capture the environmental factors, “ P ” is the population, “ A ” is the affluence, and “ T ” is the technology. The ‘ β ’s and ‘ μ ’ are the parameter estimates and the error term, respectively. EF captures environmental factors, GDP represents affluence, and urbanization can be used as the proxy of the demographic variable “ P ”. GDP and T variables are included in the model as control variables.

This study uses all relevant statistical tools, such as stationarity tests of the series, co-integration test using the ARDL bound testing approach, structural stability test of the model, and causality analysis by following Toda-Yamamoto (1995) procedure. The details of the method followed are presented in chapter four.

1.4.2 Objective 2: To explore the sustainability of an urban area in Bangladesh using EF as the methodology.

This study took the initiative to assess the sustainability of an urban area of Bangladesh named Narayanganj City (NC) by using EF as an indicator of urban sustainability. It is found that EF, introduced by Rees (1992) and then developed by Rees and Wackernagel (1994), is a biomass-based resource accounting tool which tracks human demand on nature for the supply of ecosystem services (Galli et al. 2014).

Numerous studies claimed that EF could be used to estimate sustainability on various scales. For example, Wackernagel and Yount (2000) used it on a global scale, whereas Cui et al. (2004); McDonald and Patterson (2004) used it on a regional scale. The use of EF at the national level is found in the study of Salvo et al. (2015); Galli et al. (2012); Wang et al. (2012); Medved (2006), and Haberl et al. (2001). More microlevel use, for instance, product level (Limnios et al. 2009), in business (Bagliani and Martini 2012), sectoral scale (Kissinger 2013; Herva et al. 2008), municipal (Cano-Orellana and Delgado-Cabeza 2015; Scotti et al. 2009; Rashid et al. 2018) and household level for a city or urban agglomeration (Baabou et al. 2017) are also found.

It is also spelt out that different methods for estimating the EF exist. Most prominent of them are- the synthetic method (Wackernagel et al. 1999), input-output analysis method (Bicknell et al. 1998) and bottom-up component-based method (Simmons and Chamber 1998, Simmons et al. 2000). This study adopted a bottom-up component-based approach which would be the first-ever study of this kind for NC.

The other two methods are top-down approaches, where entire city or national-level data is needed. Even in the UK, complete sub-national level data is not available to employ these top-down approaches (Simmons et al. 2000). Moreover, there would be a chance of information loss for not using local-level data (Aall and Norland 2005; Wilson and Grant 2009). On the other hand, the component-based bottom-up approach needs city-level household consumption data. Due to the unavailability of city-level household consumption data of Bangladesh, this study took the initiative to collect primary data through a questionnaire survey. This method was also employed

by Lee (2019) for Taipei, Taiwan; Holden (2004) for Norwegian towns of Greater Oslo and Førde; Simmons et al. (2000) for the island of Guernsey; Rashid et al. (2018) for Rawalpindi, Pakistan; Khan and Uddin (2018) for a ward of Khulna City Corporation, Bangladesh; Bala and Hossain (2012) for Chattagram Hill Tracts of Bangladesh and Shakil et al. (2014) for Dhanmondi residential area of Dhaka, Bangladesh.

However, the original contribution of this study in this area is that this study measures the EF by using the calculator of the global footprint network. Besides, this study also identified the major driving forces of EF of NC, which is the first-ever study for this city. Since Bangladesh is a small country and the urban areas of Bangladesh are developing in a same manner, these driving forces can be generalizable for all other cities.

The rationale of using the EF calculator of GFN is that several popular organizations (e.g., WWF, Redefining Progress, Global Footprint Network (GFN), Austrian Ministry of Agriculture, Forestry, Environment and Water Management, The Environment Protection Authority of the State Government of Victoria in Australia, Taiwan's Environmental Protection Administration (EPA)) are providing online EF calculators. Among these online calculators, the GFN calculator can inform the impacts of personal consumption habits on the environment (Rashid et al. 2018).

Different calculators have different strengths and weaknesses. Collins et al. (2018) claimed that calculators provided by Global Footprint Network (GFN) and Redefining Progress (RP) are the most comprehensive calculators (Collins et al. 2018). GFN online calculator provides the most comprehensive index regarding location-specific consumption (Franz and Papyrakis 2011), which can be applied to every country (Rashid et al. 2018). It was also considered more user-friendly, consistent with most used National Footprint Accountings (NFAs) and freely available (Collins et al. 2018).

Rashid et al. (2018) employ GFN's online calculator to measure the EF of Rawalpindi, Pakistan. Lee (2019) also calculates the EF of Taipei, Taiwan, using the online calculators of Taiwan's EPA. Following Rashid et al. (2018) and Lee (2019), this study also attempted to use online calculators to estimate the EF of NC in Bangladesh.

I have used a questionnaire survey to collect NC's consumption data. The questionnaire (Appendix-1) is designed, so that information gathered from this survey could provide complete information to measure the EF of this city. The survey questionnaire has a total of 42 questions divided into four groups. The first group of the questionnaire has eight demographic questions; the second group is about their dietary habit. The other two groups are related to household waste management and mobility, respectively. All the ideas regarding the questionnaire were conceived from Anand (2001), Global Footprint Network (GFN), Khan and Uddin (2018) and Solaiman (2019). Before conducting the final survey, a pilot survey and ethics approval were also done. The collected data is analyzed by using SPSS version 28.

1.4.3 Objective 3: To develop a Sustainable Urban Development Framework (SUDF) to encourage more sustainable practices for sustainable urban development in Bangladesh.

To achieve this objective qualitative research was used. Twenty in-depth semi-structured interviews were conducted with participants, including subject matter experts from academia, high-level policy officials from government and non-government organizations, independent urban research organizations, and volunteer organizations. The collected data is analyzed by applying theoretical thematic analysis, and data triangulation is made by using the relevant literature and survey data of this study.

In theoretical thematic analysis, themes are always guided by an existing theory and theoretical concepts (as well as by the researcher's standpoint, disciplinary knowledge, and epistemology) (Braun and Clarke 2013). As a result, the themes were chosen from well-established four dimensions of sustainable development concepts viz, social, economic, environmental, and institutions. The subthemes evolved from interviews and were discussed based on interviewees' opinions and relevant literature. These subthemes were then assigned to different dimensions of sustainability.

1.5 Contribution to the Knowledge

This study contributes to the knowledge in several ways. Firstly, theoretically, this study spells out the development of sustainability studies worldwide, focusing on different dimensions of sustainability studies on the urban scale. The theoretical basis of using the ecological footprint as an urban sustainability indicator is also explored. For setting up the foundation, this study empirically finds the effect of urbanization on the EF of Bangladesh.

Secondly, after setting up a solid theoretical foundation, this study moves on to the practical uses of this methodology. In doing so, this study uses EF to measure the sustainability of an urban area of Bangladesh named NC, the first-ever study for this city. The major driving forces of the high EF of NC are also identified. Thirdly, this study also contributes to the existing knowledge of urban studies in Bangladesh by exploring the easily achievable and acceptable sustainable practices that could strengthen existing initiatives of GoB. With these sustainable practices, this study also proposed a sustainable urban development framework (SUDF) that will work for all dimensions of sustainable development. Last but not least, this study not only spells out the challenges of current urbanization trends in Bangladesh but also provide necessary remedy measure for these challenges through a series of policy recommendations.

1.6 Outline of the Structure of the Thesis

The chapter of this thesis should be set so the reader can easily understand the steps to answer the research question. In doing so, the “conceptualization and implementation” principle was followed. As a result, following this introductory chapter, chapter two explored the understanding of the sustainable development concept. It starts with a summary of the evolution of sustainable development worldwide and then moves to its theoretical foundation. Afterwards, the information related to the research question was collected through a comprehensive literature review. The theoretical arguments, the methodologies and data used in the empirical analysis, and the existing research's strengths and weaknesses were also analyzed. Finally, the potential research gaps have been identified, and the conceptual framework for this study was developed.

Chapter three presented a link between research and theory, the research design and methodology. This chapter explained the methods and tools used to study the nexus between EF and urbanization, measuring the EF of NC, and developing a SUDF for Bangladesh. It also describes how the fieldwork was done by adapting multi-stage cluster sampling methods.

Chapter four focuses on objective one. This chapter starts with a brief discussion of the empirical studies on EF and develops a model for this study. This chapter also provides the detail of statistical tools that are used for the analysis of secondary data. It also contains the outcome of cointegration and causality tests among the variables, focusing on the EF and urbanization of Bangladesh.

Chapter five deals with objective two. This chapter measures the EF of NC. The comparison of EF among the different regions of NC and with Bangladesh's EF and Biocapacity is also presented. In addition to this, the main driving forces of EF are also explored.

Chapter six focuses on objective three. It presents the findings from the interviews of this study. The social, economic, environmental, and institutional dimensions-based findings on the urban sustainability of Bangladesh are described here. These discussions were also validated with the relevant studies and survey findings. Based on these discussions, a SUDF is developed, followed by a series of policy recommendations.

Chapter seven summarises the main conclusions of this research. This chapter identifies the answer to the research question and highlights the limitations and scope of further study.

Chapter Two

Literature Review

2.1 Introduction

This chapter aims to provide an overview of some of the key issues from the literature on sustainable urban development and EF. Besides the theoretical arguments, the methodologies and data used in the empirical analysis, their strengths and weaknesses are also explored. Finally, potential research gaps were identified that provide the scope for this research. This literature review is divided into eleven sections. Following this introductory section, section 2.2 briefly overviews sustainable development worldwide. Section 2.3 investigates the theoretical background of the sustainability concept. Sustainability at the urban scale and its measurement are presented in the 2.4 and 2.5 sections, respectively. Section 2.6 includes a detailed review of the urban sustainability indicators framework and other composite indexes usually used for urban sustainability assessment. The rationality of choosing EF for this study is discussed in section 2.7. Then the relationship between EF and urbanization, city's EF measurement studies are critically reviewed in sections 2.8 and 2.9, respectively. Section 2.10 unveils the conceptual framework of this study. Finally, section 2.11 concludes this chapter.

2.2 Sustainable Development Pros and Cons

World Commission on Environment and Development (WCED) (1987) claimed that the concept of sustainable development first appeared on the international agenda around 50 years ago. The evidence of their claim is found in the comments of Meadows and Club of 1972 (1972:123), as they circulated:

“If the present growth trends in world population, industrialization, pollution, food production and resource depletion continue unchanged, the limit to growth on this planet will be reached sometime within the next 100 years. The most probable result will be a rather sudden and uncontrolled decline in both population and industrial capacity”.

At that time, there was lots of criticism about their comments. For example, Meadows et al. (2004:00) quoted Herman Kahn's comments,

“With current and near current technology, we can support 15 billion people in the world at twenty thousand dollars per capita for a millennium – and that seems to be a very conservative statement”.

Also, Julian Simon in 1997 (cited in Meadows et al. 2004:204) said:

“The material conditions of life will continue to get better for most people, in most countries, most of the time, indefinitely. Within a century or two, all nations and most of humanity will be at or above today’s Western living standards”.

On the contrary, today’s emerging consensus is that (cited in Meadows et al. 2004: 15):

“Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources. If not checked many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms and may so alter the living world that it will be unable to sustain life in the manner that we know. Fundamental changes are urgent if we are to avoid the collision our present course will bring about.” “World Scientists’ Warning to Humanity” was signed by more than 1,600 scientists, including 102 Nobel laureates, from 70 countries”.

Some scholars argued that modern political and public concern for sustainable development of the United Nations Conference on Environment and Development (UNCED) in 1992 in Rio de Janeiro, Brazil, has been considered the starting point of formalising the sustainability concept.

Just after the publication of the UNCED report, Feitelson (1998) claimed that the sustainability concept became part of global, national, and regional environmental agreements (e.g., the Kyoto Protocol, the Aarhus Convention, the Paris agreement), national environmental policy plans (in the Netherlands, UK, Canada). Huang et al.

(2015) organized the milestones of sustainability studies more systematically. Similar to WCED, they claimed that the first meeting of the international community at the United Nations Conference on the Human Environment in 1972 was the starting point for the formalization of sustainability studies. Then, Brundtland Report (WCED 1987) 1987 produced the most widely used definition of sustainable development. Afterwards, a call for developing sustainability indicators came from Rio Earth Summit as Rio Declaration and Agenda 21 in 1992. A few years later, in 1999, the term “sustainability science” was stamped out by US National Research Council Report. Another significant milestone of sustainability studies is the Johannesburg Earth Summit of 2002, where the implementation of Agenda 21 was reaffirmed. Finally, the 2012 Rio+20 Earth Summit gave clear and practical measures for implementing sustainable development (Huang et al. 2015).

Haghparast (2018) also argued that the Brundtland Commission Report of 1987 provides the classic definition of sustainability. This commission defined sustainable development as:

“Development that is capable of meeting today’s needs without compromising the ability of future generations to meet their needs (WCED, 1987, p. 43)”.

This definition is widely accepted, and the well-known three pillars' dimensions of sustainability- social, economic and environment, comes from this definition (Moldan et al. 2012). However, several scholars criticized this definition on the basis of its implication. For instance, Norgarrd (1994), Redclift (1989), Solow (1993) argue that this definition is too vague for not defining what needs are, or for not saying what are the mechanisms to achieve an environmentally sustainable society. Anand (2014) also criticized that this definition does not draw a line to distinguish the present generation and future generation that could impose a serious ethical concern for selecting the present and future generation. He also added that this definition does not tell how much trade off we will consider to demarcate the needs of present and future generation. In any case, this definition, able to convince the pro-growth delegations at the United Nations as it reflects the political compromise between growth and environmental sustainability (Castro 2004).

Different scholars and international organizations also provide some other definitions. For instance, Enders and Remig (2014 p.15) defined sustainability as:

“Sustainability is not a word that can be manipulated at will. Nor, however, is it a rigid term, explainable in one or two formulas, to be defined once and then simply implemented. It is not a cookbook with finished recipes, or with instructions to do this or that, and then you’re sustainable. It is not a state; it is a process, a model. In other words, it is not a final goal to be achieved at some stage, but rather a compass providing orientation for a journey into an unknown future. It will help us to act on this field that evolution has prepared in such a way that human existence will not end on this planet”.

Grunwald (2014) articulated that there is a consensus among social and natural scientists that sustainable development is comprised of feelings of “we-can’t-go-on-like-this” (p. 23). Moldan et al. (2012) linked it with the earth's carrying capacity. In a similar vein, other scholars relate it with “inter-generational equity”, “intra-generational equity”, “protection of the natural environment”, “minimal use of non-renewable resources”, “economic vitality and diversity”, “community self-reliance”, “individual wellbeing”, and “satisfaction of basic human needs” (Zhang et al. 2011a, Choguill 1996, Chen 2018).

Apart from the terminology mentioned earlier, some other representation of sustainable development is also found. The insight of these representations was a better future with more growth with a minimum contribution to environmental degradation. For instance, Lee (1993) termed it a visual expression, value change, by Clark (1989). Gore (1992) prefers to call it social organization, whereas Viedermen (1994) more sophisticatedly termed it transformational processing. It is also expressed as the compromise of two interdependent issues development and conservation (Du Pisani 2006). Klein et al. (2007) added technology, economy, society, institution and culture to these interdependent issues. Despite such a wide variety of understanding, Harry and Morad (2013); Bohringer and Jochem (2007) claimed that the three pillars-social, economy and environment had received the most agreement.

However, institution or governance has also been proposed as a fourth pillar of sustainable development. The notion of inclusion of this dimension is found in the study of Lubell et al. (2009). While developing an environmental sustainability index, they proposed to include it as an additional pillar of sustainable initiatives. Using regression and cluster analysis, they proved that if we include local government in sustainability activities, those activities will be efficiently managed. It indicates that administrative and organizational structure, and their attitude to sustainability activities, are essential for sustainable development.

Besides Lubell et al. (2009), Feiock and Coutts (2013) gave a more transparent and more convincing notion of the inclusion of institutional or governance dimension of sustainability. Their primary standpoint was the coordination of different development activities. They argued that in any local government, many functional agencies work together. For instance, every local government has planners, implementers, utility, transportation, energy, and environmental services. All these functional agencies should be considered part of the sustainability portfolio, and strong coordination of their activities should be ensured. They also propose establishing a dedicated sustainable office under the direct control of the mayors or through an informal network. The appeal of the inclusion of institutional dimension is also found in the study of Krause et al. (2016).

Whatever the dimensions of sustainable development, studies also found that maintaining the balance between these dimensions would not always be possible. For instance, Davoudi and Layard (2001) claimed that planners and geographers intend to maintain the balance among all four dimensions. Nevertheless, due to various institutional constraints, they cannot do that. These institutional constraints arise from the priority of needs. Some scholars, e.g. Bond and Morrison-Saunders (2009), identified it as an inherent weakness of the sustainable development path. Despite this inherent weakness, Baker (2015) identified climate change as the outcome of unsustainable development. Wilson and Piper (2010) added that the broad goal of sustainable development is to maintain harmony among economic renewal, social justice and environmental quality. This broad goal inspires all governments to include sustainability in their political agenda (Rametsteiner et al. 2011).

In addition to this, “The environmentalism of the poor” concept of Martinez-Alier (2014) introduce a new window for sustainable development. This concept arose independently in India and Latin America as part of global ‘environmental justice’ movement. He claimed that the rich countries import raw materials and other products from poor countries and then they sold the finished products at unsustainable prices that do not include compensation for local or global externalities. Rich countries also use environmental space without payment, and even without recognition of other people’s entitlements to such services (particularly, the disproportionate free use of carbon dioxide sinks and reservoirs). This concept might help to move society and economy in the direction of social justice and ecological sustainability.

Therefore, it is found that the concept of sustainable development has been a much-discussed topic in the international forum starting only in the 1970s. However, the entire history of the sustainable development concept is 300 years old (Enders and Remig 2014). It appeared as a reaction to limits to growth, it did not grow out of the environmental movement like the appropriate technology movement or ecodevelopment, which emphasized grassroots development and empowering people. Rather, it was a product of the mainstream reaction against the radicalism of the environmental movement, which was not only proposing limits to growth but also emphasizing regulation as a means of stopping ecological degradation (Castro 2004). At first, some scholars were reluctant about sustainable development. On the contrary, the consensus among scholars is emerging, so the sustainable development concept is widespread and well-known as common-sense. It raises the concerns that “Business-as-usual” is impossible and “we cannot go like this”. Development should be within the carrying capacity of nature.

2.3 Theoretical Background of the Sustainability Concept

The theoretical underpinning of sustainability is still a mysterious issue in sustainability research. A thorough revision of the existing literature affirmed that the heart of sustainability is human needs. It would be acceptable to reconnect sustainability with the hierarchy of human needs theory, also known as Maslow’s Pyramid (Figure 2.1). This theory argues that till to a certain level of basic needs, humans behave unselfishly. However, after that, they can exert some unselfish

behaviour (Maslow 1968, 1999), indicating that the sustainable development concept is pragmatic and anthropocentric (Moldan et al. 2012).



Figure 2.1 Hierarchy of human needs (Maslow's Pyramid) (adopted from Kellerman2014, based on Maslow's 1968, 1999).

Theory of hierarchy of Human needs is not free from criticism. For instance, a very common criticism is that the order of needs within the hierarchy is arbitrary. Maslow put self-actualization at the top of the hierarchy and physiological needs at the bottom. However, their sub-componnet can vary from person to person, i.e they are subjective or arbitrary (Wuhba and Bridwell 1976). Nussbaum (2006) and Rawls (1971) criticized that if there is a set of "primary goods" or needs necessary to achieve self-actualization, it is unclear whether and how to place them within a hierarchy. Another criticism is that Self-actualization is not linear. In his early work, Maslow argued that a person could only self-actualize once they had met their basic needs. However, sometimes, not being able to meet one's basic needs helps people identify their self-

actualization goals. For instance, a person may have a stable career for many years, fulfilling their safety needs. However, if they lose their job, they may realize that their old career was not satisfying. Needing another source of income might spur them to pursue the job they truly want. Maslow also acknowledged that unmet needs could be motivation for self-actualization in his later work (Henwood et al. 2015).

Another understanding of the theoretical underpinning of sustainable development is the flow of energy from nature to the economy. In this regard, if we look at the argument of Ayres and Simons (1994), they split the economic system into two distinct spheres, the anthrosphere and the ecosphere. Humans are the primary consumer in the anthrosphere, whereas nature is a primary producer in the ecosphere. The other life forms, including human beings in the anthrosphere, also act as primary consumers. The main difference between human beings and other life forms is that the other life forms can only act as consumers, whereas humans can act as both consumers and secondary producers. As secondary producers, humans produce through economic activities like setting up industries and constructing buildings, equipment, and infrastructure. This economic activity needs a continuous flow of energy from nature. The main point here is that for sustainability, there should be a balance between the supply and demand of this energy. If any imbalance occurs, then un-sustainability occurs.

De Lannoy et al. (2001) also claimed that this energy flow from nature to the economy is critically relevant to sustainability. Because the modern interpretation of the second law of thermodynamics states that in any open system, energy flow always reaches an equilibrium condition; for example, if a drop of orange juice is given to a glass of water, it will spread throughout the glass until it reaches equilibrium. On the other hand, if we consider a duck on a leaky barrel, it takes a continuous flow of water to keep it afloat. Otherwise, it drops. Similarly, if we consider the economy a duck and the environment a barrel, the economy can sustain and grow through a continuous flow of high-grade energy and material from the environment. The environment can create an equilibrium by regenerating new energy and absorbing degraded energy.

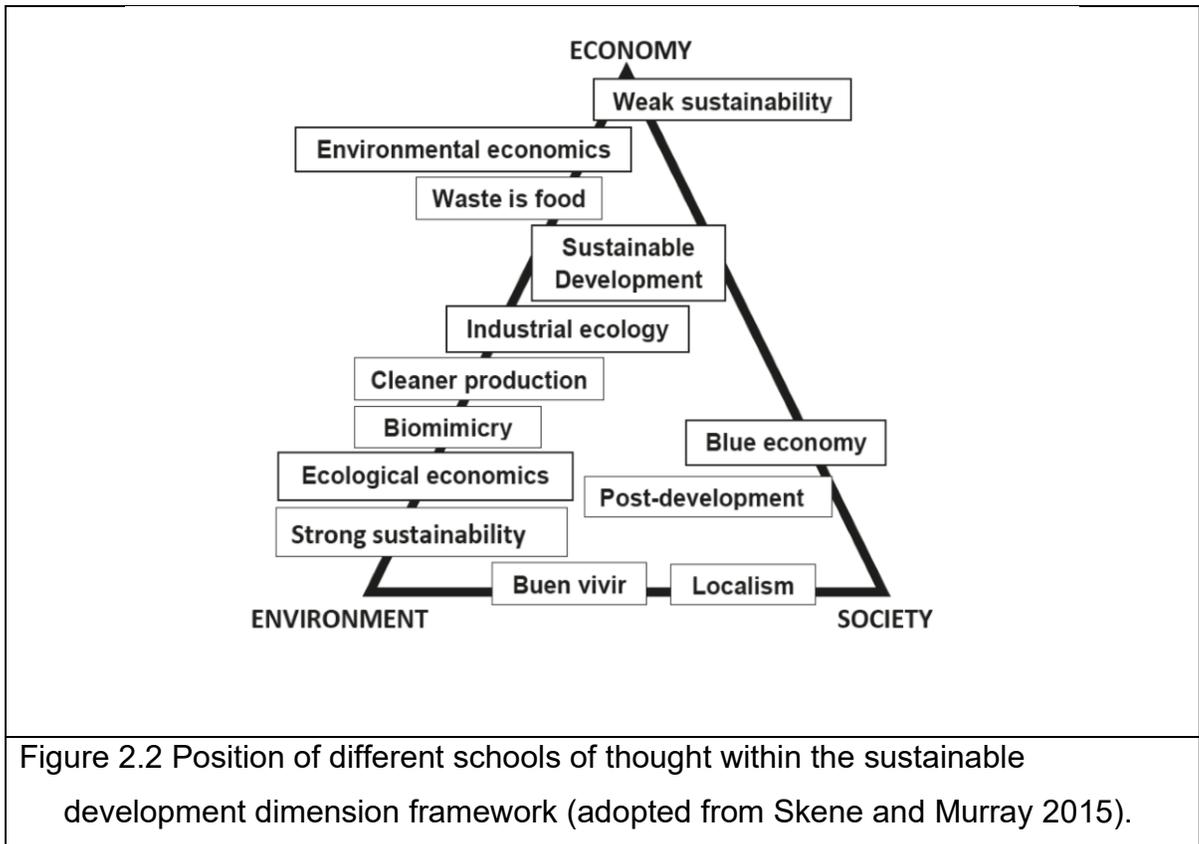
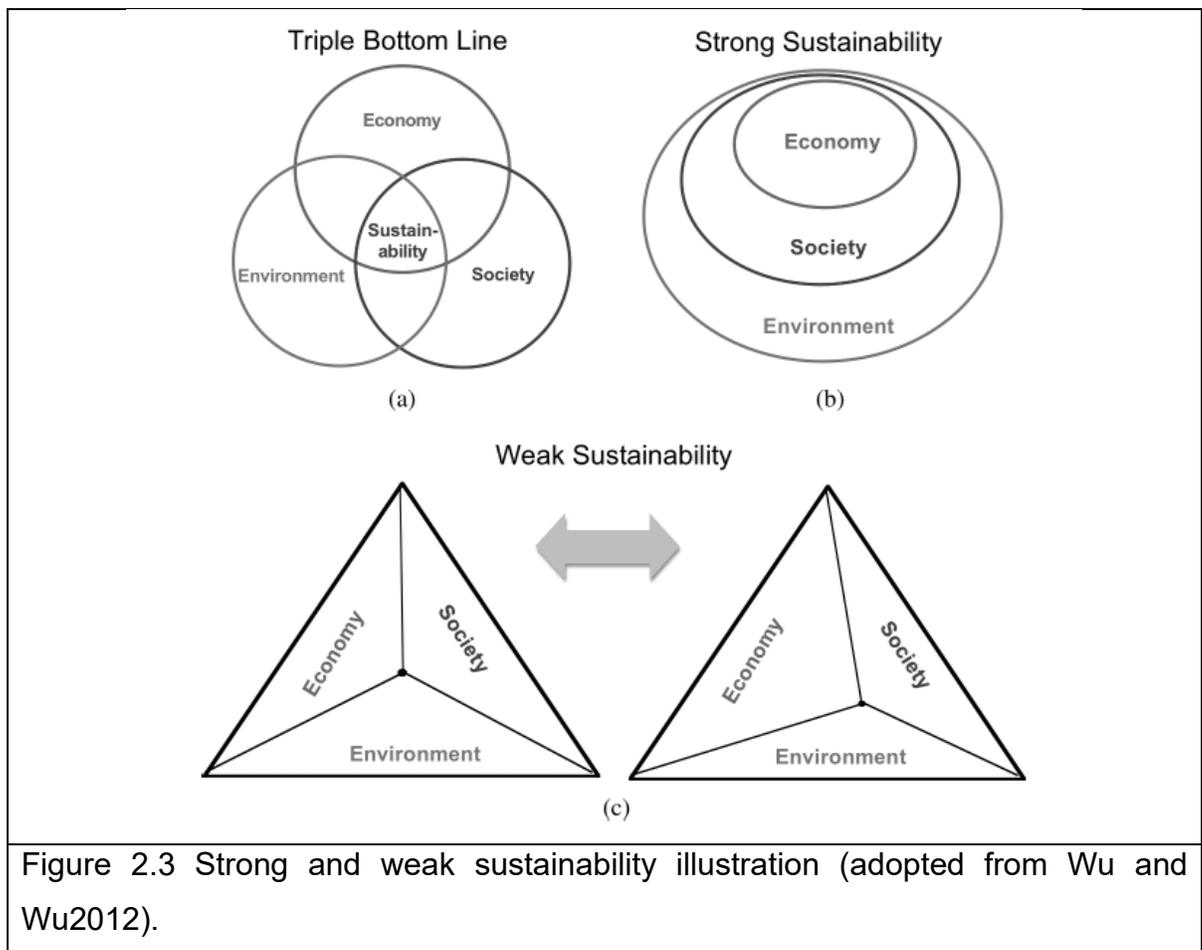


Figure 2.2 Position of different schools of thought within the sustainable development dimension framework (adopted from Skene and Murray 2015).

In sustainability literature, two strictness of condition of sustainable development are also found, strong sustainability and weak sustainability. For instance, Skene and Murry (2015) put different schools of thought on the sustainability triangle. They claim that the school of thought, which is more closure to a pillar, that school of thought is taken more seriously with that pillar. For example, in figure 2.2, we can see that the “environmental economics” school is closer to the economic pillar. It means the environmental economics is more concerned about the economy. On the other hand, “strong sustainability” is more closure to the environment, which means strong sustainability takes the environment more seriously (Skene and Murray 2015).



A clearer and more convincing opinion of taking the environment more seriously is also found in the study of Wu and Wu (2012). Figure 2.3, adopted from their study, shows that all three dimensions- economic, social and environmental are equally important and necessary for sustainability (figure 2.3a). However, in a strong sustainability view, the economic and social dimensions are embedded in environmental dimensions (figure 2.3b). The environment provides natural resources and ecosystem services for economic and social development. The other two dimensions will automatically be addressed if we consider the environment. On the other hand, weak sustainability (figure 2.3c) emphasizes three dimensions equally and allows substitution among them. Its goal is to attain overall outcomes (ibid).

Therefore, sustainable development can be ensured by fulfilling the basic needs of humans. It is also necessary to maintain a balance between supply and demand of the factors of production. Strong sustainability does not allow substitution and takes

the environment more seriously. Consequently, to ensure sustainable development, the environmental perspective of any development activities should be viewed more seriously.

2.4 Sustainability at the Urban Scale

Finco and Nijkamp (2001) claimed that sustainability is shifted from a global and national scale to an urban scale. Just after the publication of Agenda 21, this movement gained momentum in the political arena and scientific studies (Shen et al. 2011). There might be two reasons. The first one is the increase in cities and urban population, and the second one is the increase in the awareness of environmental problems. As the urban population is increasing daily, city governance highlights the urgency of sustainable urban development in their agenda (Newman and Kenworthy 1999; McManus 2012). Similarly, awareness is growing that most environmental problems have a local origin. As a result, urban areas should be taken seriously for improving sustainability (Mori and Christodoulou 2012).

There is also an international political economy dimension to take urban sustainability seriously. For instance, OECD countries and Latin American countries have urbanised a lot more than Asia and Africa. As Earth summit happened in Rio de Janeiro in 1992 may be the voice of Latin American context was amplified and for them sustainable development is impossible without sustainable urban development if 70+ per cent of population are in urban areas. In Africa and Asia this is not the case though urban population is likely to increase from now on in the next 50 years. As a result, the African and Asian countries can also take urban sustainability more seriously.

The terms “urban sustainability” and “urban sustainable development” are frequently used in sustainability studies at the urban scale. Sometimes these two terms are used interchangeably. Adinyira et al. (2007) saw urban sustainability as a desirable state or set of urban conditions that persists overtime, whereas UN-Habitat (2002) viewed sustainable urban development as a dynamic process. Process in a sense that will grow in a planned way overtime. Different scholars defined urban sustainability differently. Some important of them are presented in the following Table 2.1.

Table 2.1 Definition of urban sustainability.	
Definition	Source
“Sustainable urban development may be defined as a process of synergetic integration and co-evolution among the great subsystems making up a city (economic, social, physical and environmental), which guarantees the local population a non-decreasing level of wellbeing in the long term, without compromising the possibilities of development of surrounding areas and contributing by this towards reducing the harmful effects of development on the biosphere.”	Camagni (1998 p. 272)
“A sustainable city is one which succeeds in balancing economic, environmental and socio-cultural progress through processes of active citizen participation.”	Mega and Pedersen (1998 p. 2)
Urban sustainability is “the process of developing a built environment that meets people’s needs whilst avoiding unacceptable social or environmental impacts.”	Hamilton et al. (2002 p. 109)
“A sustainable city requires that a city provides its residents with sustainable welfare, i.e. the total amount of welfare benefit and per capita welfare will not decrease as time goes by.”	Zhao (2011 p.2)
Urban sustainability is “an adaptive process of facilitating and maintaining a virtual cycle between ecosystem services and human well-being through concerted ecological, economic and social actions in response to changes within and beyond the urban landscape.”	Wu (2014 p. 213)
“Urban sustainability is often characterized by issues such as the proper use of resources to guarantee a generational equity, protection of the natural environment, minimal use of non-renewable resources, economic vitality and diversity, community self-reliance, individual wellbeing, and satisfaction of basic human needs.”	Choguill (1996 p. v-viii)
“A sustainable city is one that relates its use of resources and its generation and disposal of wastes to the limits imposed on such activities by the planet and its organisms.”	Chi et al. (2006 p. 105)
“Sustainable city implies that major cities should be individually supported by the resources produced within their immediate surrounds.”	Roy (2009 p.278)
“In general, a sustainable city must be economically viable, socially peaceful, and environmentally friendly. More specifically, A sustainable city is where people live in peace with sufficient income earning and quality of life, and without social and mental anxiety.”	Rana (2011 p.241)

Therefore, we can say that a sustainable urban area has several characteristics that cannot be covered in a single definition. Most scholars emphasize long-lasting human well-being. In summary, a sustainable urban area should have the characteristics of minimum consumption of space and natural resources that protect natural resources. Sustainable urban development also ensures the development of surrounding areas, reducing harmful effects of development and lowering its environmental impacts, recycling its materials, and efficient energy use, combining economic development, social development and environmental development with an endless supply of natural resources by avoiding unacceptable social or environmental impacts. Further to this, in a sentence, it can be said that a sustainable city can create problems and also solve those problems.

2.5 Measuring Urban Sustainability

Cohen (2017) claimed that urban sustainability measurement is a rapidly growing sub-field of sustainability assessment. More cities and regions are now adopting sustainable policies and plans in their territories (Hiremath et al. 2013). However, due to the intrinsic holistic and multi-dimensional nature of urban sustainability (Waas et al. 2014), it is still a significant challenge to identify the appropriate measures of urban sustainability (Ciegis et al. 2009). Maintaining a balance between urban sustainability's social, economic and environmental dimensions is also a major challenge (Sala et al. 2015). Despite these challenges, Parris and Kates (2003) suggested four major areas of urban sustainability assessment, “decision-making and management”, “advocacy”, “participation and consensus building”, and “research and analysis”.

In terms of urban sustainability measurement methodology, three principal methodologies have been found in the relevant literature. They are i) multidimensional-based methods (Finco and Nijkamp 2001), ii) indicator-based assessment methods (Cohen 2017) and iii) life cycle assessment methods (Foxon et al. 1999). Cohen (2017) argued that indicator-based assessments are popularly used at the urban scale among these three methods. There are articles published those present hundreds of indicator sets. However, the various sustainability assessment methods are still evolving (Cohen 2017).

Lots of studies are also found that give more emphasis on a single-dimension-based assessment rather than a multi-dimensional assessment. For example, Jenks et al. (1996) assessed the economic dimensions of urban sustainability in the form of a vital economy. Similarly, Walsh et al. (2006) and Zhang et al. (2011b) use GDP, income, employment, poverty, and business formation data to assess urban sustainability's economic dimensions. Notions of using prosperity as an indicator for the economic dimensions of urban sustainability are found in the study of Gonzalez et al. (2011) and Mori and Christodoulou (2012).

A limited number of pieces of literature have been found that address the social dimension of urban sustainability. It might be because most planning processes now emphasise environmental and economic dimensions more rigorously than social dimensions (Sharifi and Murayama 2013; Alshuwaikhat and Aina 2006). However, Shen et al. (2011) argued that the social dimension should be considered a mandatory part of urban sustainability measurement. Brameley and Power (2009) extended social sustainability into two distinct sub-dimensions i) social equity; and ii) community sustainability. They assigned access to local services such as grocery shops, primary and elementary schools, healthcare facilities, recreational opportunities, public transit, jobs and affordable housing under social equity sub-dimensions. They put people's interaction, active participation in community activities, and security under community sustainability.

Moreover, Polese and Stern (2000, p. 15-16) defined social sustainability as: "the development and/or growth that is compatible with the harmonious evolution of civil society, fostering an environment that encourages social integration, with improvements in the quality of life for all segments of population." Their definition gives more emphasis on the quality of individual life as well as the combined function of society. Furthermore, Yiftachel and Hedgcock (1993) emphasize human interaction, communication and cultural development as the leading indicator for social sustainability measurement. Chiu (2002) argued that equality, social and ecological limits should be an indispensable part of social sustainability.

Many research studies focus on the environmental dimension of urban sustainability assessment. The term environmental sustainability was first theorized by Goodland

in 1995. He argued that social sustainability is not possible without environmental sustainability. According to his voice (p.3)

“Environmental sustainability means natural capital must be maintained, both as a provider of inputs (sources) and as a sink for wastes. On the source side, harvest rates of renewable must be kept within regeneration rates and on the sink side, waste emissions should be kept within the assimilative capacity of the environment without impairing it. This means holding the scale of the human economic subsystem to within the biophysical limits of the overall ecosystem on which it depends. Environmental sustainability needs sustainable production and sustainable consumption”.

This definition by Goodland (1995) acts as a stimulating agent for environmental dimensions of sustainability studies. For instance, after this definition, Moldan et al. (2012) introduced the term “limits to growth”. In their term, they integrate Goodland’s environmental sustainability into a resource-limited ecological, economic framework. OECD (2001) also contributed significantly to the concept of environmental sustainability. They proposed regeneration, substitutability, assimilation and avoiding irreversibility as the specific criterion for environmental sustainability.

Alshuwaikha and Aina (2006) used a series of spatial indicators to assess the environmental performance of Dammam city in Saudi Arabia. They used the number of citizens exposed to an unacceptable level of air pollutants (in percentage), land area for transportation (percentage), access to health (percentage); open spaces(percentage); basic education (percentage), and pedestrian facilities (percentage). Fiorino (2010) suggested that government policy should give equal importance to environmental and economic dimensions of sustainability. He claimed that the environmental dimension of sustainability does not mean only ecosystem vitality and efficient use of resources but also human health and well-being. He proposed “habitat protection, biodiversity preservation, water stresses, and air quality management under ecosystem vitality”; “energy, water and materials” under resources used, and “water quality, sanitation, food safety, drinking water, and protection against harmful chemicals and radiation” under human health and well-being dimension.

Chen et al. (2008) conducted a sustainability assessment for 45 major Chinese cities with five categories of environmental data, e.g., infrastructure efficiency, public transport, facilities availability, environmental externalities, domestic energy and resource consumption. For each category, they consider a series of indicators. For example, for the environmental externalities category, they select air pollution (emission of SO₂ per sq. Km of built-up area), noise (as a percentage of area under unacceptable noise level), and green spaces (as a percentage of brown space area to built-up area).

The above discussion indicates that all the dimension-based study of urban sustainability assessment is one kind of indicator-based assessment. The selection of these indicators is also a major issue. Because based on these indicators, all major decisions are taken. Meadows (1998) argued that as indicators sit at the centre of the decision-making process, their selection is risky and vital. If they are not carefully chosen, they might cause serious malfunctions. They might be a sign, symptom, grade, object, rank, tip, organism, clue, or warning of something in daily life (ibid).

Sustainability indicators can be defined in many ways. However, McGlade's (2007) definition seems more appropriate for policymakers and the general public. According to him (p:377):

“The main purpose of any sustainability indicator framework is to provide a comprehensive and highly scalable information-driven architecture that is policy relevant and understandable to members of society and will help people decide what to do”.

Johannesen et al. (2018) claimed that The United Nations describe sustainable indicators in their guidelines and methodologies for Sustainable Development as follows (p. 371):

“Indicators perform many functions. They can lead to better decisions and more effective actions by simplifying, clarifying, and making aggregated information available to policymakers. They can help to incorporate physical and social science knowledge into decision-making, and they can help to measure and calibrate progress toward sustainable development goals. They

can provide an early warning to prevent economic, social, and environmental setbacks. They are also useful tools to communicate ideas, thoughts and values”.

Josza and Brown (2005) argued that the main characteristics of sustainability indicators are the reflections of trends in the environment, social systems, economy, human well-being, and quality of life. A comparative analysis of environmental, economic, social and governance categories of sustainability indicators is found in the study of Shen et al. (2011). They present it as International Urban Sustainability Indicators List (IUSIL), where each category includes 4 to 18 subcategories.

Moreover, Singh et al. (2009) argues that there are now hundreds of sustainability indicators/indices that give a complete insight into the state and trend of sustainability. A few of them are the Index of Sustainable Economic Welfare (ISEW), Measure of Economic Welfare (MEW-precursor of ISEW), Genuine Progress Indicator (GPI), Dashboard of Sustainability (DS), City Development Index (CDI), Emergy/Exergy, System of Economic Environmental Accounting (SEEA), Human Development Index(HDI), Life Cycle Analysis (LCA), Sustainable National Income (SNI), Environmental Net National Product (ENNP), Environmental Policy Index (EPI), Living Planet Index (LPI), Material Flow Analysis (MFA), Environmental Vulnerability Index, Environmental Performance Index, Ecological Footprint (EF), The Physical Quality of Life Index (PQLI), Ecological Capacity, Ecological Deficit/Surplus, Optimum Population Size, Ecological Footprint Diversity (Wu et al. 2019), Adjusted Savings (UNDP 2011).

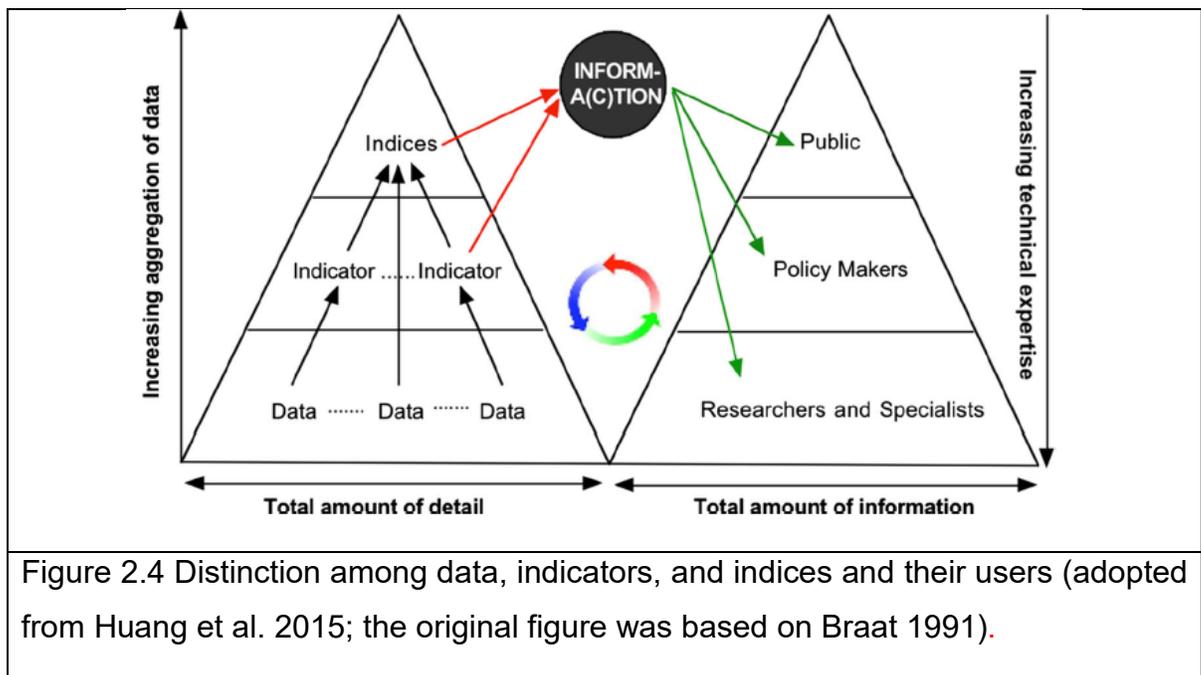
Munier (2011) argued that the indicator should reflect the maximum amount of information from the original data set in a more practical and reduced form. Apart from the traditional pillar of sustainability, he suggests six pillars with some new interactive dimensions. For instance, he proposed environmental-social, environment-economy, and economy-social interactive dimensions in addition to sustainability's social, economic and environmental dimensions.

Apart from academicians, governments and international organizations also play a crucial role in developing sustainable development indicators. For instance, The

Department of Economic and Social Affairs (DESA) of the United Nations has been developing sustainable development indicators since adopting Agenda 21. Their primary duty is to develop a comprehensive, comparable, and up-to-date set of sustainable development indicators.

DESA has now published their third edition of sustainable development indicators, a follow-up to the two earlier publications in 1996 and 2001. This third edition has 50 core indicators, part of a more extensive set of 96 indicators under 14 themes. The themes are “poverty,” “governance,” “health,” “education,” “demographics,” “natural hazards,” “atmosphere,” “land,” “oceans, seas, and coasts,” “fresh water,” “biodiversity,” “economic development,” “global economic partnership,” “consumption and production patterns.” The third edition is different from the first in two ways. Firstly, in the third edition, they introduced a core set. This core set helps to keep the indicator set manageable, whereas the larger set allows the addition of new indicators. Adding new indicators allows every country to assess their sustainable development according to its own needs. Secondly, they have kept the traditional four pillars open: social, economic, environmental and institutional, meaning sustainable development is multi-dimensional and allows the integration of its pillars (UNDESA 2016).

Besides the indicators, “sustainability indicator sets” or “sustainability indices” have also been used in sustainability assessment. Huang et al. (2015) distinguish data, indicators, and indices with a pyramid (figure 2.4). This figure indicates that data and the researchers and specialists are at the bottom of the pyramids. It means researchers and specialists have the more technical expertise to use the data. As we go up with this data, they constitute the indicators and indices. The indicator and indices are more informative and provide information to the public and policymakers. More specifically, we can say that the general public and policy maker do not understand the data. They need more aggregate information provided by the indicator or indices. It is the responsibility of the researchers and specialists to take care of data and their processing that makes this data informative to the general public and policymakers. In a nutshell, data is the fundamental component, data comprises indicators, and indices combine several indicators.



Wu and Wu (2012) also argued that indices provide an overall picture of a state or performance. As a result, it is more suitable for the public and policymakers. Whereas, an index is more complex and uses various normalization and weighting schemes to combine the multiple indicators.

Therefore, it can be summed up that urban sustainability assessment is a vast and complex area. There is no universal strategy to measure it. However, three main strategies are found viz- multi-dimensional based assessment, indicator-based assessment, and life cycle assessment. Among these methods, most sustainability assessment research adopts an indicator-based assessment approach. There are now hundreds of sustainability indicators. Sustainability researchers and specialists have developed such types of indicators which provide an overall picture of the state in a pretty straightforward way that would be easily understandable by the public and policymakers. Several international and non-government organizations are also involved in developing sustainability indicators. The following section will discuss frameworks and single composite indices typically used for urban sustainability assessment.

2.6 Urban Sustainability Indicator Frameworks and Single Composite Index

Wu and Wu (2012) defined an indicator framework as a conceptual structure that promotes indicator selection, development and interpretation. These frameworks are formulated by different international organizations (e.g., United Nations Commission on Sustainable Development (UNCSD), Organization for Economic Co-operation and Development (OECD)). The framework details can be found in Meadows 1998; United Nations 2007, and Wu and Wu 2012. From their discussion, one thing is clear indicator framework can help to identify gaps among available data, indicator sets, and a general understanding of the human-environment interaction. Only urban sustainability-related frameworks are presented here.

Pressure-State-Response (PSR) Framework

It is one of the most famous early indicator frameworks (Figure 2.5a), developed by the OECD in 1993.

Huang et al. (2015) opined that this framework had been used more frequently for developing environment-centred indicator sets.

In recent decades, different versions of PSR frameworks have been available. The driving force-State-Response (DSR) framework is one of them. UNCSD published it in 1996. Similar to their name, both PSR and DSR frameworks have three sets of indicators. Pressures or driving forces sets include anthropogenic process indicators, and State indicators sets include the present status of the environment and natural resources at a given time. Finally, response indicator sets cover social responses to environmental and natural resource changes.

UNEP 2006 added Impact and Response to the DSR framework, now popularly known as the Driving Force-Pressure-State-Impact-Response framework (Figure 2.5b). This framework follows the direction of Agenda 21 and covers the four pillars of sustainable development, i.e., environment, economy, society and institutions). From figure 2.5 (b), it is understandable that this framework emphasizes the environmental dimension as they include environmental concerns in the pressure, state and response part. They include industry, transport, and pollution as driving forces that directly create pressure on the environment. As a result of their pressure

air quality, water quality deteriorates, which causes biodiversity losses, affecting human health. They put such types of indicators in the state part. The responses part includes legislation, regulation, and economic instruments, which affect both driving forces and states.

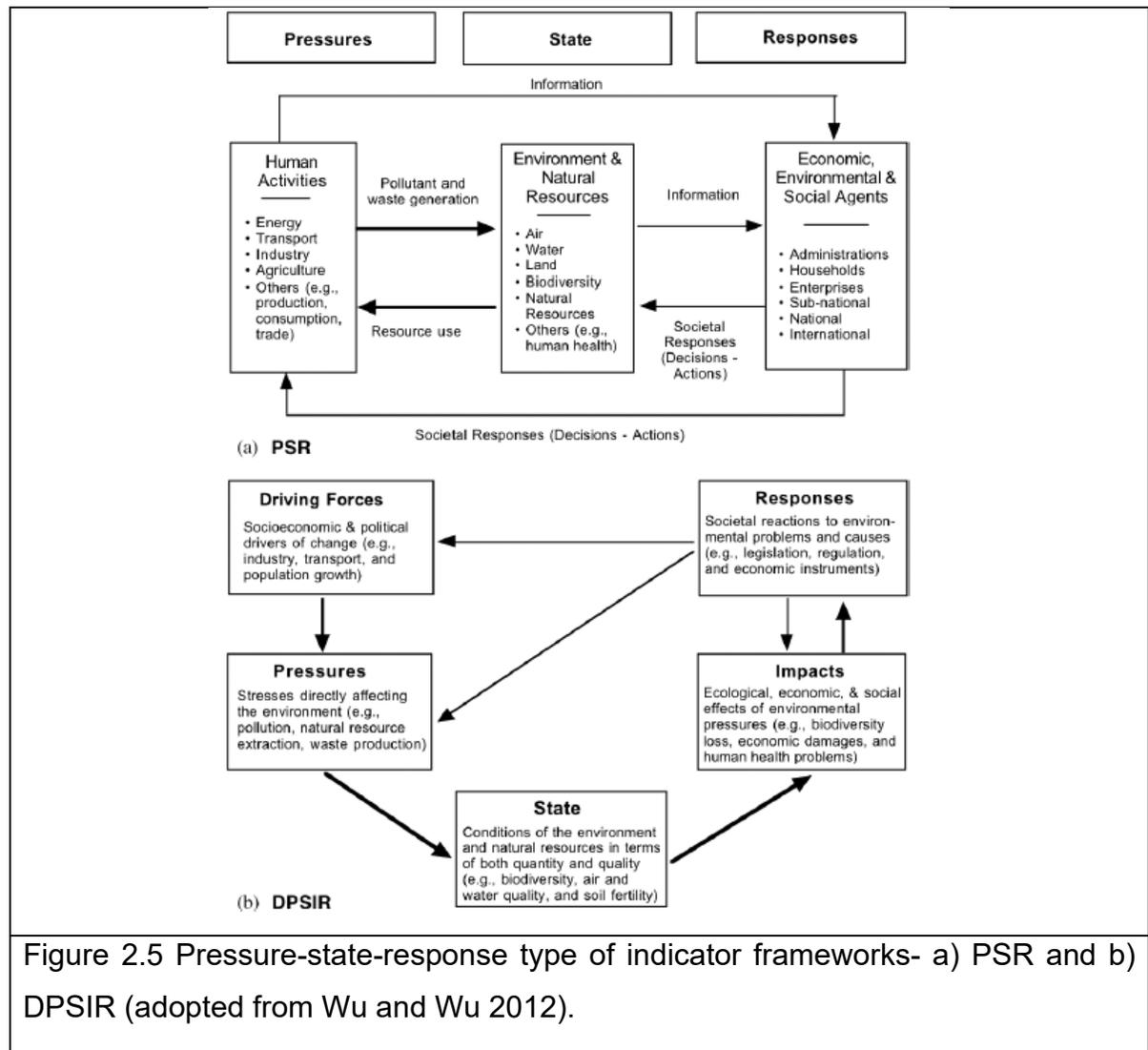


Figure 2.5 Pressure-state-response type of indicator frameworks- a) PSR and b) DPSIR (adopted from Wu and Wu 2012).

On an urban scale, this framework is first used by OECD (Alberti 1996). Huang and Chen (2002) have used PSR-based urban indicator sets for Taiwan. Zhao et al. (2005) used this framework for the sustainability assessment of the Chinese city of Mianyang.

Theme-oriented Framework

This framework is more flexible than DSPR, which considers four sustainability dimensions (environment, economy, society, and institution). Each dimension includes different themes and subthemes. The best example of a theme-based framework is the 2001 UNCSO framework that replaced the DSR framework (UNCSO 2001). In this framework, the environmental dimension includes the atmosphere, land, oceans, seas and coasts, freshwater, and biodiversity. Social dimensions include equity, health, education, housing, security, and population. Economic structure, consumption and production patterns are included in the economic dimension, whereas institutional framework and capacity are included in the institutional dimension. Each theme again includes several subthemes and indicators. In brief, this framework has 15 themes, 38 sub-themes and 58 indicators (Figure 2.6).

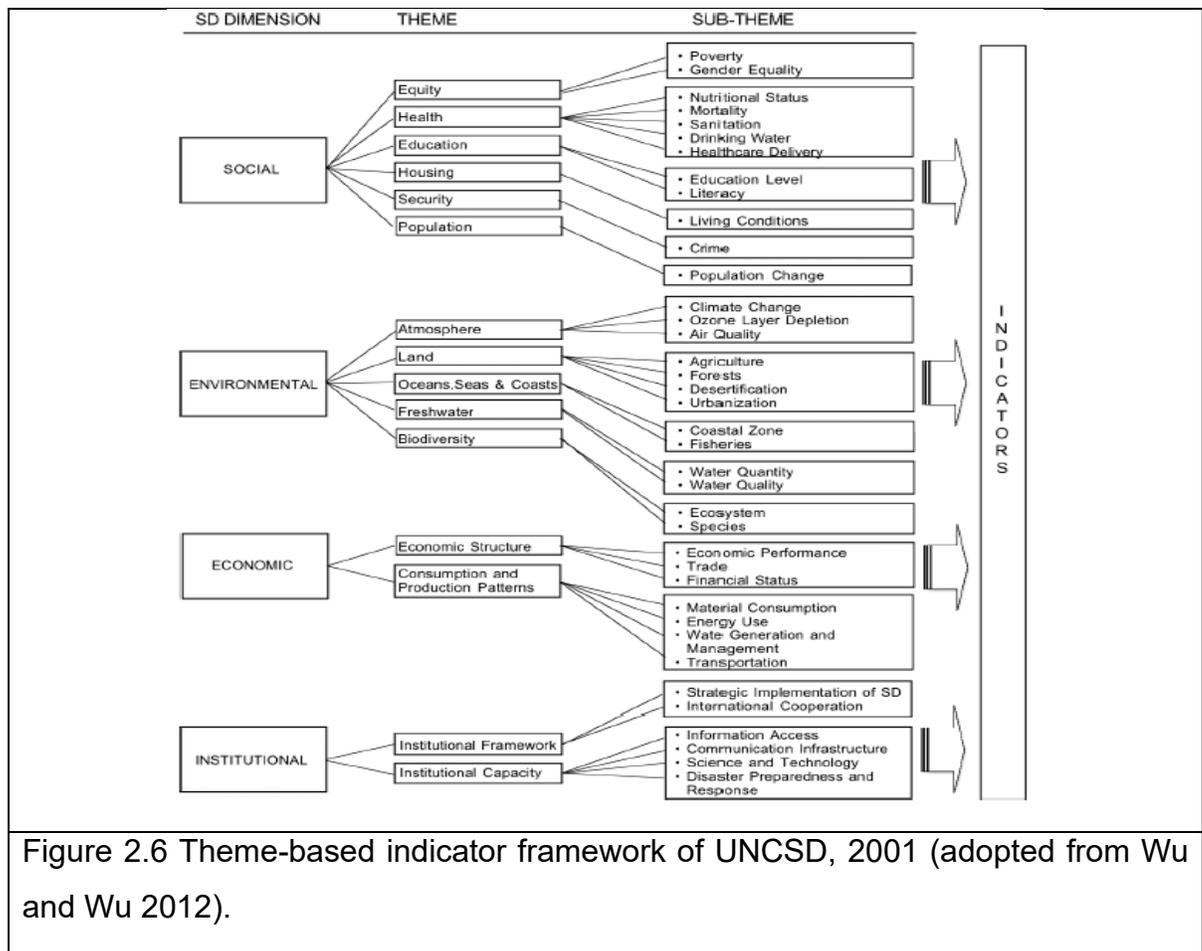


Figure 2.6 Theme-based indicator framework of UNCSO, 2001 (adopted from Wu and Wu 2012).

This framework was revised in 2007 based on evolving perspectives on indicators and experience applying the framework at the national and regional levels (UN 2007). This revised framework upholds the thematic and sub-thematic structure, which includes 14 themes, 44 sub-themes, 50 core indicators, and 96 indicators. This framework differs from the previous version, making four sustainability dimensions implicit and adding crosscutting themes such as poverty and natural hazards. It also includes the Johannesburg Plan of Implementation and eight Millennium Development Goals (Wu and Wu 2012).

Huang et al. (1998), Lee and Huang (2007) and Tanguay et al. (2010) claim that although a theme-based framework is designed to develop indicators for the national level, it can also be used for the development of urban sustainability indicators. Some international organizations, for instance, the World Health Organization (WHO), European Foundation for the Improvement of Living and Working Conditions (Eurofound), United Nations Human Settlements Program (UN-Habitat), and World Bank adopted this framework to develop city sustainability assessment indicators.

Material and Energy Flow Framework

This framework is based on socio-economic metabolism. The essential aspects of this framework are that it tracks input, output and internal dynamics of energy and material flow within the systems, ranging from society and country to the whole world. The accounting procedure for this energy dynamics has been developed over the last several decades (Huang et al. 2015).

On the urban scale, this material and energy flow is known as urban metabolism (Wolman 1965). Based on this urban metabolism “urban metabolism framework” is developed, which captures inflows, outflows and internal flows of material and energy in an urban area (Huang et al. 2015). In the real sense, EF has been developed based on this urban metabolism concept (Rees and Wackernagel 1996).

According to Finnveden et al. (2009), Life Cycle Assessment (LCA) is another material and energy-flow framework. LCA measures the environmental impacts of a production process. It was developed in 1996 and primarily used in the engineering field. However, in time, LCA is combined with the urban metabolism concept and very

relevant to urban sustainability assessment (Chester et al. 2012; Pincetl et al. 2012). In a significantly simpler explanation, LCA covers energy flow from raw material extraction to the production process, final product and their use to disposal. This assessment has become a cross-disciplinary issue by incorporating elements from social, economic, environmental and management sciences (Powers et al. 2012).

From the above discussion it is observed that PSR is the simplest framework, which needs less information than DPSIR. However, DPSIR breaks a problem to more components and so needs more information and provides more accurate and detailed results. There are also several critics for PSR frameworks. Firstly, this framework do not provide a clear indication for putting the indicators into different categories. In more detail, putting the indicators in different categories is ambiguous, because some indicators may fall into all three categories. Secondly, this framework does not provide a close and clear connection between the indicators and policy issues. On the otherhand, themebased framework is more flexible and provides a clear information for putting the indicators into different themes. As a result, UNCSO abandoned the PSR framework and favoured the theme based indicators framework (Wu and Wu 2012).

Single Composite Indices

City Development Index (CDI)

UN-Habitat developed CDI in 1997 to rank the world cities. Since then, UN-Habitat has computed CDI for 232 cities in 113 countries. It is a broad policy-based index and “the best single measure of the level of development in cities” (UN-Habitat 2002, p.3).

CDI contains five sub-indices: Infrastructure, Education, City Products, Health and Waste. Each sub-index consists of several indicators. For instance, i) infrastructure includes water availability, sewerage, access to electricity, and telephone availability; ii) education consider literacy and school enrollment; iii) city product consider GDP at the city level; iv) health combines with life expectancy and child mortality; and v) waste accounts wastewater treatment and solid waste disposal.

Huang et al. (2015) claimed that CDI effectively assesses urban poverty and urban governance as it emphasizes measuring urban development and access to urban facilities. More specifically, components of infrastructure, waste and city products represent the effectiveness of urban governance, and components of health, education and infrastructure are pertinent to urban poverty.

Green City Index (GCI)

GCI was developed by the Economist Intelligence Unit (EIU) of The Economist newspaper in 2012. It focuses on the critical issue of urban environmental sustainability by creating a unique tool that helps cities benchmark their performance and share best practices. The series began in 2009 and has assessed over 120 cities worldwide. Each report contains overall lessons for the region and detailed city profiles describing individual performance and best practices. African Green City Index, Asian Green City Index, European Green City Index, German Green City Index, Latin American Green City Index and U.S. and Canada Green City Index are some examples of GCI. However, Huang et al. (2015) claimed that GCI had been promoted exclusively by the EIU-Siemens project and has yet to be picked up by other researchers.

Sustainable Society Index (SSI) and Sustainable City Index (SCI)

SSI was developed in 2006 by the Sustainable Society Foundation, a non-profit organization in the Netherlands. SSI is a highly aggregated sustainability index and has become a globally well-established source of information for government agencies, non-government organizations, private enterprises, and academia. The latest SSI edition, published in August 2020, presented the sustainability profile of 154 countries/ territories. Together with the earlier edition, it offers an opportunity for cross-sectional and longitudinal analyses. All data and a large variety of country-specific graphs and tables are formulated based on the triple bottom line (TBL) of social, environmental and economic sustainability. In SSI, these are presented as Human well-being (HUW), Environmental well-being (ENW) and Economic well-being (ECW), respectively. HUW consists of nine indicators of three categories, whereas ENW consists of seven indicators of two categories. ECW consists of two categories

and five indicators. Therefore, the latest edition of SSI represents three dimensions, seven categories and 21 indicators. Though SSI was used for national-level sustainability assessment, now its regional-level application is also found (Huang et al. 2015).

The Sustainable Society Foundation also developed SCI in 2014. It contains 16 indicators under seven categories and three dimensions. The latest SCI 2.0 has 24 indicators under nine categories, namely, basic needs, personal development, and social development (under the human wellbeing dimension), environment and nature, resource efficiency, energy efficiency, and transport efficiency (under the environmental wellbeing dimension), work and public finance (under Economic wellbeing dimension) (Huang et al. 2015).

Environmental Performance Index (EPI)

EPI is a brainchild of Yale University and Columbia University with the close cooperation of the World Economic Forum and the European Commission's Joint Research Center (Wolf et al. 2022). The EPI offers a scorecard (from 0 to 100) highlighting leaders and laggards in environmental performance and providing practical guidance for 180 countries seeking a sustainable future.

The latest version of EPI will be published in 2022 based on three policy directions: climate change (38%), environmental health (20%) and ecosystem vitality (42%) and uses 40 indicators under 11 categories. The 11 categories are air quality, sanitation and drinking water, heavy metals, waste management, agriculture, pollution emissions, climate change, water resources, fisheries, ecosystem services, and biodiversity & habitat. These indicators are vital to identifying problems, target setting, tracking trends, understanding outcomes, and providing best policy practices. Good data and fact-based analysis can also help government officials fine-tune their policy agendas, facilitate communication with major stakeholders, and maximize the return on environmental investments.

The EPI provides a powerful policy tool to support efforts to achieve the UN Sustainable Development Goals and move society towards a sustainable future. Overall, EPI rankings indicate which countries best address every nation's

environmental challenge (Wendling et al. 2020). Huang et al. (2015) assert that although EPI has been primarily focused on the country level, it can also be used to deal with urban issues by properly modifying problem areas and related indicators. However, this is yet to be done.

Human Development Index (HDI)

HDI is a composite index of life expectancy, education and living standard. UNDP first published it in 1990, when a novel approach was introduced for advancing human well-being. Human development – or the human development approach - is about expanding the richness of human life rather than simply the richness of the economy. HDI focused on people and their opportunities and choices (UNDP 2023).

HDI has been published annually by UNDP for all countries since 1990. The countries were ranked from 0 to 1 (the higher the score, the higher the development). Raudsepp-Hearne et al. (2010) claimed that HDI is the most widely used indicator among all sustainability indicators. It is straightforward, easy to compute and captures essential elements of human well-being. However, it includes sustainability's economic and social dimensions but ignores the environmental dimension (ibid).

Huang et al. (2015) argued that, though HDI is commonly used for sustainability at the national level, it has also been used to assess major cities' sustainability worldwide. For instance, UN-Habitat's 2011 report shows that some cities in developing countries are becoming more prosperous (with higher HDI values), reflecting considerable progress in health and education and sometimes even in the absence of sustained economic growth. Cities with high HDI values act as engines for positive change and as beneficiaries of prosperity. In developing countries, some urban areas are becoming so prosperous that they have closed the gap with or even surpassed the HDI of cities in developed nations. For example, Seoul, South Korea, features an HDI of 0.911, higher than many European cities, particularly the Southern and Eastern regions (ibid).

Happy Planet Index (HPI)

HPI relates natural resource consumption with human well-being. It tells how well nations are doing at achieving long, happy and sustainable lives. This index was first created in 2006 by New Economics Foundation (NEF). It is calculated as the ratio of Happy Life Years (happiness-adjusted life expectancy) to environmental impact (measured by EF) and measures “the ecological efficiency with which human wellbeing is delivered” (Wellbeing Economy Alliance 2021).

The main argument of HPI is that human well-being should be measured not only in terms of wealth but also in terms of quality of life, particularly for countries with high GDP growth. The high GDP growth does not necessarily mean everyone in the country is enjoying a better life.

The latest HPI was published in 2016 for 140 countries. The result shows that wealthy western nations tend to score highly on life expectancy and well-being but do not score highly on the Happy Planet Index overall because their economy is running with a high environmental cost. The USA (United States of America) achieves a high Happy Life Years score, but it has the largest EF in the world and, therefore, a low HPI score. Many other countries achieve a higher Happy Life Years score with a smaller EF. The top-ranking country, Costa Rica, achieves a slightly higher Happy Life Years score than the USA, with a significantly smaller EF (Happy Planet Index 2016). Mega (2013) suggested that although HPI is used only at the national level, it can also be used at an urban scale.

Genuine Progress Indicator (GPI)

The genuine progress indicator (GPI) has evolved as a prominent sustainability indicator since the early 1990s as a part of the Green GDP movement. The GDP has been widely used to measure the economic growth of a region or a country. However, it cannot identify which economic activities improve well-being and which activities reduce it. It does not reflect social, economic, or environmental sustainability (Wen et al. 2007) and ignores resource consumption and environmental degradation (Kubiszewski et al. 2013). In contrast, GPI represents economic well-being in a single matrix of more than 20 indicators under the social, economic and environmental

dimensions (Talberth et al. 2006). According to Posner and Costanza (2011), GPI also covers conventional economic transactions, nonmarket natural and social benefits, and positive and negative impacts of economic activities on human wellbeing.

Posner and Costanza (2011) also claimed that although GPI is usually used at the national level, it can be used at subnational scales. For instance, they estimate GPI for Baltimore, Baltimore County, and the State of Maryland of the United States. They identify the impact of development activities on long-term prosperity. Wen et al. (2007) measure the GPI of four cities in China (Suzhou and Yangzhou in Jiangsu province, Ningbo in Zhejiang province, and Guangzhou in Guangdong province). They suggested that GPI could be accepted as an alternative measure of economic growth and welfare development to traditional GDP. Their study also proved that GPI is a better measure of economic welfare than GDP at an urban level. Costanza et al. (2004) reported that applying the GPI approach at the city, county and state levels is feasible. They measured the GPI for the American state of Vermont, Chittenden County (the county with the largest population) and Burlington (Vermont's and Chittenden County's largest city). They concluded that all three Vermont scales had had much higher GPI per capita since 1980 than the national average. The GPI per capita for all Vermont scales was twice the national average in 2000, indicating Vermont's economy is more sustainable and has much better environmental performance than the national average.

Genuine Savings (GS)

The World Bank developed GS, also known as green GDP, in 1997. GS assumes that the country's overall capital stock should be non-decreasing. It measures the net change in the real assets of a country by subtracting the values of natural resource consumption and depletion, costs of pollution damage (including those related to human health) and deducting net foreign borrowings from gross domestic savings. It treats education expenditure as saving rather than consumption (increasing human capital). Pearce and Atkinson (1993) and Greasley et al. (2014) argued that only an increase in GDP does not necessarily mean that the wealth of nations is increasing.

It must consider resource depletion, environmental degradation, and changes in technologies and human resources. GS saving evolved to meet this gap.

Rogers and Srinivasan (2007) claimed that conceptually GS and GPI are the same but technically different. GS focuses on stock changes, whereas GPI considers “flows” of transactions. GPI is widely used to measure national level sustainability, while limited use of GS is found in several cities in China, India, and the United States (Wen et al. 2005, Rogers and Srinivasan 2007; Zhang et al. 2008).

Wellbeing Index (WI) (Barometer of Sustainability)

WI is developed by the IUCN (International Union for Conservation of Nature) in the 1990s. The interesting point is that, instead of the traditional three or four dimensions of sustainability, it only considers two dimensions- people and ecosystems. The main argument for taking two dimensions is that three dimensions reduce the weight of the environment to a third, and four dimensions reduce it to a quarter. Whereas it is two-dimensional, it can give equal weight to each dimension. Prescott Alen (2001) compares it to the egg. In egg white part surrounds the yolk. If both are good, the egg is good. Similarly, the ecosystem surrounds humans. If any of these is unwell, the whole system is unsustainable.

WI is the arithmetic means of two different indexes, the human well-being index (HWI) and the ecosystem well-being index (EWI). Sometimes it is also presented as the two-dimensional EWI (x-axis) and HWI (y-axis) graph. HWI comprises health, population, wealth, knowledge and culture, community, and equity. EWI focuses on land, water, air, species and genes, and resource utilization. Both axes are divided into five equal bands: Bad, Poor, Medium, OK, and Good and scaled from 0 to 100. The intersection between EWI and HWI represents the overall well-being of the system. The plot is called the “Barometer of Sustainability” (Prescott-Allen 2001).

Huang et al. (2015) argued that WI could be used from municipality to the entire world besides the country-level sustainability analysis. However, this has not been widely used due to the invention of other new sustainability indicators.

City Prosperity Index (CPI)

UN-Habitat introduced CPI in 2012 to measure urban sustainability and prosperity. Anarfi et al. (2020) claimed CPI as a comprehensive package for measuring urban sustainability.

The CPI was developed by surveying 54 cities from developing countries where experts from Asia, Africa, Arab countries, and Latin America were included. They agreed that a prosperous city integrates six critical dimensions, popularly known as the wheel of a city's prosperity, as shown in Figure 2.7. Six dimensions (productivity; infrastructure development; quality of life; equity and social inclusion; environmental sustainability, and urban governance and legislation) are considered the wheel's spokes, and local authorities' capacity is considered the wheel's outer rim. These spokes transmit the cumulative forces of six dimensions to the rim, i.e. local authorities.

CPI is an aggregate index of six sub-indices of six dimensions with 72 indicators. The city-level data calculates each indicator from the available last year. So, CPI can identify well or poor-performing dimensions, thus informing which features require more attention (UN-Habitat 2016).

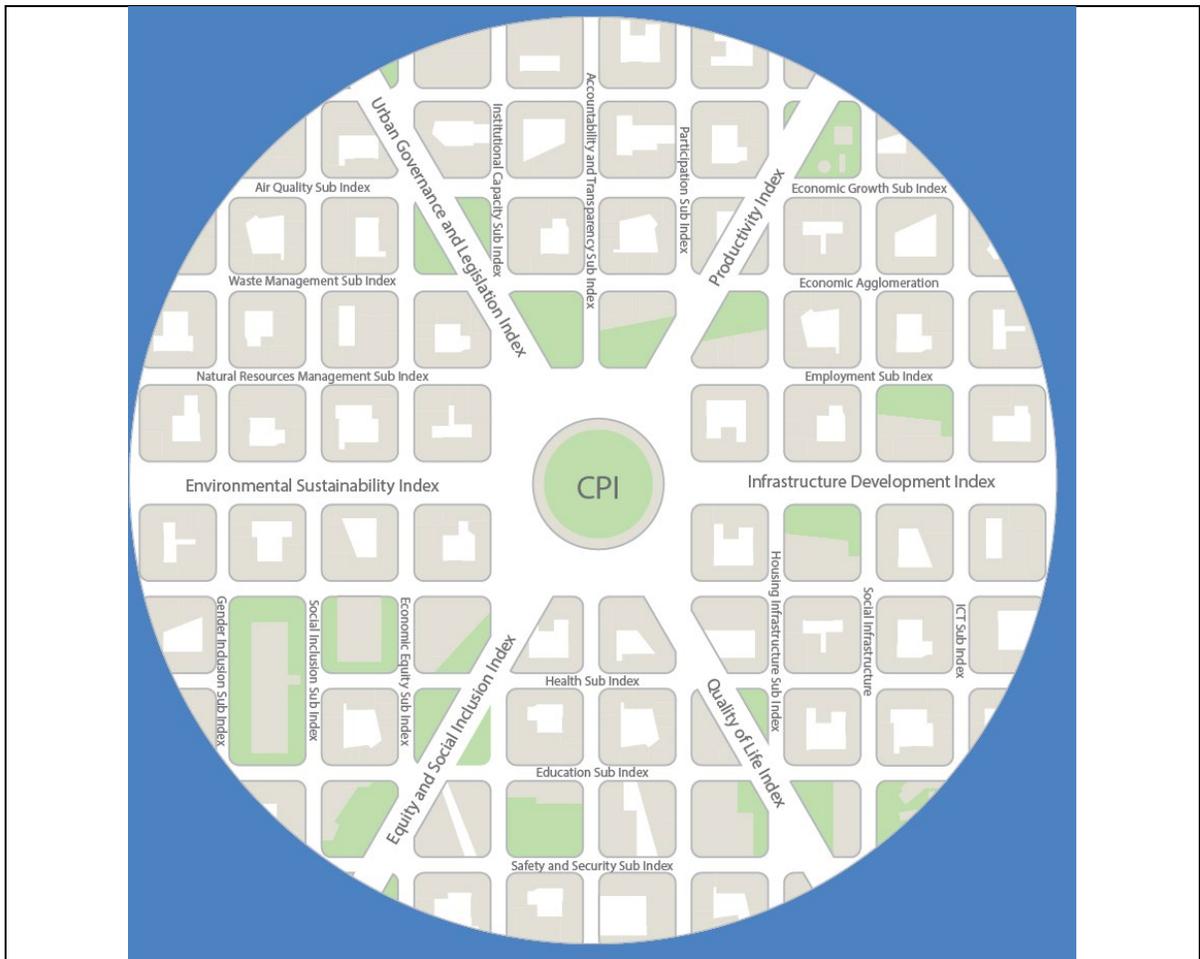


Figure 2.7 Wheel of urban prosperity (adopted from UN-Habitat 2016)

Human rights are the core principle of CPI. Access to housing, water, sanitation, and cultural, economic, political and social rights are some of the human rights included in the CPI calculation. CPI considered urbanization as a process, and the city is the outcome. Therefore, the city development process should consider human rights adequately. UN-Habitat provides the detail of CPI measurement on its website as the “Measurement of City Prosperity, Methodology and Metadata” of UN-Habitat (2016).

UN-HABITAT (2016) measured CPI for 400 cities across 46 countries. There are two ways to participate in CPI initiatives. One way is the willingness of city authorities, and another way is the government initiative. City authorities can approach UN-Habitat out of their interest. On the other hand, national governments can send a list of cities to UN-Habitat to measure their CPI. A substantial amount of city-level data

is required to develop this CPI. In the case of Bangladesh, city-level disaggregated data is not available. Therefore, an initiative from a particular city or government is required to measure the CPI of cities in Bangladesh.

Smart City

Anand (2021) claimed that the idea of 'Smart City' evolved around the late 1990s. This concept mainly focusses on the use of ICT to manage the city. A web of science search by key words "smart city" comes up with 10623 results. Among which 8,955 claimed it as science and technology related, while 4,118 claimed it as social science and 340 described it as arts and humanities. However, another web search by key words "smart city, ethics" comes up with only 24 records. This indicates that smart cities is predominantly a computer science and engineering concept with some emerging use and adaptation in the social sciences and public policy sciences. By reviewing 120 definitions, The International Telecommunications Union (ITU) provide the following definition of Smart city:

"A smart sustainable city (SSC) is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects (ITU-T, 2014)".

The International Organization for Standardization (ISO) (2017) also comes up with the following definition of smart city:

'effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens'.

However, Anand (2021) identifies several shortcomings of this definition. Firstly, he claimed that this definition does not address governance and ethical issues in the framing of a market-based approach to smart cities. Secondly, this definition excludes the issue of equity and equality. Thirdly, Gender inequality is not specifically raised. In addition to these, issues relating to power, the political economy, climate

emergency and the ethics of dataveillance and privacy are also raised in their definition. He comes up with the conclusion that smart cities would be those cities who by default ensure the healthy lifestyles, promotes multiple uses of spaces by different stakeholders, compassion, universalism and sustainability are embedded and promoted as the norms; or where integrity rather than corruption is 'the normal. Though smart city projects are normally seen as 'toys for the rich' essentially digital and ICT applications in high income countries, they are now also implementing in some global south countries like Republic of Korea, Brazil, Colombia, China, India, Indonesia, Nigeria and Rwanda (Anand 2021).

Ecological Footprint (EF)

EF is a land area-based sustainability indicator developed by Wackernagel and Rees in 1996. The environmental dimension of sustainability is this indicator's main focus, presented as a land area in the global hectare. Six components of this indicator are cropland, grazing land, forest area, build-up land, carbon uptake land and fishing grounds. According to Rees (1996) and Wackernagel and Rees (1996), EF represents the land (and water) area needed to provide all the energy and material consumed and to absorb all the wastes discharged to support a population or an activity, given prevailing technology and resource management practices.

Wackernagel and his colleague first presented a systematic approach to EF in 1997 (Wackernagel et al. 1997), and National Footprint Accounting (NFA) programme started in 2003 (Baabou et al. 2017). Global Footprint Network (GFN) provides annual EF data for 160 countries. At least twelve national and intergovernmental agencies incorporated EF into their official initiatives (Giljum et al. 2007). It provides a benchmark for comparing the human demand placed on the ecosystem. EF measurement takes actual data on a wide range of energy and material flows and represents them in terms of a single concrete variable, land area. Land is a powerful indicator because it is easily understandable by ordinary people (Delannoy et al. 2001).

Since the invention of the EF concept, it has been a much-discussed issue in the sustainability literature. For instance, Huang et al. (2015) claimed that EF could track

a city's food, water and other natural resources demands. EF has been used for sustainability assessment on national, regional, municipal and local scales.

Delannoy et al. (2001) opined that the significant strength of EF is that it captures the human-environment interaction. Because it follows the earlier conceptual definition of human impact on the environment formulated by Ehrlich and Holden (1971): $I = PAT$, Where I = impact, P = population, A = affluence and T = Technology. It also reflects the critical role of the second law of thermodynamics in human affairs.

Furthermore, Defries et al. (2004) assert that economics and the environment are the components of a single interlinked system. EFA (Ecological Footprint Accounting) offers a reference framework to visualize the big picture of this interlinked system. Moreover, a big picture is essential before identifying and tracking many socio-ecological issues (Clapp and Dauvergne 2005). Galli (2015) claims that the world is interconnected with multiple problems. As a result, there is no scope to think only about one problem. Systematic thinking is needed to deal with multiple problems.

In this regard, Goldfinger et al. (2014) argue that EF offers such systemic thinking to integrate environmental and economic policies. For instance, from a general perspective, the EF of a specific area covered by forest may appear to decrease when it is converted to cropland. However, in systematic thinking, the transformation of the forest into agricultural land, particularly in tropical zones, has reduced the net bio-capacity of that area, thereby increasing the EF. Since most nutrients are absorbed in trees rather than soil, leading to low crop production (ibid).

EF can also identify ecological overshoot levels and factors of un-sustainability and track progress towards sustainability (Wackernagel and Yount 2000) by adding spaces for the ecological services we consume. These spaces include resources, housing, infrastructure, and waste absorption using prevailing technology and management practices (Wackernagel 1991; Wackernagel and Rees 1998; Wackernagel et al. 2002).

Though, EF methodology has attracted much attention (for instance, Wackernagel and Rees 1997; Levett 1998; Wackernagel et al. 1999; Costanza 2000; Lenzen and Murray 2001; Haberl et al. 2001; Senbel et al. 2003) and some scholar is in favour

for its general use in sustainability policy formulation (Rees 2000; Templet 2000; Wackernagel and Silverstein 2000; Costanza 2000). While others acknowledged the limited use of EF in policy formulation (Ayres 2000; Opschoor 2000; van Kooten and Bulte 2000; van den Bergh and Verbruggen 1999a, b). Because EF is still developing, certain aspects are not yet included, or some data need to be improved (Wackernagel and Yount 2000). Thus, EF analysis does not intend to provide a dynamic window on the future but a snapshot of the future (Rees 2000).

There is a different mathematical formula to measure the different indicators/indices of sustainability. A compilation of these formulas can be found in Huang et al. (2015). The following table 2.2 shows a comparative analysis of these indicators. Table 2.2 indicates that EF, EPI, GCI, PSR-based indicators set, and Material and energy flow indicators sets bear strong sustainability strictness, whereas CDI, GPI, GS, HPI, HDI SSI, WI and Theme-based indicators sets bear weak sustainability strictness.

Table 2.2 Urban sustainability indicators based on weak and strong sustainability criteria.

Sustainability Criteria	Weak Sustainability Indicators	Strong Sustainability Indicators
Indicators Sets	Theme-based Indicators sets	PSR-based indicator sets Material and energy flow indicator sets
Composite Indicators	CDI, GPI, GS, HPI, HDI, SSI, WI	EF, EPI, GCI
Source: Authors creation based on Huang et al. (2015)		

Among these indicators and indicators sets the indicators that have been or can be used for urban sustainability is presented in Table 2.3. This table shows that EPI, GPI, GS, HDI, HPI, SSI WI can be used in Global and National sustainability assessments. All of them except HPI and WI are also applied in urban scale. CDI, GCI and Smart City are developed to use in urban scale, whereas EF can be used from local to global scale.

Table 2.3 Comparative analysis of sustainability indicators.

S. N.	Indicator	Publication year	Developer	Scale Originally Intended	Applied at Urban Scale?
1.	CDI	1997	UN-Habitat	Urban	Yes
2.	EF	1992	Wackernagel and Rees	Local to global	Yes
3.	EPI	By-yearly since 2006	Yale University and Columbia University	Global, National	Not yet
4.	GPI	1994	Redefining Progress	Global, National	Yes
5.	GS	1999	World Bank	Global, National	Yes
6.	GCI	2009	Economic Intelligence Unit and Siemens	Urban	Yes
7.	HDI	Yearly Since 1990	United Nations Development Programme	Global, National	Yes
8.	HPI	2006	New Economics Foundation	Global, National	Not yet
9.	SSI	2006	Sustainable Society Foundation	Global, National	Yes
10	WI	2001	IUCN and International Development Research Centre	Global, National	Not Yet
11	Smart City	1990s	---	Urban	Yes

Source: Author's creation based on Huang et al. (2015) and Anand (2021).

In summary, it would be claimed that there are several sustainability indicators framework and single composite index whose can be used for both national and city level sustainability assessments. For instance, PSR frameworks, Theme oriented frameworks, Material and energy flow frameworks, Sustainable Society Index (SCI), Environmental Performance Index (EPI), Human Development Index (HDI), Happy Planet Index (HPI), Wellbeing Index (WI), Ecological Footprint (EF) can be used for both national and city level sustainability measurement. Whereas, City Development Index (CDI), Green City Index (GCI), Sustainable City Index (SCI) are specifically designed to use at city level. Among these urban sustainability indicators, some indicators fall under the weak sustainability criteria and some under the strong sustainability criteria. The following section discusses why EF is a good indicator to explore specifically for Bangladesh.

2.7 Rationale for Choosing EF as an Urban Sustainability Indicator for this Study

From the above discussion, it is clear that urban sustainability measurement can be a multi-dimensional, indicator-based, or life cycle assessment method. Among the three methods, sustainability assessments at the urban scale typically adopt indicator-based assessment. There is no lack of urban sustainability indicators. However, selecting indicators is challenging and essential because it directly affects the results and conclusions upon which policymakers will decide. If the selection is imperfect, that may cause long-term harm for an urban area, region, country, or whole globe. Morse et al. (2001) argued that this selection process is very subjective and depends upon a value judgement of what is essential.

In addition, Wu and Wu (2012) argued that multidimensional sustainability concepts might be considered a measurement of weak sustainability that allows mutual substitution among the three dimensions. However, strong sustainability does not allow substitution. Strong sustainability emphasizes the environment. The main reason is that increasing natural resource depletion and the growing human population creates more pressure on the environment, creating an imbalance in ecosystem services and biodiversity losses. No economic or social development is sustainable without adequate ecosystem services and biodiversity.

Moreover, according to Daly (1995) and Wu (2013), weak sustainability is eventually not sustainable. Thus, urban sustainability assessment should include at least one strong sustainability indicator, such as EF, GCI, EPI, or PSR-based indicator sets (Huang et al. 2015). In addition, Mori and Christodoulou (2012) claim that city sustainability indicators/indices should consider external impacts (leakage effects) of cities from which the cities under assessment import goods, resources, and services and should cover the triple bottom line of sustainability. However, no index/indices cover both the external impacts and the triple bottom line of sustainability. Therefore, there is still a need to create a new relevant city sustainability index that covers both the external impacts and the triple bottom line of sustainability (Mori and Christodoulou 2012).

As a result, EF is more acceptable in measuring the urban sustainability of developing countries, particularly Bangladesh. Because Bangladesh has a high population density, and the urban population has also increased more rapidly. This rising trend of the population has a significant impact on the urban ecosystem. EF can capture this human impact on the environment because EF follows the Ehrlich and Holden (1971) concept, I=PAT (Where I=impact, P= population, A=affluence and T= technology). EF also takes the environment seriously, which is relevant to strong sustainability. It also presents a big picture of the economy and environmental relationship and can identify ecological overshoots and factors of un-sustainability and track progress towards sustainability.

However, there is a fair share of criticism about using EF, which is also met by counterarguments (Galli et al. 2016). Nevertheless, improvement of footprint accounting practices is continuing, and few alternative methodological approaches are yet to offer.

It is also claimed that EF can be used to estimate sustainability in global (Wackernagel and Yount 2000)/regional (Cui et al. 2004; McDonald and Patterson 2004)/national (Salvo et al. 2015; Galli et al. 2012; Wang et al. 2012; Medved 2006; Haberl et al. 2001)/product (Limnios et al. 2009; Frey et al. 2006)/ business (Bagliani and Martini 2012)/ sectoral (Kissinger 2013; Herva et al. 2008)/municipal (Cano-Orellana and Delgado-Cabeza 2015; Scotti et al. 2009; Rashid et al. 2018)/household level for a city or urban agglomeration (Baabou et al. 2017). EF is also suggested as a biomass-based resource accounting tool that tracks human demand on nature to supply ecosystem services (Wackernagel et al. 1996; Galli et al. 2014).

Therefore, it can be said that EF accounting application ranges from a single product to the entire world (Kitzes et al. 2009) and offers responsibilities for environmental intervention from producers to final consumers (Weinzettel 2014). Some scholars termed it as an accounting tool (Wackernagel and Yount 2000) to quantify humanity's consumption of natural capital, appropriated carrying capacity (Rees 1992), overall assessments of human impact on the earth, and can be used to plan for sustainable future development (Yue et al. 2006). This indicator is conceptually discussed in

urban areas (Wackernagel et al. 2006). As a result, this study has chosen EF as an indicator for sustainability measurement.

2.8 Empirical Study on EF and Urbanization

Solarin et al. (2021) explore the effects of urbanization on EF for Nigeria using data from 1977 to 2016 along with other variables viz economic growth, trade, and foreign direct investment. They have employed ARDL simulations for model estimation, the Bayer and Hanck J Time Ser Anal 34: 83-95, (2013) combined co-integration and the ARDL bounds test for co-integration. Their findings affirm that urbanization has no harmful effects on EF.

By applying the Augmented Mean Group (AMG) algorithm, Nathaniel et al. (2020b) explore the impact of urbanization, energy consumption and economic growth on the EF in the Middle East and North Africa (MENA) countries from 1990 to 2016. They found that urbanization significantly impacts the EF of Egypt, Israel, Oman, Sudan, Tunisia, UAE, and Yemen. They also found that urbanization has a unidirectional causality from urbanization to EF. However, in the case of Jordan, they found that urbanization decreases EF. With a similar approach, Nathaniel et al. (2020c) observed that urbanization increases the EF of CIVETS (Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa).

Al-Mulali and Ozturk (2015) employed the FMOLS technique in a panel model representing EF and Urbanization from 1996-2012 for 14 MENA countries. They found that urbanization increases EF in the long run. They also conduct Granger causality and found that urbanization has a unidirectional causality to EF in the short run.

Solarin and Al-Mulali (2018) also used the AMG algorithm for twenty developed and developing countries from 1982 to 2013. They utilized the Westerlund (2007) Test for co-integration among the variables. Furthermore, the CCEMG estimator and the augmented mean group estimators were utilized to examine the effect of urbanization, GDP, energy consumption, and foreign direct investment on EF, CO₂ emission and carbon footprint. They found urbanization have mostly negative or

insignificant effect in developed countries, but for developing countries, urbanization increases EF, CO₂ emission and carbon footprint.

Ahmed et al. (2020a) examined the influence of urbanization on the EF of G7(the United States, Canada, the United Kingdom (UK), Germany, Italy, France, and Japan) countries. They used advanced panel data estimates such as CUP-FM and CUP-BC on data from 1971 to 2014 and found that urbanization increases the EF of these countries. Ahmed et al. (2020b) also found that urbanization in China increases EF. Danish et al. (2020) used FMOLS and DOLS techniques and found that urbanization reduces EF in BRICS.

By applying ARDL estimation, Nathaniel et al. (2019) found that urbanization has the most significant impact on increasing EF for South Africa in the short run. However, in the long run, urbanization decreases EF. Baloch et al. (2019) have also found a positive impact of urbanization on EF for 59 Belt and Road countries from 1990 to 2016. They have employed the Driscoll-Kraay panel regression model.

Most of the studies in Bangladesh tried to find out the impact of urbanization on CO₂ emissions other than EF. For instance, Rahman and Alam (2021) used urban population as a proxy for urbanization and CO₂ emission for environmental degradation and other variables from 1973 to 2014. They found that urbanization harms the environment in the long run, i.e., urbanization increases CO₂ emissions. They also found unidirectional causality running from urbanization to CO₂ emission.

Rahman et al. (2018) use EF along with CO₂ emission to find out their relationship with per capita GDP and energy consumption. However, they did not use urbanization in their data series. Although they found a direct and monotonous threat to environmental pollution from economic growth, this study suffers from the limitation of the causality test and uses only environmental data. Because CO₂ emission, EF and energy consumption are all representing environmental degradation. They also did not conduct any statistical tool for establishing long- or short-term relationships between the indicators.

Alam et al. (2012) conducted a more intensive study on economic growth and environmental degradation for Bangladesh. However, they did not use EF as a proxy

for environmental degradation. They also did not use urbanization as a variable. Mondal (2019) explored the only correlation between CO₂ emissions, population growth and GDP by applying the Pearson correlation coefficient. He also did not use EF and urbanization. His study also suffers from spurious outcomes as he did not analyse the quality of the data series, whether there is any statistical problem (unit root, endogeneity, multicollinearity) or not. He also did not establish a long or short-run relationship between indicators or no causality test. Instead, he focused more on descriptive analysis of literature on the impact of population and climate change on the sustainable development of Bangladesh.

Miah et al. (2010) used GHGs, CO₂, SO_x and NO_x to prove the EKC hypothesis for Bangladesh. Nevertheless, they did not carry out any econometric analysis to prove the existence of the EKC hypothesis for Bangladesh. They only summarized the findings of different scholars in this research area and suggested that, like other countries, Bangladesh may follow the EKC hypothesis. They also did not use EF and urbanization in their analysis.

Islam et al. (2013) also investigate the EKC hypothesis for Bangladesh using data on CO₂ emissions, trade openness, urbanization, and energy consumption. They apply the ARDL approach to cointegration for a long-run relation and the Granger causality within the vector error correction model for the short-run dynamics. They found that energy consumption significantly contributes to CO₂ emissions; trade openness lowers CO₂ emissions, but urbanization worsens it. Economic growth, energy consumption, trade openness and urbanization Granger cause CO₂ emissions. However, they did not use EF.

Rahman and Kasem (2017) also examine the empirical co-integration, long and short-run dynamics and causal relationships between carbon emissions, energy consumption and industrial growth in Bangladesh. They found long-run co-integration between the indicators and unidirectional causality from industrial production and energy consumption to carbon emissions, i.e., industrial development in Bangladesh is taking place at the expense of the environment. They also did not use EF as an indicator of environmental degradation.

Therefore, it is found that a quantitative analysis with a robust econometric framework looking at the EF and urbanization has yet to be carried out for Bangladesh. Most of the studies use CO₂ emission rather than EF. However, EF is found to be more aggregate data than CO₂ emission. Because CO₂ emissions only represent part of the environmental degradation based on the concept of air pollution (Ulucak and Lin 2017).

2.9 City Sustainability Assessment with EF

Baabou et al. (2017) claimed that since the first city EF assessment of Santiago de Chile by Wackernagel (1998), 63 city EF assessments had been documented across 20 countries. However, as these studies have employed different approaches, their comparability is challenging.

For instance, Rashid et al. (2018) estimate the EF of Rawalpindi, Pakistan, using an online calculator of GFN. They conducted a questionnaire survey by which they collected data on household size, household members, income, lifestyle, food quality, transport, energy resources, water-saving habits, energy saving habit, recycling of materials and consumption of non-toxic products from two areas of Rawalpindi (Gulriaz colony and Bahria Town). They found that urbanization in these areas is moving away from sustainable development. Consequently, the gap between the EF and bio-capacity is widening. Their findings additionally revealed that the carbon footprints of these urbanized areas are two times higher than the national carbon footprint. However, the per capita housing and goods footprint are approximately equal to the bio-capacity of Pakistan.

Rashid et al. (2018) also perform a regression analysis to evaluate the association between major footprint values and indicators of household living status. They found that an increase in annual income would cause a corresponding increase in EF. Similarly, distance travelled (km) in personal vehicles significantly affected carbon footprint.

Baabou et al. (2017) also calculated the EF of 19 Mediterranean cities (Valletta, Athens, Genoa, Marseille, Rome, Barcelona, Thessaloniki, Valencia, Telavi, Venice, Palermo, Naples, Istanbul, Tunis, Izmir, Cario Antalya, Alexandria and Tirana) with a

top-down approach based on a multi-regional input-output (MRIO) analysis using data on average household expenditures and national Consumption Land Use Matrix (CLUM). They have collected data from NFA- 2014 edition, Annual household expenditure from oxford economics. They found that cities of high-income countries have higher EF than that of low- and middle-income countries. The main footprint drivers were food expenses. Moreover, they found that cities with high EF also have a higher carbon footprint associated with transportation. However, they acknowledged the limitation of their study as the tourism sector was not included. Their study also suffers from the homogeneity assumption. For instance, consumer purchase a final product from different sectors, e.g., Bovine, Cattle, Sheep and Goats. Those may have different environmental impacts. However, their study assumes that all the products have the same environmental impacts.

Isman et al. (2018) measured the carbon footprint subcomponent of the EF for 15 Canadian cities. They analyse the data in three steps: NFA, environmentally extended MRIO analysis and scaling procedures at the city level. EF data on production from the NFA-2016 edition were used as input to an environmentally extended MRIO model based on the Global Trade Analysis Project (GTAP 8) database. The resulting EF is categorized into final demand in 57 economic sectors and then translated into COICOP consumption categories from which the National CLUM of Canada is derived with the help of the input-output table of GTAP 8. Then they estimate' cities' EF starting with the national CLUM of Canada by applying a top-down approach, where they scale the national CLUM to each city using average household expenditures. Across all cities, they found that energy source (renewable vs non-renewable) is the most influential factor in determining the carbon footprint of cities. Further, transportation was the most significant component of the carbon footprint. However, their study did not measure the other component of EF, thus not providing a complete picture of EF to assist the policymakers in decision-making towards resource efficiency and sustainability policy.

Applying direct component analysis, Moore et al. (2013) measure the EF of Vancouver, Canada, Metropolitan region. They use local authority data on several urban components such as buildings, transportation, water, food, material, and

waste. They found that water has the smallest EF. Food contributes the most prominent component to the EF, including crop and grazing land and carbon sinks required to sequester emissions from food production and distribution.

Lee (2019) measured the carbon, build-up land and water footprint of 12 Taipei, Taiwan districts using a component-based bottom-up approach. They have conducted a questionnaire survey to collect primary data on personal consumption. They have used the Taiwan Environment Protection Agency (EPA) carbon reduction behaviour calculator to calculate carbon footprint, individual floor area of residents for personal build-up land and water footprint calculator for water footprint. They compared their results with the results of Taiwan's national footprint accounts. They found that carbon footprint significantly varies among the district, but there is no significant variation in water and build-up land footprint. They also found that the built-up land footprint is similar to Taiwan's national footprint accounts and that personal carbon footprint is smaller than that of the national. It is revealed that although EF has six components, they only measure the carbon, built-up land, and water footprint part. The other components, i. e. cropland, grazing land, forests and fishing grounds, were not studied. As a result, their findings have faced a shortcoming in presenting a complete picture of EF.

Galli et al. (2020) calculate the EF of 6 Portuguese municipalities (Almada, Braganca, Castelo Branco, Vila Nova de Gaia, Guimaraes and Lagoa) by employing a top-down approach where they use GFN's 2014 edition of EF results of Portugal. Firstly, they measure the national Consumption Land Use Matrix (CLUM) with the help of the Multi-regional Input-Output (MRIO) GTAP 9.0 model. Then this national CLUM was scaling down to acquire Municipal CLUMs with the help of municipal level purchasing power data from the Portuguese National Statistical Institute and Household expenditure data from Oxford Economics. Finally, this municipal CLUM was used to measure the EF of different cities. They found that, in 2016, the EF of the residents of each of the six municipalities was higher than the respective municipal bio-capacities (and higher than the national per capita bio-capacity), indicating a bio-capacity deficit situation for all six cities. This deficit indicates that these municipalities

are not growing in a sustainable way and consuming more natural resources than are available.

Their study extensively relies on secondary data from various sources, which may not be able to capture an accurate picture of the local community. Because Aall and Norland (2005) and Wilson and Grant (2009) claim that there would be a chance of information loss and evaluation of local policies may be more difficult for not using local data.

Zhang (2020) assesses the sustainability of Xi'an city of Shaanxi Province, China, with the EF method. He used data from 2001 to 2017 from the Xi'an city statistical yearbook and Shaanxi Province statistical yearbook. Using the EF model, ecological carrying capacity model, ecological surplus, and ecological deficit model, he found that from 2001 to 2017, an ecological deficit occurred every year, and the ecological deficit in each year exceeded the global average per capita ecological deficit. Besides, both EF and ecological deficit tend to increase year by year, and the growth rates are higher than the growth rate of ecological carrying capacity.

Zhang (2020) used city-level data, which is available in China. However, in the case of Bangladesh city level data for EF measurement is not available. Therefore, city-level primary data from Bangladesh should be collected. Some other studies on different cities in China are also found, for instance, Wu et al. (2019) for Tianjin and Yue et al. (2006) for Gansu (Western inland province of China). They also use city-level data to estimate the EF of these cities.

Holden (2004) uses EF analysis for policy development of sustainable urban form in two Norwegian towns, Greater Oslo and Forde. They have collected household consumption data from 537 households. He has found that the small rural town of Forde has an EF of 10 per cent less than their urban counterparts of the city suburb of Greater Oslo. From this finding, he finally suggests that sustainable urban development points towards decentralized concentration, i.e., small cities with a high density and short distances between the houses and public/private services.

EF analysis was also used by Khan and Uddin (2018) to measure the ecological stress of a ward of Khulna City Corporation of Bangladesh. They use component and

direct methods to determine the EF (demand) and measure that area's bio-capacity (supply). They also conducted a household survey to collect home-based material consumption data. By following GFN guidelines, they measure the EF and bio-capacity. The gap between EF and bio-capacity was identified using Geographic Information System (GIS). They found that the study area's per capita EF and bio-capacity were 0.7161 gha/capita and 0.0144 gha/capita, respectively, for 2015. They conclude that ecological demand for household-based consumption exceeded its ecological capacity by 49.73 times. However, their study was confined to a small area (a single ward of a city corporation) that might not represent the whole city.

Muniz and Galindo (2005) use EF of travel-to-work as a leading indicator to measure ecological stress in the 163 municipalities of the Barcelona Metropolitan Region. They found that urban form has an apparent effect on EF.

Therefore, it is found that EF measurement is carried out by using different techniques around the world, including in Bangladesh. Most of the studies use national or local secondary data and apply a top-down approach to measure the EF of respective cities. It is also found that a limited number of studies use primary data collected by questionnaire survey (e.g., Holden 2004, Lee et al. 2019, Rashid et al. 2018; Khan and Uddin 2018). The uses of primary data are relevant for Bangladesh. Because in Bangladesh city level data is not so robust or, more precisely, unavailable. In addition, in a top-down approach, there would be a chance of information loss (Aall and Norland 2005; Wilson and Grant 2009). A new but highly effective and efficient measurement of personal EF is now available online, widely known as an online calculator. Like statistical software (STATA, Microfit, EViews), this online calculator can measure any city's EF.

A fair share of criticism is also found regarding the use of online calculators for EF measurement. For instance, by reviewing numerous popular online EF calculators, Franz and Papyrakis (2011) claim that even a person has chosen the most environmental friendly options, he/she still exceeds the planet's biocapacity levels. In these calculators, there are also on options to fully offset one's environmental impacts. As a result, one cannot be able to understand what his/her sustainable level of consumption would be. However, all online calculators' providers claim that their

purpose is to educate consumers to promote sustainable behaviour (Franz and Papyrakis 2011).

Another common criticism of EF is the failure of distinguishing the sustainable and unsustainable level of land use (van den Bergh and Verbruggen 1999, van Kooten and Bulte 2000; Venetoulis and Talberth 2008). The intensive land use (with the use of fertilizers and pesticides) might decrease the EF of food, however, it might increase groundwater pollution and health damage for surrounding populations (Herendeen 2000, van den Bergh and Verbruggen 1999). Some also argued that EF is a rather romantic idea- its main aim is to show that we are living beyond the limits of our planetary boundaries. In that sense it is a revised or different version of the same idea as Limits to growth. There are huge ethical issues and also there is a bit of static perspective- in real world technological growth means the same number of resources now support a lot more people than they would have done 100 years ago. Many people who call for a halt to development or halt to growth are also using the same argument as Garret Hardin 1968 - in essence that there are far too many people now. What is the solution? Forced family planning? Why do some people having the moral authority to tell others they cannot produce more children? (Anand 2023).

Costanza (2000) argues that EF does not specify whether biodiversity is being lost or acquired, whether the forest area is increasing or declining, and whether ecosystem services will be improved or acquired (Skene and Murray 2015). As a result, its relevance to policy direction is not above criticism, and debate is underway on its relevance in policy making (Galli 2015).

Moreover, the EF concept cannot include all types of environmental degradation, notably the depletion of non-renewable resources and pollution (except CO₂ emissions). Furthermore, many human activities and consequences, such as heavy metal pollution, persistent organic pollutants (e.g., PCBs, CFCs) and radioactive materials, fall utterly outside footprint calculations. Water use, resource degradation, and sustainability's economic dimensions are out of EF's scope (Kitzes and Wackernagel 2009). Criticism also arose on the carbon footprint calculations (Giampietro and Saltelli 2014a; van den Bergh and Gazi 2014, van den Bergh and Verbruggen 1999), and various methods of calculating the carbon footprint have been

proposed and discussed (Kitzes et al. 2009). Even so, no significant changes have been made to the carbon footprint method calculations in recent years, but deeper explanations have been offered (Mancini et al. 2016), and criticism met with counterarguments (Galli et al. 2016; Goldfinger 2014; Rees and Wackernagel 2013, Ewing et al. 2010, Kitzes et al. 2009 and Monfreda et al. 2004).

Therefore, many footprint practitioners and critics have emphasized improving national footprint accounting (Kites et al. 2009). However, few alternate methodological approaches, for instance, tracking greenhouse gases other than carbon dioxide (e.g., Dias de Oliveira et al. 2005; Walsh et al. 2009); the removal of the carbon component from EF accounting (e. g. van den Bergh and Verbruggen1999b); incorporation of input-output models (e.g. Bicknell et al. 1998; Lenzen and Murray 2001; Wiedmann et al. 2006), net primary productivity (NPP) data (e.g. Venetoulis and Talberth 2008) and emergy (Zhao et al. 2005) or exergy (Chen and Chen 2007) analyses were used in calculating EF. Giljum et al. (2011) argued for giving focus on various ecosystem compartments separately, such as the Carbon Footprint (Hertwich and Peters 2009), water footprint (Hoekstra and Chapagain 2007), land footprint (Weinzettel et al. 2013), nitrogen footprint (Leach et al. 2012) material footprint (Wiedmann et al. 2015) and chemical footprint (Sala and Goralczyk 2013). It is also found that footprint indicators have also been used as a Footprint Family (Galli et al. 2012a, 2013; Steen-Olsen et al. 2012).

Although EF calculation has faced a fair share of criticism, it should consider what it intends to do. EF only measures one central aspect of sustainability -how much bio-capacity humans demand compared to how much is available (Borucke et al. 2013). A senior GFN scientist (Galli 2015: 212) states that:

“At a national level, when a country's EF is greater than its bio-capacity, a bio-capacity deficit occurs. When a country's EF is smaller than its bio-capacity, it is said to have a bio-capacity reserve. This does not determine whether the country is sustainable- but it describes an essential minimum condition for sustainability.”

The above statement indicates that the most common use of EF is to compare it with the bio-capacity of the same country. If the bio-capacity is greater than the EF, it can be said that the country is on the track of sustainability and vice-versa. It is also claimed that the most common interpretation of sustainability with the EF concept is based on a combination of the political principle of a territory, the ecological principle of carrying capacity and the moral principle of consumer responsibility (Syrovatka 2020).

It is found that several popular organizations (e.g., WWF, Redefining Progress, GFN, Austrian Ministry of Agriculture, Forestry, Environment and Water Management, The Environment Protection Authority of the State Government of Victoria in Australia, Taiwan’s Environmental Protection Administration (EPA)) are providing online EF calculators.

Table 2.4 Popular online EF calculators

S. N.	Organization	Website
1.	Worldwide Fund for Nature (WWF)	www.footprint.wwf.org.uk
2.	Global Footprint Network (GFN)	https://www.footprintcalculator.org/home/en
3.	Best Foot Forward (BFF)	www.ecologicalfootprint.com
4.	Austrian Ministry of Agriculture, Forestry, Environment and Water Management	www.mein-fussabdruck.at
5.	BioRegional (BR)	www.calculator.bioregional.com
6.	Redefining Progress (RP)	www.myfootprint.org
Source: Authors creation based on Franz and Papyrakis (2011).		

The above table 2.4 summarizes some of the most popular online EF calculators. Although the list is not exhaustive, the list was made according to the highest returns from popular google search engine (Franz and Papyrakis 2011). These online calculators can inform the impacts of personal consumption habits on the

environment (Rashid et al. 2018). Different calculators have different strengths and weaknesses. Collins et al. (2018) suggest that calculators provided by GFN, and Redefining Progress (RP) are the most comprehensive calculators. Between these two GFN online calculator provides the most comprehensive index regarding location-specific consumption (Franz and Papyrakis 2011), which can be applied to every country (Rashid et al. 2018). It was also considered more user-friendly, consistent with most used National Footprint Accountings (NFAs) and freely available (Collins et al. 2018).

Table 2.5 Outcome of GFN Online Calculator

S. N.	Categories	Components
1.	Land Type	Build-up Land
		Forest Products
		Cropland
		Grazing Land
		Fishing Grounds
		Carbon Footprint
2.	Consumption Type	Food
		Shelter
		Mobility
		Goods
		Services

In addition to this, GFN claim that their online calculator is aligned with the international Ecological Footprint Standards, which were adopted in 2006. It calculates how much biologically productive area is required to produce the resources for the human population and to absorb the carbon dioxide emissions. Table 2.5 shows the output of GFN calculator. When personal consumption data is uploaded to the calculator, the calculator comes up the result of EF into two categories in global hectares. One is by land type and another one is by consumption category. Rashid et al. (2018) employ GFN's online calculator to measure the EF of Rawalpindi, Pakistan. Lee (2019) also calculates the EF of Taipei, Taiwan using the online calculators of Taiwan's EPA. Following Rashid et al. (2018) this study also uses the online calculator of GFN to estimate the EF of NC.

2.10 Conceptual Framework of the Study

After reviewing the literature, the following framework has been conceptualized for this study:

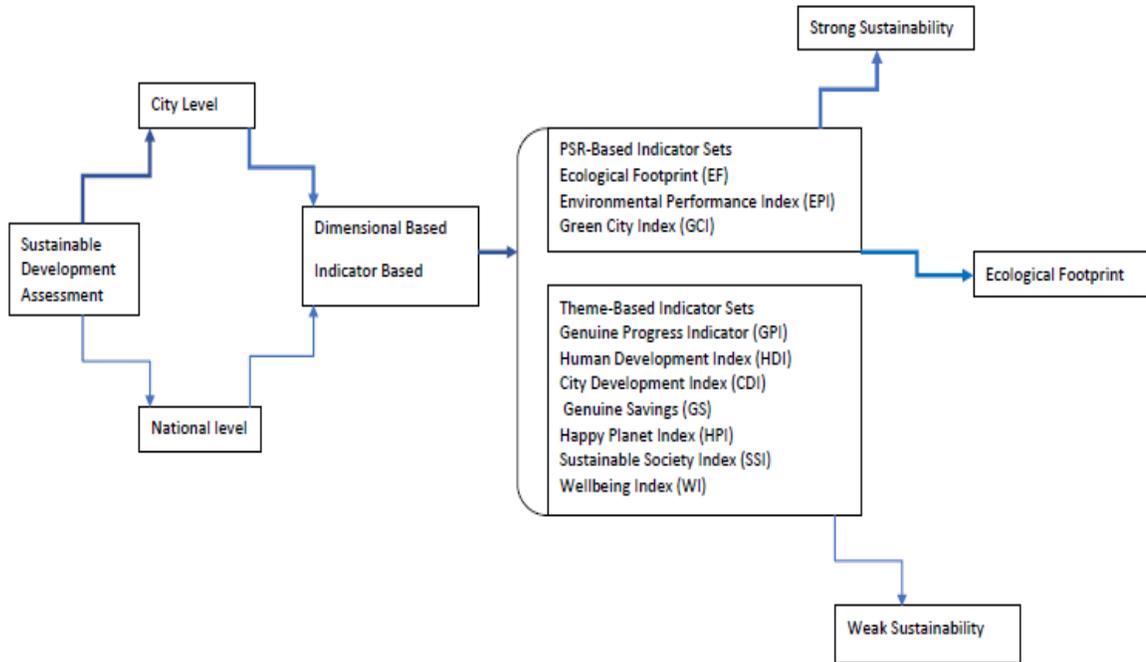


Figure 2.8 Conceptual framework of the study

This conceptual framework communicates that sustainable development assessment can be performed at a city or national level. Assessment at both levels could be dimension-based or indicator based. All the dimensional-based assessment measures the indicators/index of sustainable development. These indicators/ indices again represent strong or weak sustainability. PSR-Based Indicator Sets, EF, Environmental Performance Index (EPI) and Green City Index (GCI) represent the strong sustainability assessment. On the other hand, Theme-Based Indicator Sets, Genuine Progress Indicator (GPI), Human Development Index (HDI), City Development Index (CDI), Genuine Savings (GS), Happy Planet Index (HPI), Sustainable Society Index (SSI) and Wellbeing Index (WI) represent weak sustainability. Among these indicators/indexes, this study uses EF for empirical analysis and measuring the EF of a city in Bangladesh named Narayanganj City.

2.11 Conclusion

This literature review presents the sustainable development concept's origin and theoretical background. In addition, the sustainability practices worldwide, urban sustainability assessment and its framework, and single composite index are also discussed. It is revealed that strong sustainability assessment emphasises the environmental dimension of sustainability, and EF is one of the indices that capture sustainability's environmental dimension. The rationality of choosing the EF as a sustainable development indicator is also elaborated. Then empirical studies on the relationship between EF and urbanization, and the measurement of the EF of cities with potential research gaps are also explored. Finally, a conceptual framework for this study is drawn up with the idea conceived from this literature review. This review pointed out the following points:

- 1) Urban sustainability measurement is a rapidly growing sub-field of sustainability studies. There are three principal methodologies i) multidimensional-based methods, ii) indicator-based method and iii) life cycle assessment methods;
- 2) Importance of indicator-based methods and detail comparative analysis of different indicators frameworks and single composite index uses in global to national and city level are also made;
- 3) Two strictness of condition of sustainability assessment are available. Strong sustainability and weak sustainability. Strong sustainability gives more emphasis on environmental dimensions of sustainability and does not allow substitution. In this view other two dimensions social and economic dimensions are embedded in environmental dimension. Whereas weak sustainability allow substitution and give equal emphasis on all three dimensions. As a result, while measuring urban sustainability, it would be better to give more emphasis on environment that will automatically address the other dimensions of sustainability;
- 4) Ecological footprint is such type of indicator that address the strong sustainability conditions and have the capability to capture the human impact of the environment as it follow the earlier concept of I=PAT of Ehrlich and

Holden (1971). It also covers the 2nd law of thermodynamics which is highly related to sustainability concept. EF can also be used in global, regional/national/product/business/sectoral/household/urban sustainability assessment.

- 5) In case of urban sustainability assessment with EF most of the studies used top-down approaches by using local level secondary data. However, in case of Bangladesh local level, more specifically city level data is not available. In case of top-down approach there is also a scope of loss of information. As a result, it would be better to extend the use of ecological footprint measurement methodology by applying a bottom-up approach, where primary data can be used.
- 6) While measuring the EF by applying bottom-up approach, primary data collected by questionnaire survey is used. In addition to this, personal EF measured by using online EF calculators is also used to measure the EF of a city.
- 7) The following chapter is methodology chapter, which will explain the methodological approach developed and applied to answer the research questions by achieving the objectives of this study.

Chapter Three

Research Methodology

3.1 Introduction

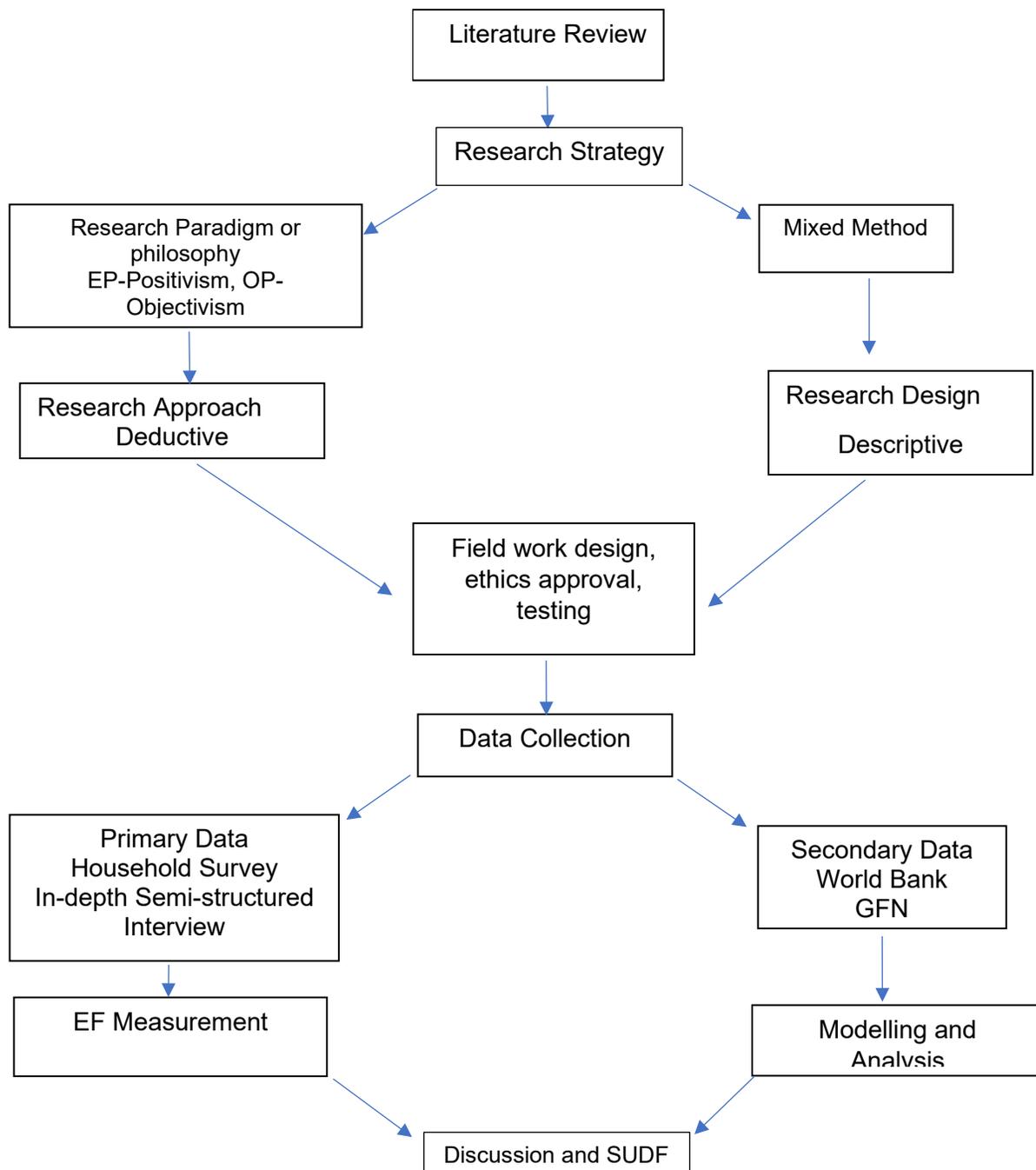
As explained in Chapter one the main goal of this research is to explore the urban sustainability of Bangladesh with ecological footprint analysis, this chapter is to define the method for data collection and analysis strategies to achieve that goal. Furthermore, the main aim of this chapter is to explain the combination of methods and tools that were used to use the ecological footprint as an urban sustainability indicator.

Research can be classified as carefully investigating a particular discovery. This discovery would be a direct discovery or support of other forms of knowledge (Fellows 2008).

Against this backdrop, this chapter will link research and theory, the research design and methodology. This chapter will also explain the combination of methods and tools used to study the nexus between EF and urbanization, EF of NC Bangladesh, and for developing a Sustainable Urban Development Framework (SUDF) for Bangladesh. To do so, section-3.2 presents a schematic diagram of the methodological approach followed in this study. Section-3.3 deals with the research strategy, which begins with the research philosophical position and proceeds with the debate of the research methodology used by expounding the dichotomy of quantitative, qualitative, and mixed methods. Research design is discussed in section-3.4. A detailed discussion regarding the data collection procedure is presented in section-3.5. Section-3.6 comes up with research ethics and compliance. Data analysis, generalization (data reliability) and risk due to covid-19 pandemic are presented in section-3.7 3.8 and 3.9, respectively. Section 3.10 summarizes this chapter.

3.2 Schematic Diagram of Methodological Approaches of the Study

This study follows the following methodological approaches:



EP = Epistemological Position; OP = Ontological Position

GFN = Global Footprint Network

SUDF = Sustainable Urban Development Framework

Figure 3.1 Schematic diagram of the methodological approach of the study

The schematic diagram reveals that this study took a mixed research strategy. While the study has a major focus on positivist and objectivist stance, it also includes normative and subjective dimensions or aspects. In terms of research design, this was guided by descriptive research with a deductive approach. After a comprehensive review of the literature, a conceptual framework was formulated. In the first step, this study empirically examines the relationship between EF and urbanization of Bangladesh by using secondary data from World Bank and GFN. Secondly, the EF of NC was measured using primary data collected through a questionnaire survey. A SUDF was developed at the final step to encourage more sustainable practices for sustainable urban development in Bangladesh using the primary data collected through 20 in-depth semi-structured interviews.

3.3 Research Strategy

Saunders et al. (2016) describe research strategy as a general plan for responding to the research question. Bryman (2016) termed it as a general orientation to conduct the research. Saunders et al. (2016) also added that the research strategy's relevance depends on the research objectives, time, available resources, the extent of existing knowledge and the philosophical stands on the subject area to be explored. According to Bryman (2016), research strategy has two major subdivisions, i) research paradigm or philosophy and II) quantitative or qualitative or mixed method research.

3.3.1 Research Paradigm or Philosophy

A research paradigm can be defined as a set of beliefs and agreements shared by researchers on how to understand and address problems (Kuhn 1962). Therefore, this is a specific way of perceiving the research that shapes how we seek a way of answering the research questions. Guba and Lincoln (1990) argued that a research paradigm is characterized by its epistemological, ontological and methodological dispositions.

Epistemological and Ontological Consideration:

Epistemology provides a philosophical background for deciding what types of knowledge are legitimate and appropriate (Gray 2018). Depending on epistemological positions, the same phenomenon may often lead to different research approaches (Grix 2004). Therefore, clear symmetry between epistemological positions, research question/hypothesis, and related social research techniques are crucial (Bryman 1984). Positivism and interpretivism are the two prominent epistemological positions.

Positivism advocates applying natural sciences methods to study the social reality and beyond (Bryman 2016). **Interpretivism** usually refers to an alternative to the positivist strategy that respects the differences between people and the objects of the natural sciences (ibid). It seeks culturally derived and historical interpretations of the social life phenomenon (Crotty 1998).

The ontological perspective of research examines the nature of existence and what constitutes reality (Gray 2018). Objectivism and constructionism are the two common standpoints of ontology (Bryman 2016). **Objectivism** considers social phenomena and their meanings as external facts beyond our reach or influence (ibid), which can be observed and measured without bias using standardized methods (Rubin and Rubin 2012). **Constructionism** is an ontological position that takes social phenomena and their meanings as internal facts (Bryman 2016) and cannot be measured directly (Rubin and Rubin 2012).

In **epistemological** consideration, this research took positivism, and ontologically, it took an objectivist position because common social realities, i.e., EF and urbanization, are covered in this study.

It is now well established that the environment is engaged in more economic activities (Masud et al. 2018) and is becoming more polluted in developing countries (Alvarado and Teledo 2017). Conflicts between urban development and the environment also intensify over time (Zhang et al. 2015) as most human social and economic activities are concentrated in urban areas (Mori and Christodoulou 2012). The urban area is also considered a country's economic growth centre (Kampa and Costanza 2008).

In this study, EF is used as an indicator of urban sustainability/environmental degradation, representing sustainability's environmental and social dimensions (Huang et al. 2015) and is directly measurable. The relationship between Bangladesh's recent EF and urbanization was examined. In addition, NC's EF was measured to determine whether urban development is sustainable or not. Moreover, environmental degradation is now a social reality for both developed and developing countries. Because economic growth in the sense of gross domestic product is highly desirable for all countries, this unavoidable growth will inevitably require more natural resource consumption that could degrade the environment (Ayres 2008). It is also found that 71% of energy related GHGs can be assigned to cities (Hoorweg et al. 2011), and it is expected to reach 76% by 2030 (Baabou et al. 2017). This environmental degradation exists externally and can be measured directly. This externality is a major theme of positivism (Gray 2018) and objectivism (Bryman 2016).

3.3.2 Quantitative, Qualitative and Mixed Research

A quantitative research strategy is an empirical study of quantitative characters, phenomena, and their relationship (Given 2008) through statistical, mathematical, or numerical data or computational techniques. Here, numerical data collection to clarify a particular phenomenon is critical. In this strategy, the researcher needs to use methods that minimize researchers' involvement in research (Gunderson and Aliaga 2005). Scientific thinking is used here to test theories and laws and reject or provisionally accept them (ibid).

According to Sekaran and Bougie (2016), quantitative research follows the deductive or top-down research process where numerical and statistical data test hypotheses and theories. Quantitative research is descriptive, explanatory, and predictive, involving two or more variables, and the researchers try to discover the relationship among those variables; individual beliefs and feelings are not countable, and the results are generalizable (ibid)

On the other hand, **qualitative research strategy** uses such techniques for data collection that emphasize explaining a situation or a specific social setting in detail without depending on their numeric shapes (Maxwell 2013). This strategy is appropriate

for the micro-level social organization or phenomenon investigation, whereas quantitative strategy focuses on the macro-level investigation (Silverman 2013).

Sekaran and Bougie (2016) argue that qualitative research strategy generates a hypothesis from data, attempts to study personal and social phenomena in descriptive, explanatory and discovery motives, and the research results are specific. Bryman (2016) also clarifies that qualitative research follows an inductive or bottom-up approach emphasising generating theories. This research ignores natural scientific model practices and norms, and researchers try to discover how individuals interpret their social world, where individual beliefs and feelings are widely counted.

Indeed, quantitative and qualitative research strategies have distinct differences in their role of theory generation/testing, epistemological, and ontological orientation. The following table summarizes the comparison in terms of these three areas.

Table 3.1 Comparison between quantitative and qualitative research strategies (adapted from Bryman 2016).

Orientation	Quantitative	Qualitative
Role of Theory	Deductive: testing of theory	Inductive: generation of theory
Epistemological orientation	Natural science model, in particular, positivism	Interpretivism
Ontological orientation	Objectivism	Constructionism
Some basic contrast	Numbers	Words
	Point of view of researchers	Points of view of participants
	Researchers distant	Researchers close
	Theory testing	Theory emergent
	Static	Process
	Structured	Unstructured
	Generalization	Contextual understanding
	Hard, reliable data	Rich, deep data
	Macro	Micro
	Behaviour	Meaning
	Artificial settings	Natural settings
Some similarities	Both are concerned with data reduction	
	Both are concerned with answering the research question	
	Both relate data analysis to the research literature	
	Both are concerned with variation	
	Both treat frequency as a springboard for analysis	
	Both ensure that no deliberate distortion is made	
	Both argue for the importance of transparency	

Many researchers argue that quantitative and qualitative research strategies can be combined within a single research project, called a **mixed methods strategy** (Bryman 2016). It has been defined as the third methodological movement (paradigm) (Benz et al. 2008; Teddlie and Tashakkori 2009).

Advocates of mixed method research strategy contend that this strategy is better than a single strategy (Venkatesh et al.2013). However, much debate has been on its application or appropriateness to projects with radically different paradigmatic assumptions (Denzin and Lincoln 1994; Guba 1987). Despite these debates, it has been suggested that conducting research with a mixed method strategy is more feasible (Mingers 2001, Benz et al. 2008; Teddlie and Tashakkori 2009) and peaceful coexistence of multiple methods is possible (House 1994).

Some also argue that it is possible to get a deeper understanding of phenomena by combining the qualitative and quantitative research strategy, especially by triangulation of qualitative and quantitative data (Jick 1979; Mingers 2001). Further to this, Gray (2018) illustrated the possibility of a mixed method strategy when research includes methods between (to a lesser extent within) the items presented in the following figure:

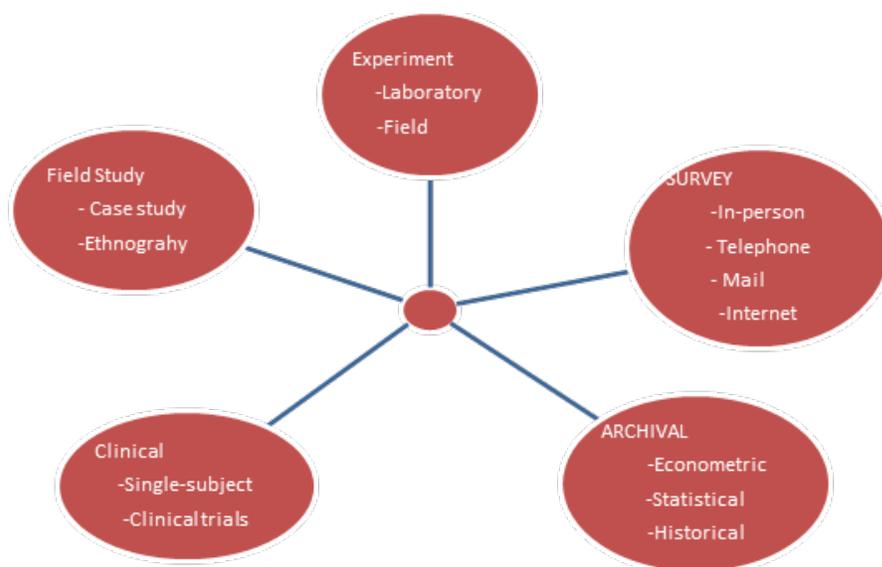


Figure 3.2 A broad variety of mixed methods research (Adapted from Yin 2006 cited in Gray 2018).

However, strategy adoption depends on the research question, purpose, and context (Venkatesh et al. 2013). In addition, every research should start with research questions rather than a position of epistemological purity and select the most appropriate strategy(ies) (Teddlie and Tashkkori 2009).

The explicit purposes of this study are three. Firstly, this study empirically investigates the relationship between EF and urbanization of Bangladesh. Secondly, the sustainability of urbanization of Bangladesh is measured by calculating the EF of NC. Finally, this study has developed a SUDF for Bangladesh. This research accumulates the relevant data and applies different data analysis techniques to achieve these objectives. This empirical, descriptive, explanatory, and predictive research involves collecting secondary and primary data with a survey and in-depth semi-structured interviews. The secondary data is mathematical or numerical, primary data were categorical and numerical, where individual beliefs and feelings were countable (to some extent), and the results were generalizable. As a result, this study adopts mixed research methods with equal emphasis on quantitative and qualitative parts.

3.4 Research Design

Research design is a framework for collecting and analysing evidence chosen to answer the research question(s). It also refers to the criteria for evaluating social research (Bryman 2016). In other words, research design can be considered a guide to the researchers for collecting, analysing, and interpreting observations (Frankfort and David 2008). Without doing so, researchers can neither collect data nor solve the problem under examination. Daunce and Cosenza (1996) also claim it is a road map for researchers.

Bryman (2016) covered five main research designs summarised in Table 3.2.

Table 3.2 Research design and research strategy (adapted from Bryman 2016).

Research design	Research strategy	
	Quantitative	Qualitative
Experimental	Typical form: Use quantitative comparisons between experimental and control groups concerning the dependent variable	No typical form, however, a study was found where qualitative data on schoolchildren were collected within a quasi-experimental research design.
Cross-sectional	Typical form: Survey research or structured observation on a sample at a single point in time. Content analysis on a sample of documents.	Typical form: Qualitative interviews or focus groups at a single time. Qualitative content analysis of a set of documents relating to a single period.
Longitudinal	Typical form: Survey research on a sample multiple times, as in panel and cohort studies.	Typical form: Ethnographic research for an extended period, qualitative interviewing on

Research design	Research strategy	
	Quantitative	Qualitative
	Content analysis of documents relating to different periods.	more than one occasion, or qualitative content analysis of documents relating to different periods. This type of research is termed longitudinal when there is a worry about mapping change.
Case study	Typical form: Survey research of a particular case to reveal prominent features about its nature	Typical form: Intensive study of a particular case like organization, life, family, or community, with ethnography or qualitative interview.
Comparative	Typical form: Survey research with a direct comparison between two or more cases, as in cross-cultural research.	Typical form: Qualitative interview or Ethnographic on two or more cases.

In addition, it is found that Robson (2002) proposes two kinds of research design: fixed and flexible. Fixed design refers to the design where data is prespecified and always numerically. It cannot be changed during the main data collection-hence this type is usually defined as a quantitative strategy. On the other hand, flexible design refers to no pre-specified data, usually non-numeric and evolved during data collection-hence called a qualitative strategy. Table 3.3 represents the details of this research design from where researchers can choose or combine different types.

Table 3.3 Fixed and flexible research design (Adapted from Robson 2002).

Fixed research design	Features
<p>Experimental strategy</p> <p>The researcher intentionally introduces changes in the participant's situation, circumstances, or experiences to observe the effect of these changes in their behaviour.</p>	<ul style="list-style-type: none"> • Samples are chosen from an unknown population • Different experimental conditions for the samples are applied • Planned changes are in one or more variables and control other variables • Usually carried out for hypothesis tests
<p>Non-experimental strategy</p> <p>The approach is the same as the experimental strategy; the only difference is that the researchers do not employ any changes in the situation.</p>	<ul style="list-style-type: none"> • Samples are chosen from a known population • Different experimental conditions for the samples are applied • Planned changes are in one or more variables and control other variables • Hypothesis testing may or may not be carried out
Flexible Research Design	Features
<p>Case Study</p> <p>Detail or intensive study of a particular case or a small number of related cases to reveal prominent features of its nature</p>	<ul style="list-style-type: none"> • Selecting a particular case or a small number of related cases • Data collection by several techniques viz observation, interview, documentary analysis • Context analysis of a case

<p>Ethnography studies</p> <p>This study refers to capturing, interpreting or explaining the lives of a group, organization or community, experiencing and making sense of their lives and world.</p>	<ul style="list-style-type: none"> • Group, organization, or a community selection • Researchers' impression in that setting • Using participant observation
<p>Grounded theory</p> <p>Generation of theory from collected data during research</p>	<ul style="list-style-type: none"> • Mainly interview based • Systematic but flexible research strategy and applicable to a wide range of phenomena • Delivers intensive prescriptions for data analysis and theory generation

Marshall and Rossman (2011) also noted a quadripartite classification of research that differentiates exploratory, descriptive, explanatory, and emancipatory research. These classifications depend on the objective of the investigation (Robson 2002, Sekaran and Bougie 2016), which are briefly described below.

Firstly, **exploratory research** tries to discover what is happening in a completely unknown phenomenon. It is observation and interview-based, provides pertinent information, seeks new insights, asks questions, and generates ideas. The most important feature of this research is that it develops a primary hypothesis for the researchers for future investigation (Purnomo 2014). Therefore, it is primarily a flexible research design.

Secondly, **descriptive research** provides an accurate profile of a person or situation. This research needs previous intensive knowledge of the phenomenon to answer questions about who, what, where and how (Purnomo 2014). Descriptive research, in principle, is not aiming at forming a hypothesis or development of theory, and objectivity or neutrality is the main characteristic of this research (Lans and van der Voordt 2002).

This research used observation and survey techniques to collect data. This research falls into a fixed research design.

Thirdly, **explanatory research** is done when there is little about phenomena, and no previous theories or ideas apply. This research does not merely describe the phenomena intended to explain (Maxwell 2013). This research can be flexible and or fixed research design.

Lastly, **emancipatory research** differs from traditional research in producing value-free knowledge and objectives. This research empowers social inquiry subjects, creates opportunities, and tries to engage in social action (Jupp 2006). This research can be a flexible research design.

Bryman (2016) suggests reliability, replication, and validity are the criteria for evaluating any research. Reliability is concerned with the consistency of measurement used for social science concepts and whether study results are repeatable (Bryman 2016). If it yields the same result repeatedly, the measure is considered reliable (Venkatesh et al. 2013). It is typically associated with quantitative research, called dependability in qualitative research. Without reliable measures, a quantitative study is deemed invalid (Straub et al. 2004).

Another important criterion for evaluating social research is replication and validity. Replication is remarkably close to the reliability and rare in the social sciences as the fundamental research needs to be duplicated. However, most researchers in social science do not elaborate on their detailed procedure. Without obtaining a detailed procedure, replication is impossible (Bryman 2016). Validity refers to the legitimacy of the findings, i.e., how accurately the research findings represent the truth of the real world (Venkatesh et al. 2013).

Therefore, the research design is an important stage of any research. Without a perfect research design, it is impossible to construct a framework for collecting and analysing data. A perfect research design directs the researcher to conduct research clearly and systematically. Any research design must answer the question of what kind of data should be gathered, how to gather it and how to analyse them. Based on the above discussion, this study deployed descriptive research conducted by non-experimental

and fixed research design. Because this study deals with the EF and urbanization of Bangladesh, collecting data from a known population, both primary and secondary data are used, and primary data is collected through a survey and in-depth semi-structured interviews.

3.5 Research Approaches

Saunders et al. (2016: 144) claim three main research approaches are deductive, inductive, and abductive (Table-3.4).

Table-3.4 Different types of approaches (adapted from Saunders et al. 2016)			
	Deduction	Induction	Abduction
<i>Logic</i>	Both Premises and conclusion are true	Known premises are used to generate untested conclusions	Known premises are used to generate testable conclusions
<i>Generalizability</i>	General to specific	Specific to the general	Interaction between specific and general and then generalizing
<i>Data uses</i>	Data are used to test hypotheses related to an existing theory	Data is used to creating a conceptual framework	Data are used to creating a conceptual framework and test this through subsequent data collection and so forth
<i>Theory</i>	Theory verification or falsification	Theory generation	Theory generation or modification

This study uses deductive research approaches to achieve this research's goal. Because sustainability is a well-established concept, it follows the modern interpretation of the second law of thermodynamics. This research starts with a very general idea of sustainability and then goes down with specific dimensions. The literature review reveals that strong sustainability analysis takes the environment more

seriously (Skene and Murray 2015; Wu and Wu 2012). This study takes an environmental-related indicator, i.e., EF, as a measure of sustainability. In addition, interview data were analysed based on four dimensions of sustainability.

3.6 Data and Methodology

This study employs mixed-method research comprising both quantitative and qualitative analysis. Firstly, this study empirically examined the relationship between EF and urbanization of Bangladesh by using secondary quantitative data from World Bank and GFN. Secondly, this study measures the EF of NC with primary data collected via a questionnaire survey. The calculated EF of the city is compared with the Bangladesh footprint and biocapacity measured by GFN. Moreover, as the study area comprises three regions, a comparison among the EF of these three regions was also carried out. In addition, 20 in-depth semi-structured interviews were also conducted to develop a SUDF for BD.

3.6.1 EF and Urbanization

To answer the research question of this study, i.e., “To what extent can we extend the ecological footprint analysis to draw inferences about the sustainability of urban development in Bangladesh? What are the policy implications of this?”

This study uses EFs as an indicator for urban sustainability. The rationale for using this indicator is that EF represents sustainability's environment and social dimension (Huang et al. 2015). If EF increases or decreases with the increase of urbanization, we may be able to conclude that the urban development of Bangladesh is unsustainable or sustainable, respectively.

EF can cover the broader impact of human activities on nature, especially soil, air and water (Al-Mulali and Ozturk 2015; Charfeddine and Mrabet 2017; Uddin et al. 2017; Solarinet et al. 2018; Danish et al. 2019). Nathaniel et al. (2019) use EF to study the relationship between urbanization, EF, and other variables in South Africa. Similarly, Solarin et al. (2021) for Nigeria, Hassan et al. (2019) for Pakistan, Wang and Dong (2019) for 14 Sub-Saharan Africa Countries, Al-Mulali and Ozturk (2015) for the Middle East and North African region, Al-mulali et al. (2016) for 58 developed and developing

countries, Solarin and Mulali (2018) for 20 countries, studied the relationship between these two along with other variables. To the best of my knowledge, no studies have been found whose examine the link between EF and urbanization of Bangladesh.

Proposed Model

To explore the effect of EF on urbanization of Bangladesh, this study uses The Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model. This model was developed by Dietz and Rosa (1994) and further explored by York and Rosa (2003), Rosa et al. (2004) and by Dietz et al. (2007). STIRPAT model is the reformulation of Ehrlich and Holdren (1971) I = PAT where the population (P), affluence (A) and technology (T) are the influencing factors of environment (I). The coefficients associated with influencing factors show elasticity because the model is a multiplicative function of population, income, and technology (York and Rosa 2003; Knight et al. 2013). Real GDP can proxy affluence, while urbanization can be utilized to proxy the demographic characteristics of a country. Technology represents all factors other than population and affluence (Suh 2009). In this backdrop, the model for this study is:

$$I_t = \gamma_0 P_t^{\beta_1} A_t^{\beta_2} T_t^{\beta_3} \mu_t$$

Where “*I*” capture the environmental factors, “*P*” is the population, “*A*” is the affluence, and “*T*” is the technology. The ‘ β ’s and ‘ μ ’ are the parameter estimates and the error term, respectively. EF captures environmental factors, GDP represents affluence, and Urbanization can be used as the proxy of the demographic variable “*P*”. GDP and T variables are included in the model as control variables.

The details of the model construction and data sources could be found in chapter four.

Estimation Strategy

The literature review found that different statistical tools were used for analysing the data. Some important of them but not limited to are Johansen Co-integration test, ARDL Bound Testing approach for co-integration, FMLOS, DOLS, Lagrange Multiplier Test of Breusch and Pegon (1980), Bootstrap Unit Root Test of Smith et al. (2004) Swamy's (1970) Slope Homogeneity Tests, Pedroni's (2000) Heterogeneous FMOLS Estimator, GMM, Durbin Wu-Hausman Test for endogeneity, Arellano-Bond GMM, Phillips and Perron (PP) Test, Vector Error Correction Modeling (VECM), Vector Autoregression (VAR), Pearson Correlation Analysis, Bayer and Hanck (2013) co-integration test, Ng and Perron's (2001) unit root test, kwiatkowski-Phillips-Schmidtshin (KPSS) unit root test, Coronical Co-Integrating Regression (CCR) and FMOLS technique to validate the long-run findings of ARDL, CUSUM (Cumulative Sum) and CUSUM sq (Cumulative Sum of Square), Dickey-fuller Generalized Least Squares (DG-GLS), Zivot and Andrew (2002) Structural Break Unit Root Test, Toda and Yamamoto (1995) (TY) procedure, Unit root test by Clements et al. (1998) two-break test, Gregory and Hansen (1996) Co-integration test to examine the robustness of long-run relationship, bounds testing approach complemented by Johansen-Juselius Maximum Likelihood Procedure in a Multivariate Framework. Among these tools this study uses the following tools:

Unit root tests

In applied econometrics, various unit root tests are available. These are ADF by Dickey and Fuller (1979); P-P by Phillips and Perron (1998); KPSS by Kwiatkowski et al. (1992), DF-GLS by Elliot et al. (1996) and Ng-Perron by Ng and Perron (2001). This study uses ADF, P-P, KPSS and DF-GLS tests.

Cointegration testing

The ARDL bound testing approach is used in this study to investigate the possible existence of cointegration among the variables, whether they possess long-run equilibrium relationships, and exert both the long-run and short-run dynamics.

Stability Test of the Model

Recursive CUSUM and CUSUM squares (Brown et al. 1975) for stability and the Ramsey RESET test were conducted to identify the functional misspecification.

Causality test

This study conducted a causality test following the Toda-Yamamoto (1995) procedure. Because TY-procedure can be applied to any arbitrary level of integration (Soytas et al. 2007), it also considers vector autoregression (VAR) in levels. Hence there is no chance for the loss of information due to differencing. This procedure also can capture the feedback effects through several lags; thus, pre-testing the series' co-integration properties is unnecessary (Peng and Sun 2010; Zapata and Ramboldi 2010).

3.6.2 EF of NC and SUDF for Bangladesh

3.6.2.1 Primary Data collection

3.6.2.1.1 Preparations

Place and participants are the two essential things to consider while conducting research. In other words, firstly, the researchers must have a clear idea about the institutions/population to be investigated and, secondly, the community's motive for whether they will accept the research (Goldthorpe et al. 1968). The fieldwork (household survey) of this research was conducted in NC. As this study is empirical, descriptive and predictive, it involves collecting primary and secondary data. Firstly, secondary data from World Bank and GFN were collected. Secondly, primary data were collected through household survey and in-depth semi-structured interviews. The interviews were conducted to develop a SUDF for BD with key informants, including subject matter experts from academia, high-level policy officials, NGOs, independent research organizations and Volunteer organizations.

Survey Questionnaire

Bryman (2016) argued that fieldwork planning could begin once the research questions have been developed. Accordingly, after finalizing the research questions, a decision was taken to conduct a household survey in NC.

Bryman (2016) also suggested that the survey developer needs to ensure that the targeted population is appropriately managed and suited for investigation with research instruments. Research instruments mean something like a self-administered questionnaire or structured interview. The study area is well-known, and the people of this city are very supportive of face-to-face interviews. As a result, face-to-face interviews were conducted to collect information (cross-sectional study) with a survey questionnaire. The survey questionnaire (Appendix-1) was developed through an extensive literature review.

One of this study's objectives is to explore the sustainability of an urban area of Bangladesh with EF. There are **three methods** for calculating EF- synthetic method, input-output analysis method and bottom-up component approach. The first one is the Synthetic **method** proposed by Wackernagel et al. (1999), and it can be applied at the national, regional and global levels. The second method is an input-output analysis of Bicknell et al. (1998). It calculates the flow, outflow, and ultimate demand of EF with the input-output model. The third method is the Bottom-up **Component approach proposed** by Simmons and Chamber (1998) and Simons et al. (2000), where EF is calculated using data on resident consumption collected by a questionnaire survey.

Furthermore, it is revealed that most city-level sustainability analyses with EF and BC employed a top-down approach with different models. Babou et al. (2017) claimed that the top-down approach allows for city and national results comparisons and minimizes extensive local data collection time. However, data availability is one of the most important criteria for employing this approach. Even in the UK, complete data is not available to employ a top-down approach (Simmons et al. 2000). Moreover, there would be a chance of information loss and evaluation of local policies may be more difficult for not using the local data (Aall and Norland 2005; Wilson and Grant 2009).

Therefore, this study adopts a component-based bottom-up approach to measure the EF of NC, which is this city's first-ever study. As discussed in the literature review this study uses online calculator to measure the EF of NC. This online calculator need local level household consumption data. Due to the unavailability of local household consumption data, this study takes the initiative to collect primary data through a questionnaire survey. Punch (2003) argued that where possible prefer to use already

existing instruments, in whole or part, to develop your instrument. Moreover, Saunders et al. (2016) argued that questions could be developed by 1) adopting questions used in other questionnaires, 2) adapting questions used in other questionnaires, and 3) developing their questions. I have developed my questionnaire by adopting questions from the questionnaire of Anand (2001), GFN, Khan and Uddin (2018) and Solaiman (2019).

The questionnaire (Appendix-1) has 42 questions divided into four parts. The first part of the questionnaire has eight demographic questions about the households, such as gender, age, religion, occupation, education, income level, household size, and accommodation type.

In part B, respondents were asked to answer questions about their dietary habits. In part C of the questionnaire, respondents were asked to choose options for their energy use behaviour related to housing. Besides, respondents were asked about their attitudes toward household waste management. Part D is related to energy use in their mobility.

Due to covid-19 pandemic, there were travel restrictions and the issue of quarantine in both countries, i.e., Bangladesh and the UK. As a result, a decision was taken to conduct the household survey by employing two local well-versed enumerators with the approval of the UoB research ethical committee. Moreover, local government authorities' permission was also collected (Appendix-2). It was hard to get permission to pursue it from abroad. I applied for permission on 3rd February/2022 (Appendix-3). After continuous contact, I got permission on 23rd February/2022 (Appendix-2).

While waiting for permission, I have advertised on social media to appoint two experienced enumerators, requesting to drop their curriculum vitae (CV) via a newly created email address named nccsurvey2022@gmail.com. Accordingly, 13 CVs were found. After reviewing their CV, only four applicants were selected for the interview. After the interview, they were requested to conduct a demo survey with the survey questionnaire. Finally, among four applicants, two were selected. They were fully briefed about Covid risks and protocols and were instructed to follow the Government of Bangladesh public health guidelines. With their help, a pilot survey of 20 respondents

was conducted to check the data's reliability. Following the feedback from the pilot survey, the preliminary questionnaire was revised, and the final survey was conducted with the revised questionnaire.

In-depth Semi-structured interview

In qualitative research, interviews are different from daily face-to-face conversations. It mainly focused on the researcher's desire to gather data. Maintaining reliability and validity in the context would be a central issue for conducting interviews. Despite this, it is one of the most popular methods of generating data (Patton 2002).

There are a few guidelines concerning the qualitative aspect of interviews. Saunders et al. (2016) claim that a minimum of 5-25 semi-structured/in-depth interviews is enough for a general study for analysis. As a result, the target of this study was to conduct twenty interviews.

Due to COVID-19 pandemic, thirty potential interviewees were contacted via email/phone. As the one of the objectives of this research was to develop SUDF with policy direction, the interviewee was selected on the basis of their experience in urban studies and also in the policy formulation process. Primary target was to select equal number of participants from academic, government officials, NGOs, local government officials, environmental activities and journalists. To do this mixture of technique were applied. For instance, firstly, I have found some literature where scholars expressed their views about the urban sustainability. I contacted with them and asked them to provide the name of another scholar in this field. Secondly, there are some dedicated urban research centres in Bangladesh, for instance Centre of Urban Studies, Urban Development Directorate, Bangladesh Institute of Planners. I have contacted the head of the organization. Sometimes, they themselves wished to give interviewee or some cases the nominated relevant person to be interviewed. For the selection of NGO representatives, I have applied snowball techniques. A snowballing method which is considered more suitable for respondents who are difficult to reach (Atkinson & Flint 2001). Fourthly, there are some dedicated departments for urban studies in some universities of Bangladesh, for instance University of Khulna, Rajshahi, BUET, Jahangir Nagar University. Besides other educational universities, I have specially selected Rajshahi and Khulna University to get the view from those city perspective. This offers

me the opportunity to get a complete picture of all major cities in Bangladesh. For environmental activities and environmental journalist, I have contacted Bangladesh Poribesh Andolon (BAPA) and Environment Reporters Forum Bangladesh. However, I did not get any response from them. To minimize their, gap I have contacted a volunteer organisation named Volunteer Opportunities. The head of operations kindly consents to participate in my interviewee. Finally, I was able to interview twenty-six respected interviewees.

Overall, it took more than seven days to get a response after repeated contact. Notably, it took over one and a half months to get the appointment of the Hon'ble state minister of Planning. After getting initial consent from twenty-six interviewees, the questionnaire was shared with a standard consent form. Afterwards, a suitable time was fixed for taking the interview using zoom/phone (whichever is suitable). Due to the time difference and the busy schedule of the honourable participants, fixing the time was challenging. Another challenge was the selection of public sector officials in the Bangladeshi bureaucracy and government structure. Because officials are frequently transferred from one sector to another, a mismatch of expertise is common. However, as a senior civil servant in Bangladesh, I had a good connection with some relevant experienced officers and could utilize my connectivity properly.

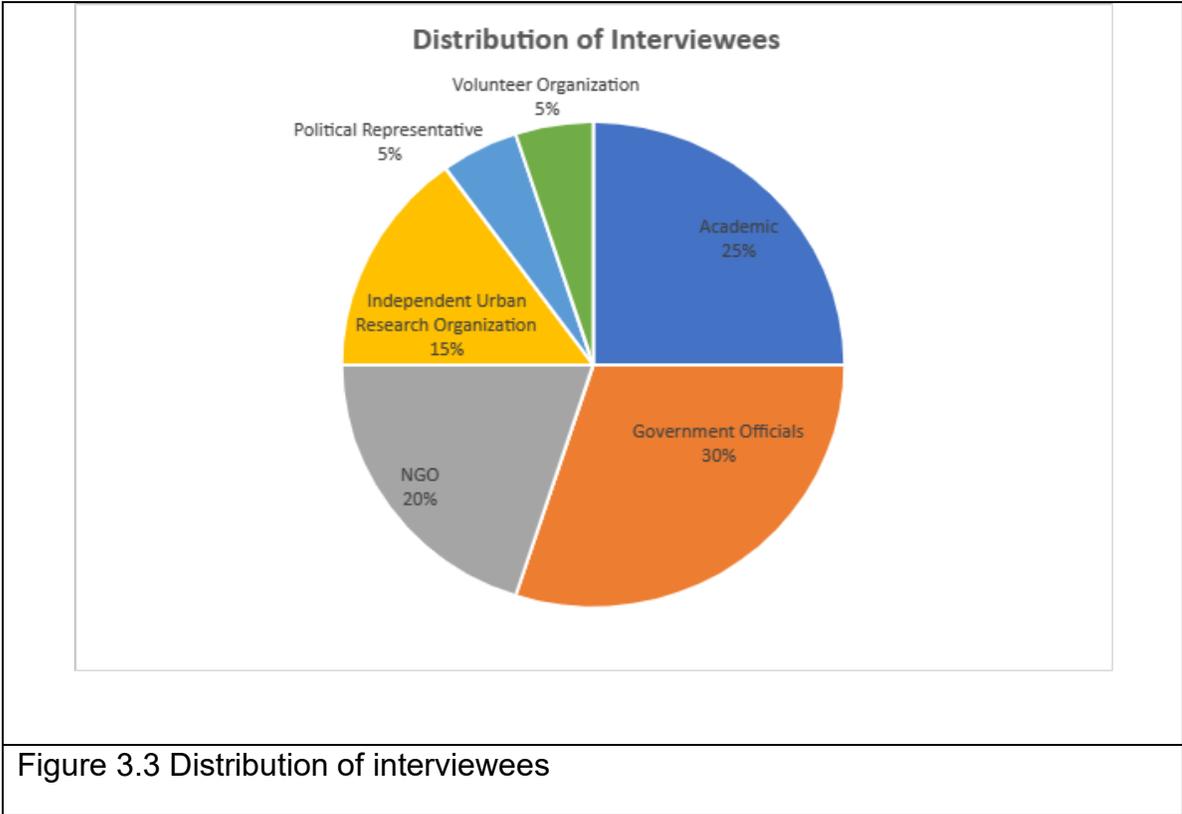
This study deploys in-depth semi-structured interviews for a complete understanding of sustainable urban development from different stakeholders to develop a SUDF for Bangladesh. A major purpose of the interview was to extract knowledge from experiences. As a result, the interviewees were not restricted or guided in their answers and comments. Instead, they were asked to express their views and opinions about the present challenges of urbanization, the effect of present food consumption habits of urban dwellers, household energy uses, future transport system uses prospects and their view about a sustainable city (Appendix-4). Though twenty-six interviews were conducted, twenty were finally selected as no new information was found from the other six interviews. For referential purposes and to protect their anonymity, the twenty interviewees were coded as follows (Table 3.5):

Table 3.5 Interviewees and their subsequent codes

S. N.	Category	Code	Description
1.	Academic	A1	Professor, Professional Experience (Exp): 20 Years, Jahangir Nagar University.
2.		A2	Professor, Professional Exp. 19 Years, Khulna University.
3.		A3	Professor, Professional Exp. 19 Years, Rajshahi University.
4.		A4	Professor, Professional Exp. 22 Years, BUET.
5.		A5	Professor, Professional Exp. 19 Years, BUET.
6.	Government Officials	G1	His Excellency, Ambassador of Germany, Ex, Senior Secretary, Ministry of Industries, Professional Exp. 40 Years (10 Years as Senior Policy Leader).
7.		G2	Town Planner, RAJUK. Professional Experience: 17 Years.
8.		G3	Deputy Director (Planning), Directorate of Environment, BD, Professional Exp. 14 Years.
9.		G4	Additional Secretary, MoEF&CC. Professional Experience: 3 Years at this Ministry.
10.		G5	Director, Urban Development Directorate, Professional Exp. 30 Years.
11.		G6	Town Planner, Rajshahi Dev. Authority, Professional Exp. 21 Years.
12.	NGO	N1	Manager, Action AID, BD, Professional Exp. 16 Years.

S. N.	Category	Code	Description
13.		N2	Manager, Action AID, BD, Professional Exp. 15 Years.
14.		N3	Programme Manager, BRAC, Professional Experience: 18 Years (6 Years in Urban Planning).
15.		N4	UNDP Bangladesh Official, Professional Exp. 18 Years in Project Planning.
16.	Independent Research	I1	Int. Consultant, Ministry of Housing and Public Works. Professional Exp. 40 Years.
17.	Organization	I2	Chairman, Centre for Urban Studies, BD. Professional Exp. 58 Years.
18.		I3	President, Bangladesh Institute of Planning, Professional Exp. 19 Years.
19.	Volunteer Organization	V1	Head of Operation, Volunteer Opportunities
20.	Political Leader	P1	Hon'ble State Minister for Planning Professional Exp. 47 Years (15 Years in Planning).

Figure 3.3 represents the distribution of interviewees from different organizations. Though primary target was to take equal number of participants from each sector, due to unresponsive, it was not possible. However, if I was in Bangladesh, it would be possible. In spite of this, it is noticeable that the highest percentage (30%) of participants are government officials, which is very inspiring. Because in Bangladeshi culture, government officials usually try to avoid this kind of interview. The following highest percentage is academic (25%), followed by NGOs (20%), independent urban research organizations (15%), and political and volunteer organizations 5% each.



3.6.2.1.2 Fieldwork and Survey Design

The fieldwork of this research was designed to conduct the household survey and in-depth semi-structured interviews. The framework for the fieldwork is presented in Figure 3.4.

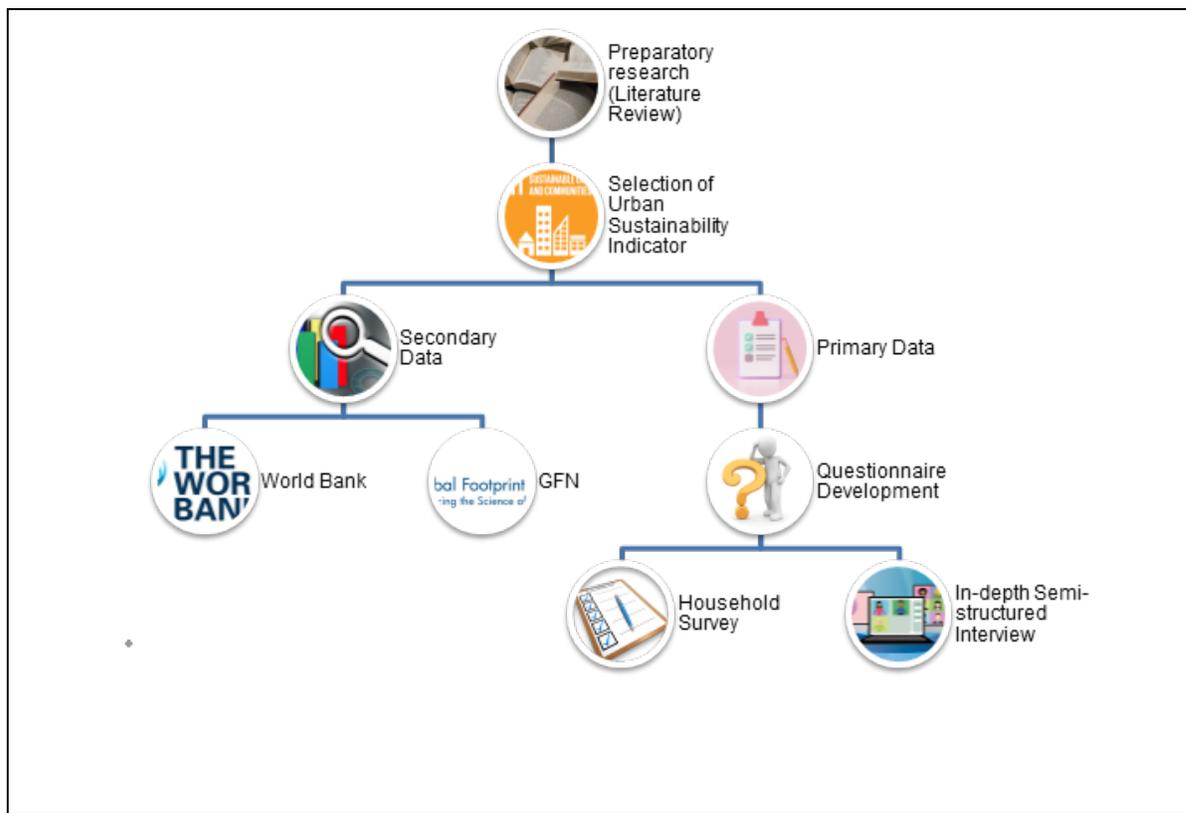


Figure 3.4 Data collection strategy

Household Survey

According to Punch (2003), the logic of surveys is to collect information from some group of people-or sample- to answer research questions. This small group of people or sample represents a larger group, technically called a population. As a result, the sample design for a survey is an important issue. In this regard, Foreman (1991, p.179) argued that:

“-----the term sample design refers to the process by which decisions on a sample plan are reached, together with any incidental research, analysis and calculations. The essential decisions include the sample units to adopt, the sample selection method, the frame to use, the size, stratification, allocation and clustering of the sample, the sample estimation procedure and if required, the procedures for evaluating sample and non-sample errors to which needed sample estimates may be subject.”

As a result, during data collection, researchers need to consider several things. For instance, matters related to sample selection (how to select a sample) and sample size (how many to select) (Anand 2001).

Sample Selection Method

While conducting survey research, sample selection is a fundamental issue. Because our populations vary in terms of attitudes and behaviours. Usually, we do not get a homogenous element in our population. Therefore, the first and foremost criterion of sampling is to fulfil the condition of giving equal opportunity to each element in the population (Frankel 1983). It is an obligation that the sample must be representative of the entire population (Nardi 2018). To do so, probability sampling is done. Nardi (2018) claimed that the most common types of sampling include:

- Simple random sampling
- Stratified random sampling
- Systematic random sampling
- Cluster or multistage sampling

Rashid et al. (2018) utilized simple random sampling techniques to measure the EF of two urban areas, Bahria Town and Gulraiz Colony of Rawalpindi, Pakistan. Anand (2001) used multi-stage cluster samples to study the water supply and waste management in Madras (Chennai), India; Lee (2019) employed stratified random sampling to study the vulnerability and EF of urban Taipei and rural Yunlin, Taiwan; Khan and Uddin (2018) used random sampling procedure to study the household level consumption and ecological stress in an urban area of Bangladesh.

Following Anand (2001), I have decided to use multistage cluster sampling because this technique involves drawing several samples to minimize the cost of the final interview (De Vaus 2014).

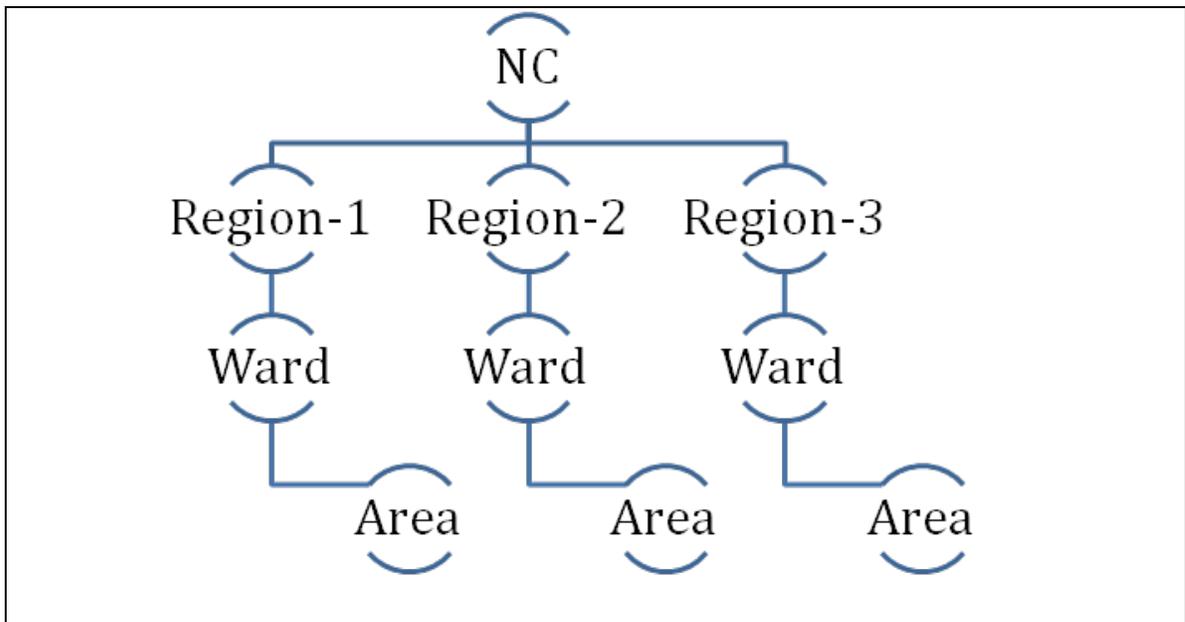


Figure 3.5 Multi-stage cluster sampling of NC

Figure 3.5 illustrates the clustering stages. NC is divided into three regions with 27 wards (small administrative units). The regions were considered as the first stage cluster. And then, the regions' wards were considered second-stage clusters. Finally, NC authorities have a list of areas included in each ward. From this list, a binary number was allocated for each area, and the survey's final unit was selected using simple random sampling (SRS).

In the selected area, two binary number for the two roadsides of the area was allocated. For instance, 01 and 010 for the left- and right-hand side of the road, respectively. If '01' is randomly assigned, the survey starts from the left side of the road. Then the number of houses on that side was counted and assigned another binary number for each house. The survey started from a house randomly selected from the allocated binary numbers. Depending on the number of houses, a gap of two or three houses was followed to reach the survey household. If no one lived in the selected house or it was uninhabited or used for a small shop/business, the next house was selected by following the nearest neighbour principle. This principle was followed by keeping in mind that the characteristics of the neighbour house should be the same. For instance, if a non-response was from a middle-income household, a similar household was chosen as a substitute.

The rationale for Sample Size

According to the latest census of Bangladesh Bureau of Statistics/2011, the total population of NC is 709,381. Sample size depends on the method of sample selection, expected error, and what inferences from sample data are planned to be applied to population data. There is no such thing as a correct sample size. My study is descriptive, and sampling aims to get a broad representation of the population of Narayanganj. There are 27 wards with a population size of 6812 (smallest) and 47079 (largest). However, Narayanganj city corporation claims its population is over 2 million (NCC 2022). As a result, I have fixed a target sample size of 500 (excluding the non-response rate).

In many household surveys, there tends to be a non-response of 10-40%. For any research, a 100 per cent response rate is unlikely; hence, the sample must be larger (Saunders et al. 2016). Hence, I aim to cover 600 to 650 households expecting a non-response rate of up to 20%, giving me a final sample of around 500. However, I finally I have got 498 valid respondents.

EF analysis is conducted at the city level, not the ward level. A much bigger sample size is needed to conduct this at the ward level. An alternative approach was considered to select up to 6 wards out of 27 wards and use a sample of up to 50 households from each of the selected wards. However, I favored drawing samples from all 27 wards and conducting EF analysis at the city level only. Moreover, during my consultations with NC Corporation officials, we agreed that conducting the survey covering all city wards would be feasible. The logic of the city officials was that it is a small city with some differences among the different regions of the city. As a result, I finally decided to survey the whole city area, which gave a complete picture of the city. Accordingly, the target respondents were distributed to all wards in the city in proportion to the population (Table 3.6).

Table 3.6 Distribution of sample in NC			
	Ward No.	Total Population	No. Respondents
Region-1 (Siddirganj Region)	1	36592	26
	2	25585	18
	3	35947	25
	4	23385	16
	5	18421	13
	6	25100	18
	7	21888	15
	8	42704	30
	9	27138	19
Sub-total		256760	181
Region-2 (Narayangan j Region)	10	20489	14
	11	24550	17
	12	40187	28
	13	47079	33
	14	29431	21
	15	24096	17
	16	34496	24
	17	35518	25
	18	30484	21
Sub-total		286330	202
Region-3 (Kadam Rasul Region)	19	11822	8
	20	17694	12
	21	22176	16
	22	30728	22
	23	30572	22
	24	20358	14
	25	12636	9
	26	6812	5
	27	13543	10
Sub-total		166341	117
Total		709431	500

Table 3.6 represents that the highest number of respondents were in region-2 (202), followed by region-1 (181) and region-3 (117).

3.7 Ethics Approval and Compliance

This research was carefully implemented the ethical considerations while conducting the survey and in-depth semi-structured interviews. Because in any research, respondents have a right to get a clear idea and ethical information about the research (Silverman 2013, Shore 2007). Accordingly, detailed information about the nature of the research, probable outcome, and their right was shared with the participants.

Before conducting the survey and interview, an application was submitted to Humanities, Social and Health Sciences Research Ethics Panel at the University of Bradford. After scrutinizing everything, ethics approval was granted on 02/12/21 (Ethics Approval Number: EC 26848). A copy of the approval is attached in Appendix-5.

Moreover, as it is academic research, I did not provide any direct benefit such as incentives or gifts to the respondents. Luckily, I have received strong support from them. The interviewee freely expressed their idea and thoughts. It was noticeable that all respondents have their interests and priorities, which might not be similar to the researchers. All efforts to avoid and minimise disruption in their personal lives have been taken. Questions that might make them stressed or depressed were not asked (Robson 2011).

All the survey questions were translated into local languages (Bengali) for their easy understanding. Before approaching the questionnaire and semi-structured interview, a consent letter (Appendix-6) was handed over to the potential participants. Additionally, for the questionnaire survey, on my behalf, the two field enumerators introduced me as a PhD researcher at the University of Bradford and presented a letter of introduction from my supervisor (Appendix-1). Then, the reasons for the study were explained. The importance of the research was also highlighted. Every effort was made to conduct this research ethically, and respondents willingly consented.

The enumerators approached the survey participants, and the first step was to explain the purpose of the study. If they were unwilling to participate, the survey was

terminated, and the enumerator moved on to another similar household in the street by following the 'nearest neighbour' principle. After the survey, the participants were given three days to contact if they wished to withdraw, and then any data collected from them were discarded. Participants received response confirmation that their records had been deleted. Fortunately, I did not get any request to withdraw the participation.

The in-depth semi-structured interview participants were contacted in advance, and an interview consent form and study details were sent. If they consented, the next step was to set up the interview via Zoom, WhatsApp, or another platform. The interview participants were given two days to consider. After the interview, a scope of withdrawal was also given within up to seven days.

Participation was not offered financial/in-kind payments, as it is voluntary. Only the interview part of this study was recorded with the full consent of the participants. The video and audio were recorded on my laptop and phone with a screen lock. After the interview, the files were stored on a highly secured University of Bradford one drive.

3.8 Data Analysis

The researcher must apply an appropriate analytical method to get accurate results from the data. As a result, data should be analysed from different perspectives. Consequently, in this research, data were analysed in several ways.

Both survey and in-depth semi-structured interviews have generated a substantial amount of data. The survey data were analysed by SPSS 28 version, whereas interview data were manually analysed by following the principle of theoretical thematic analysis of Braun and Clarke (2013).

3.8.1 Quantitative Data Analysis

The national level secondary data collected from the World Bank and GFN were analysed using EVIEWS and Microfit-5.5. From the survey, both numerical and categorical data were collected. Categorical data were coded with a unique number. Both numerical and categorical data were then analysed using the statistical software SPSS version 28. Initially, the demographic information was analysed with basic statistical analysis techniques, such as frequency, mean and mode. In the second

stage, the information for EF measurement was uploaded to the EF calculator of GFN to get the EF of every respondent. This EF calculator then generates 12 data for each respondent (one for total EF, six for the sub-component of EF as land type and five for the sub-component of EF as consumption type). In the second stage, this vast amount of data was analysed to get the total EF of NC. The comparative analysis of EF of NC was conducted in the third stage. At the final stage, the major driving force of the EF of NC was identified by applying cross-tabulation tests, correlation and regression analysis.

3.8.2 Qualitative Data Analysis

King and Horrocks (2010) claimed that qualitative data analysis usually varies based on approaches. For instance, the approach firmly focussed on language is generally located within the social constructionist tradition and includes varieties of discourse and narrative analysis. It focuses more on how language is used to achieve specific goals in social interaction or to create a story that understands aspects of the life of the tellers for a particular audience.

On the other hand, understanding the participants' lived experiences from their contextual or realist philosophical positions includes phenomenological approaches, grounded theory and most qualitative or mixed-method case studies (ibid). I have used experience-focused mixed methods case studies in this research by following theoretical thematic analysis (TA).

Braun and Clarke (2013) opined that thematic analysis is flexible, reflective and suitable for qualitative data sets like interviews. It is flexible because it allows similarities and differences of opinions and views of different participants. Reflective because it reflects the experience and expertise of the respondents. Except for language practice questions, it can be used to answer any question. A deep theoretical construct is also not needed to apply this technique. It is suitable for a new researcher to learn extensive data handling and coding skills.

Braun and Clarke (2013) also presented four types of TA analysis I) inductive TA, ii) theoretical TA, iii) experiential TA and iv) Constructionist TA. Among these types, theoretical TA is guided by an existing theory and theoretical concepts (as well as by

the researcher's standpoint, disciplinary knowledge and epistemology). This research follows theoretical TA, where themes were chosen from well-established four dimensions of sustainable development concepts: social, economic, environmental, and institutions. The subthemes evolved from interviews were discussed based on interviewees' opinions and relevant literature. These subthemes were then assigned to different dimensions of sustainability by following United Nations Sustainable Development Goals-11 (SDG-11) and Shen et al. (2011).

All interviews were video/audio recorded. All Bangla recordings were then translated into English word for word (verbatim) (King and Horrocks 2010). To organize the data, all the information the interviewees provided was manually coded (Appendix-7). The emerging sub-themes were then assigned under different dimensions of sustainability.

3.9 Generalization

Polit and Beck (2010) argued that generalization is an act of reasoning to conclude unobserved things based on observed things. It helps the researcher to confirm their general findings (Rowley 2002). As a result, careful attention is needed to generalize a finding from qualitative and quantitative research. However, it is often ignored by both groups of researchers (Polit and Beck 2010).

The above fact of generalization means it creates a robust research foundation so that the research findings are accurate and can be replicable. Polit and Beck (2010) also argued that in quantitative research, generalization is widespread and considered a major tool for evaluating the research. However, qualitative researchers do not all agree about the importance of generalization. It is also very complicated. One reason for this is that qualitative research always tries to contextualize human experience through an intensive study of cases.

There are also some challenges in generalizability in both quantitative and qualitative research. For instance, one challenge is extrapolation. Guba (1978) and Erlandson et al. (1993) argued that extrapolation could never be fully justified. Because it is always embedded in a context. Another challenge is the non-uniqueness of qualitative research findings. Some researchers believe the higher-level concepts or theories from

qualitative research are not unique to a particular setting or participant (Glaser 2002; Misco 2007). However, Ayres et al. (2003: p.811) argued that:

“Just as with statistical analysis, the end product of qualitative analysis is a generalization, regardless of the language used to describe it.”

Therefore, it can be said that generalization is an issue of great importance in both forms of research, whether quantitative or qualitative. In this regard, Firestone (1993) proposed three models for generalisation- i) statistical generalization, ii) analytic generalisation and iii) case-to-case translation (transferability). The first model deals with quantitative studies; the other two are relevant to qualitative research (Schwandt 1997).

Polit and Beck (2010) proposed different strategies to enhance the generalization of research. For example, they proposed a) replication in sample, b) replication of studies, c) integration of evidence, d) thinking conceptually and reflexively, e) knowing thy data, f) thick description, g) mixed methods research, h) pragmatic trials and RE-AIM framework.

I have applied mixed methods research in this research, which involves collecting, analysing and integrating qualitative and quantitative data. In my interview, the representative of governments, academics who works in different cities of BD, and views of the representatives of NGOs, independent research organizations, voluntary organisations, top-level policy formulator, and political leader were collected. The survey was conducted by applying the multistage clustering approach, where data were collected from the whole city, representing people from all walks of life. So collected data were analysed in an integratory way. I have also collected secondary data from World Bank and GFN. Therefore, the result of this research represents a detailed and diverse description of information from different types of data. The research findings and developed SUDF could apply to all the major cities of Bangladesh or other developing countries.

3.10 COVID-19 Risk Analysis of the Research

The COVID-19 pandemic has caused the biggest disruption ever since world war–2 (Howarth et al. 2020). It has created some changes in human behavioral patterns, which are challenges for conducting research with primary data collection, especially which have to deal with individual respondents. The world has faced an unbelievable and unprecedented situation of Public Health as well as an economic crisis. By considering the COVID-19 pandemic in Bangladesh, this research took the following measures to overcome the potential risk of primary data collection:

Table 3.7 COVID-19 pandemic risk analysis of the research
Risk 1. Covid-19 pandemic conditions continue to affect the survey
Overcoming measure: Like every country in the world, it was complicated to predict the COVID-19 pandemic situation in Bangladesh. However, during the data collection period (February/2022 to March/2022), it was assumed that the situation of the COVID-19 pandemic would be improved because the Government of Bangladesh was taking the initiative of a mass vaccination program which significantly decreased the infection rate. There was also a sign of improvement: Bangladesh started the mass COVID-19 vaccination program on 8 th February 2020. Though this program faced a sudden halt due to the vaccine shortage, the Government was able to collect vaccines from different sources apart from previous single sources. It was noted that as of 8 July/2021, more than 10.2 million people had received at least one dose of vaccine. It was also expected that more than 100 million doses of vaccines would be available in Bangladesh by December/2021. With these vaccines, 50 million (44% of people between the age of 15 to 64, as of WDI 2020) will be fully vaccinated (Ittefaq 3 July 2021). Therefore, it was assumed that during data collection, the situation of Covid-19 would be improved, and it would not affect the fieldwork. Moreover, extra precautionary measures, e.g. frequent hand

sanitizing, maintaining social distancing, and using multiple masks, were also taken beside the government guidelines.

Risk 2. Get fewer responses than planned

Overcoming measure:

According to the latest census of Bangladesh Bureau of Statistics/2011, the total number of populations of NC is 709,381. However, because of the lapse in time since the last census was conducted, I assume that the total population will be more than 709,381. NC authority also claims that the present population is two million. Moreover, for any research, a 100 per cent response rate is unlikely; hence, the sample will need to be larger (Saunders et al. 2016). Israel (2009) also claims that if the total population is more than 100,000 sample size should be 400 at a 95% confidence level and $P=0.5$ (maximum variance). As a result, in dealing with this potential non-representativeness of the sample, I have fixed the sample size of 500. Considering the average household size (4.11) of NC (BBS 2019), this sample represents 2055 people.

All the necessary initiatives were taken to collect the targeted data. I have a few benefits for conducting the survey. For instance

- a. As a member of Bangladesh Civil Servant, I have a connection with NCC's Chief executive officer (CEO). He is also a government representative. As a result, gaining permission from the local authority was easy.
- b. NC was the hometown of the data enumerators and had relations with the local people. As a result, there was no problem with accommodation, and they could also use the benefit from being local people.
- c. To ensure a high response and clarification of the survey questionnaire (if needed), face-to-face interview was conducted following the COVID-19 pandemic guideline of the government.
- d. The respondents were selected with a multi-stage cluster sampling technique from all wards of NC.

Risk 3. Getting a high-quality interview more than anticipated

My target is to conduct 20 interviews, and interviewees were chosen from different occupational sectors of Bangladesh. Subject matter experts from academia, high-level policy officials, experts from NGOs, and independent research organizations were selected. As mentioned earlier, as a member of Bangladesh civil servants and alumni of countries' highest rank public universities, the researchers benefited from positive responses from the probable interviewees. Due to covid-19 pandemic, all the interviews were taken online. This method of interview is widely accepted (Janghorban et al. 2014, Barratt and Maddox 2016). The researcher was highly optimistic that high-quality data would emerge from the interviews. The plan B of this research was, ' If I have failed to collect the required survey data, the interview data will be the main part of the analyses.' Therefore, it can be claimed that this research would not be affected much more for not getting the required survey data.

Saunders et al. (2016) claim that for a general study, semi-structured/in-depth interviews minimum sample size should be 5-25. All out efforts were taken to achieve the targeted 20 interviews. However, my plan c was that If I have failed to achieve this target, at least ten interviews must be conducted.

Risk 4. Some new developments are taking place in NC that I did not previously think of.

Overcoming Measure:

Usually, some unexpected things might arise during the data collection. Some of them and their management measures are set out below:

- i. Bangladesh now often experiences sudden weather changes problem. In winter, the weather can become highly foggy and sudden heavy rainfall, leading to unnatural working conditions. In any unfavourable or extreme weather condition, it is always advisable to avoid any journey. As the research area was the hometown of the researcher and two local enumerators were employed to conduct the survey, there was no need to

travel. On the other hand, due to the Covid-19 pandemic, group work or crowd gathering was also avoided. Nonetheless, social distance and hygienic measurements were taken (e.g., masks, hand gloves and using hand sanitization) during data collection.

- ii. Bangladesh is a risk country for political violence and civil unrest. Especially local political leaders might cause trouble or bargain when they see new people in their areas. However, since the coronavirus infection came out, there has been no political unrest or clash. The public gathering has been banned until the following announcement. Moreover, as a home researcher, there would be no problem with a stranger. In addition, formal permission for conducting the survey was also collected from the NCC (Appendix-2). As a result, no unexpected incidence happened.
- iii. Majority of Bangladeshi highly follow religious values and local norms. Any potential threat to local people's religion or belief is perilous and non-conventional. As a result, any sensitive issue like hurting anyone's religious belief or cultural clashes was avoided. The research strictly respected the local community and local practices. The research function was to remain neutral and non-biased.

3. 11 Summary

Various aspects of this research, starting with research strategies followed by research design and research approaches, have been discussed in this chapter. A detailed discussion about field work for primary data collection was also presented. A multistage cluster sampling method was used to conduct the survey in NC.

This chapter also explained the research philosophy as well as details of data analysis. While epistemologically this research took positivism, and ontologically objectivism stands, it also includes normative and subjective dimensions or aspects with a mixed-method research strategy. Regarding research design, this chapter justifies deploying descriptive research conducted by a non-experimental and fixed research design by following a deductive research approach.

This chapter also illustrated the quantitative and qualitative data analysis techniques. Equal emphasis was given to both data analyses. Quantitative data were used to study the relationship between EF and urbanization, and to measure the EF of NC. Major driving forces of EF were also identified by using the qualitative data of the survey questionnaire. Qualitative data were also collected through in-depth semi-structured interviews. This data was analyzed using theoretical thematic analysis to develop SUDF for Bangladesh. Ethical consideration was also explained clearly.

Furthermore, this chapter explains the COVID-19 risk management system for this research. One major limitation of the data collection was that I could not present in the field for the uncertainty of COVID-19 restrictions. However, the survey was conducted by two experienced data enumerators. They were also asked to take pictures of the respondents with their consent. During data collection, I also made some sudden video calls to observe the scenario. The complete questionnaires for each day were sent to me via email (nccsurvey2022@gmail.com), which was opened only for this survey. This was done to minimize the alteration of the answer to the questions. I also contacted some randomly selected respondents over phone to cross-check the authenticity of the data. If any mismatch was found, the enumerators were asked to retake the responses. Another limitation is that interviews of local government division officials and mayors of any city corporation were not possible. This might not have happened if I had been able to move. However, as a proxy of their view, RAJUK and RDA (Rajshahi Development Authority) representatives were interviewed.

The following three chapters will detail the findings of applying this research methodology, including results and discussion concerning the relevant literature. This will give the study scope for the generalization of the findings.

Chapter Four

Ecological Footprint and Urbanization in Bangladesh

4.1 Introduction

Most social and economic activities are concentrated in urban areas (Mori and Christodoulou 2012) which are considered a country's economic growth centre. Cities account for about half of the GNP in low-income countries, more than 70% in middle-income countries and more than 80% in high-income countries. So, more urbanization leads to higher national income, and more people move to urban areas (Arfanuzzaman and Dahiya 2019).

This growing trend of urban population is usually known as the process of urbanization. This also increases the conflict between urban development and the environment (Zhang et al. 2015). Over the past few decades' urbanization has led to natural resource depletion and environmental degradation (Breheny 1992; Jenks et al. 1996; Haughton 1999; Williams et al. 2000). Poverty and social inequality (Calthorpe et al. 2001; Duany et al. 2001), local climate change (Berke 2008), greenhouse gas emission (Camagni et al. 1998) and biodiversity decline (Vitousek et al. 1997) are also found as critical issues for rapid urbanization. These impacts of urbanization are expected to vary from country to country. Particularly for Bangladesh, the indiscriminate industrialization in the surrounding area of the capital city of Dhaka and the port city of Chattagram causes unplanned urbanization and substantial environmental degradation (Rahman and Kashem 2017).

Following the detailed discussion in the literature review, it is pretty reasonable to assume that EF can capture the impacts of the rapid urbanization of Bangladesh on its environment. Recently, the nexus between EF and urbanization has attracted the attention of many researchers worldwide. Bangladesh have also experienced rapid urbanization, one-third of its population lives in urban areas (BBS 2019), and more than half will live in urban areas by 2040 (UNFPA 2016). A comprehensive study of EF (as an indicator for environmental degradation) and urbanisation in Bangladesh is yet to be done. Against this backdrop, in this chapter, I have explored the relationship between

the EF and urbanization of Bangladesh. Section 2 briefly summarizes the current empirical research trend on environmental degradation with EF, and section-3 presents modelling and econometric methods. The results and discussion of this analysis are contained in section-4, and section-5 summarizes this chapter.

4.2 Empirical Study on Environmental Degradation

Apart from the discussion in Chapter-2, it is generally found that most academics take CO₂ emission as an indicator of environmental deterioration. For instance, while searching the determinates of EF using data from 58 countries, Al-mulali et al. (2016) summarize 47 studies, among which only two use EF as an indicator of environmental degradation. It is also observed that most studies work on the EKC (Environmental Kuznets Curve) hypothesis. This EKC hypothesis tells that environmental degradation increases at the initial stage of development. However, after a certain period, as the country develops, people's awareness increases for environmental contamination, and at the same time, technology and efficiency improve, and contamination increases at a lower rate. However, over time development permits allocating some resources to reduce the contamination (Stern et al. 1996; Stern 2004; Azlina and Mustapha 2012).

Furthermore, Mehmood and Salman (2020) claim that Globalization is responsible for more natural resource depletion in developing countries and due to globalization, CO₂ emissions increased more than 45 years ago. On the contrary, Leal and Marques (2020) argue that there is an EKC relationship between economic growth and environmental degradation for Highly Globalized Countries, but the EKC hypothesis is not confirmed for Low Globalized Countries (LGC). Detailed analysis of the EKC hypothesis is also found in the study of Sarkodie and Strezov (2019). They claim that trade policy is one of the most crucial factors for the EKC hypothesis. Trade policies with weak environmental regulations attract developed countries to shift their pollution-intensive industries to developing countries, popularly known as the pollution heaven hypothesis (Levinson and Taylor 2008) On the other hand, as more employment and income rise activity are needed in developing countries, they welcome the pollution-intensive and energy-intensive industries at the expense of their environment (Sarkodie and Strezov 2019).

Moreover, trade liberalization assists countries in developing domestic industries for which they have a competitive advantage. A country with a competitive advantage and lax environmental regulations attracts pollution-intensive industries. However, if innovation, research and development, and clean and modern technologies are transferred through foreign direct investment, the pollution level will be reduced by replacing the old production technology in emerging countries. Sarkodie and Strezov (2019) argued that most of the studies of the EKC hypothesis employed atmospheric indicators. Future research should give more focus to other environmental indicators.

Ang (2008) argues that economic growth is the outcome of inputs that increase the input's productivity. Productivity rises through industrialization, and industrialization demands more energy consumption. More energy needs more natural resources, such as gas, coal, and oil, but over-consumption can adversely affect environmental quality. Moreover, a degraded environment may negatively affect the economy by affecting human health and reducing economic growth in the long run. On the other hand, an increase in environmental quality by sacrificing growth should be considered cautiously (Masud et al. 2018), particularly for developing countries, where more employment, production and income are required instead of environmental conservation (Alvarado and Toledo 2017).

While explaining the EKC, Panayotou (1994) pointed out that economic growth can damage the environment to a certain level, and after that, a country can afford environmental protection and regulations. In a real sense, EKC can help the current generation by increasing per capita income while ensuring a better life for future generations by providing a better environment (Masud et al. 2018). Sustainable economic growth also requires focusing on reducing income inequality (ibid) because Mikkelsen et al. (2007) suggest that If the Gini ratio increases by 1%, then threats to species (an indicator of environmental degradation) will rise by 2%. In addition, Holland et al. (2009) opine that income inequality and threatened bird species have a positive relation, indicating that greater income inequality can degrade the environment more. Hence, countries with better inequality indexes have less environmental degradation (Masud et al. 2018).

Much empirical research is also found on the nexus among economic growth, environmental degradation, energy consumption and CO₂ emissions, which can be classified into three lines (Farhani and Rejeb 2012). The first line of research emphasizes economic growth and energy consumption nexus with granger causality analysis. For instance, Stern (1993), Aqeel and Butt (2001), Yuan et al. (2008), Ghosh (2010), Lau et al. (2011), Binh (2011) and Kaplan et al. (2011).

The second line of research focuses on testing the validity of the EKC hypothesis. Different researchers have different views in this regard. For example, Selden and Song (1994) and Galeotti et al. (2009) found evidence of the validity of the EKC hypothesis. On the other hand, Holtz-Eakin and Selden (1995) report a monotonic rising curve, and Friedld and Getzner (2003) claimed an N-shaped curve. However, Agras and Chapman (1999); Rochmond and Kaufman (2006) suggested that economic growth and EKC are different things; they are independent of each other.

The third line of research introduces a modelling framework that simultaneously considers pollutant emissions, energy consumption and economic growth. In this line, the causal relationship between these three variables was determined by combining the literature on EKC with the energy consumption-growth literature (Richmond and Kaufman 2006; Soytas et al. 2007; Ang 2007; Soytas and Sari 2009; Akbostanci et al. 2009; Acaravci and Ozturk 2010; Apergis and Payne 2010; Ozturk and Acaravci 2010; Arouri et al. 2012; and Wang et al. 2011).

Furthermore, empirical research on groups of countries where panel data econometrics predominates and research on single countries where time series econometrics is applied are also found. The findings of the studies are summarized in Appendix-8.

Appendix-8 was constructed by considering more than 30 studies in a wide range of countries, including the Union of top 25 countries, 19 European countries, 15 Middle East and North American (MENA) countries, 43 developing countries, 12 African countries, 20 Latin American countries, Great Britain, Japan, Turkey, India, Malaysia, Brazil, Indonesia, China, Tunisia, Portugal, Pakistan, and others. The data period ranges from 18 to 50 years. It is found that several numbers of studies consider CO₂ emissions as an indicator of environmental degradation. For instance, CO₂ emissions

have been used as an indicator of environmental degradation by Bhattacharya and Ghoshal (2010), Acaravci and Ozturk (2010), Farhani and Rejeb (2012), Ozcan (2013), Omri (2013), Narayan and Narayan (2010), Arouri et al. (2012), Al-mulali (2011), Apergis and Payne (2010), Chang and Soruco Corballo (2011), Alam et al. (2012), Ang (2008), Ozturk and Acaravci (2010), Pao and Tsai (2011), Hwang and Yoo (2014), Hossain (2012), Zhang and Cheng (2009), Shahbaz et al.(2012), Shahbaz et al.(2013), Shahbaz et al.(2016), Fodha and Zaghdoud (2010), Halicioglu (2009), Ghosh (2010). Bio-chemical Oxygen Demand is used as an indicator of environmental degradation by Gurluk (2009). Giovanis (2013) used Micro level data of air pollution, Alvarado and Toledo (2017) used vegetal cover, and Fodha and Zaghdoud (2010) used SO₂ as a proxy for environmental degradation. It is also noticed that EF has also been widely used as a proxy for environmental degradation by Nathaniel et al. (2019), Hassan et al. (2019), Ahmed and Wang (2019), Charfeddine and Mrabet (2017) and Jorgenson (2016). Nathaniel et al. (2019) also claims that EFs are a more aggregate indicator and capture environmental degradation better than CO₂ emissions.

The findings of these studies differ from country to country and vary depending on the methodology used. Firstly, some studies found that CO₂ emissions can influence GDP/GNI and energy consumption. For example, Shahbaz et al. (2015) found this relationship for Portugal and Halicioglu (2009) for Turkey and Bhattacharya and Ghosal (2010) for all top 10 per capita income countries in the Union of 25 countries. These results indicate that more CO₂ emissions led to economic growth. Secondly, if the relationship goes from energy consumption to GDP and CO₂ emissions, then GDP/or CO₂ emissions can increase through more energy consumption. For example, Omri (2013) found this relationship for 14 MENA countries, and Al-mulali (2011) also found this for MENA countries except for Iraq, Libya, Palestinian and Djibouti due to data unavailability. Finally, most of the study conducted a causality test and found unidirectional or bidirectional causality running to/from economic growth to/from environmental degradation. However, Farhani and Rejeb (2012) found no causal relationship in the short run but found it in the long run. On the other hand, Ghosh (2010) found that economic growth and environmental degradation are not related in the long run, but in the short run, there is bi-directional causality between them. In addition, some studies found that the growth path follows the EKC hypothesis (Gurluk

2009, Ozcan 2013, Hassan et al. 2019), whereas Giovanis (2013) found no evidence favouring EKC for Great Britain.

The search for an empirical study on EF and urbanization in Bangladesh also revealed that (in chapter 2) a quantitative analysis with a solid econometric framework looking at the EF and urbanization has yet to be carried out. Most of the studies use CO₂ emission rather than EF. However, EF is found to be more aggregate data than CO₂ emission. Because CO₂ emissions only represent part of the environmental degradation based on the concept of air pollution (Ulucak and Lin 2017). In contrast, EF is a comprehensive index that captures the biologically productive areas needed for human consumption (Solarin and Al-mulai 2018). As a result, in recent years, CO₂ has been replaced by EF as EF has been considered a more comprehensive and reliable indicator of environmental degradation (Chen et al. 2021).

4.3 Model Construction and Econometric Methodology

Model construction is developing a regression equation describing the relationship between a dependent variable and one or more independent (or explanatory) variables. Finding the proper functional form of the relationship and choosing explanatory variables are critical issues of a model construction process.

As discussed in the methodology chapter (Chapter three), this study used the STIRPAT model for empirical study. The basic form of the STIRPAT model is specified as follows:

$$I_t = \gamma_0 P_t^{\beta_1} A_t^{\beta_2} T_t^{\beta_3} \mu_t \text{-----}(1)$$

Where “*I*” capture the environmental factors, “*P*” is the population, “*A*” is the affluence, and “*T*” is the technology. The ‘β’s and ‘μ’ are the parameter estimates and the error term, respectively. EF captures environmental factors, GDP represents affluence, and Urbanization can be used as the proxy of the demographic variable “*P*”. GDP and *T* variables are included in the model as control variables. These two variables also significantly contribute to ecological pressure (Ahmed et al. 2019). The “*T*” can be decomposed into various variables depending on the focus of the researchers (Bello et al. 2018).

Technology transfer refers to the acquisition, development and utilization of technological knowledge by a country other than that where this knowledge originated (Derakhshani 1983). So, only importing modern technology might not work to increase the productivity of LDCs. Besides the technology, LDCs should have the capacity to utilize this. They need proper scientific institutions, R&D facilities, vocational, technical and management training institutions and skilled personnel of different specializations to benefit from these technologies (ibid).

Technology transfer is also viewed as a vital process of industrialization of LDCs. Jafarieh (2001) argued that while importing technology, there should be a matching between existing and imported technology. This matching could lead to rapid industrialization. Industrialization contributes to increasing growth and living standard in a country by transforming agriculture, construction, transport, and other service industries into highly productive sectors. Thus, the industrialization of a country can be seen as an essential proxy for technology transfer.

It is also found that financial development and trade openness are also used as the proxy of technology transfer. For instance, Baloch et al. (2019a, 2019b), Hafeez et al. (2018), and Shabaz et al. (2013) used financial development as a proxy for technology transfer. They claimed financial development supports more manufacturing activities, technological advancement, research, and development, which ultimately help technology transfer.

On the other hand, Solarin et al. (2021) adopted trade openness as a medium of technology transfer. They claimed that trade openness helps to transfer technological innovation from developed countries to either emerging or less developed countries, which is vital for reducing energy pollutants and rapid economic growth. However, developed countries sometimes take less developed countries as pollution heaven and try to extort outdated technology. Because developing countries sometimes relax their environment and tax-related law to attract more FDI for rapid economic growth. As a result of this relaxation, developed countries try to set up industries in developing countries with their outdated technology. On the other hand, as rules and regulations are becoming more rigid in developed countries, they take the opportunity of dumping

activities. Therefore, in the long run, trade openness could also negatively impact (ibid).

In line with the above theoretical debate, this study adopted trade openness as an indicator of technology transfer. Consequently, the expanded model to be estimated, in its functional form, is specified as follows:

$$EF_t = f(\gamma_0 U_t^{\beta_1} Y_t^{\beta_2} T O_t^{\beta_3} \mu_t) \text{-----}(2)$$

The variables were further divided by population to express them in per-capita terms.

$$ef_t = f(\gamma_1 u_t^{\beta_1} y_t^{\beta_2} to_t^{\beta_3} \mu_t) \text{-----}(3)$$

The lowercase letters ‘ef,’ ‘u,’ ‘y’ and ‘to’ are the variables’ per-capita terms. By taking the logs of each of the variables, the linearized model is shown in Eq. 4

$$\ln ef_t = \beta_0 + \beta_1 \ln u_t + \beta_2 \ln y_t + \beta_3 \ln to_t + \mu_t \text{-----}(4)$$

“ln” is the natural logarithm, “ef” is the ecological footprint (global hectares per capita), “y” is the GDP per capita (in constant 2015 USD), “u” is the urbanization (urban population as a share of the total population in percentage), “to” is the trade openness.

Data and Data Source

Yearly data spans from 1971- 2017 in Bangladesh (Appendix-11). The period was solely based on data availability. The data of EF was collected from GFN. GFN provides up-to-date EF data for more than two hundred countries, territories and regions from 1961 based-on 15,000 data points (GFN 2023). EF is a reliable tool to measure human consumption and waste generation pressure on our ecosystem. It provides valuable information to prevent the misuse of our limited natural resources (Ahmed et al. 2019).

Urbanization, GDP, and trade openness data are collected from WDI (World Development Indicators). WDI provides globally comparable high-quality statistics (Ahmed et al. 2019). The World Bank database contains 1600 indicators (time series) for 217 economies and over 40 country groups. Table 4.1 gives detailed information about variables, their measurement, and sources.

Table 4.1 Data and their source for Bangladesh				
Variables	Symbol	Definition	Unit of measurement	Data Source
Ecological Footprint	EF	Per capita ecological footprint	Global hectares	GFN
Urbanization	U	Urban population as a share of the total population	Percentage	World Development Indicators (WDI) of the World Bank
GDP	GDP	Gross domestic product Constant 2015 USD (per capita)	USD	WDI
Trade Openness	TO	(Export + Import) as a percentage of GDP (Constant 2015 USD)	Percentage	WDI

Based on the STIRPAT model, urbanization and GDP are expected to positively impact the EF, while trade openness might have either positive or negative impacts.

Econometric Methodology

It was found that different statistical tools were used for analysing the data. Among these tools this study uses the following tools.

Unit Root Tests

While dealing with time series data, it is necessary to ensure that individual time series is stationary or co-integrated. If not, we may engage in spurious (or nonsense) regression analysis (Gujarati and Porter 2010).

In applied econometrics, various unit root tests are available to test the stationary properties of the variable. This study applied ADF by Dickey and Fuller (1979), P-P by Phillips and Perron (1998), KPSS by Kwiatkowski et al. (1992) and DF-GLS by Elliot et al. (1996) unit root tests. Shahbaz et al. (2014) argued that the traditional unit root test

is unreliable if the series has a structural break. In this case, Zivot and Andrews structural break unit root test is reliable (Ahmed et al. 2019). As a result, this test has also been applied.

ARDL Bounds Test

In applied econometrics, various cointegration tests are available. Among them, the ARDL bounds test, Engle and Granger (1987), Johansen's (1988) cointegration test, Banerjee et al. (1998), and Johansen and Juselius (1990) co-integration test are widely used. However, different tests have different limitations. For instance, Shahbaz et al. (2016a) claimed that Engle and Granger cointegration method is based on two steps, and an error in one step can carry over to the next step, eventually causing biased estimations. Ahmed et al. (2019) argued that Johansen and Juselius's (1990) cointegration approach is based on a single equation, and it requires a uniform order of integration I(1) and a large sample size.

According to Harris and Sollis (2003); Jalil and Ma (2008) ARDL bounds test has some advantages over the traditional testing approach. For example, i) it is very flexible regarding the stationary properties of the variables and allows analysis with I(0) and or I(1) data, (ii) provides efficient and consistent empirical evidence for small sample data (Narayan and Smyth 2005); (iii) as it is a single equation set-up, its implementation and interpretation is simple; (iv) it investigates short run as well as long run parameters instantaneously; (v) it provides an unbiased estimation of long-run relationship and long-run parameters, and (vi) the autocorrelation and endogeneity problems are adequately addressed (Harris and Sollis 2005; Jalil and Ma 2008).

Due to the above-mentioned advantages, the ARDL bound testing approach developed by Pesaran et al. (2001) is used in this study. Following Rahman and Kashem (2017) for bounds testing of cointegration, the following ARDL model is used:

$$\Delta \ln ef_t = \alpha + \sum_{i=1}^p \beta_1 \Delta \ln ef_{t-i} + \sum_{i=0}^q \gamma_i \ln u_{t-i} + \sum_{i=0}^r \delta_i \ln y_{t-i} + \sum_{i=0}^s \epsilon_i \ln to_{t-i} + \theta_0 \ln ef_{t-1} + \theta_1 \ln u_{t-1} + \theta_2 \ln y_{t-1} + \theta_3 \ln to_{t-1} + \epsilon_{t1} \text{-----} (5)$$

Where, 'ef', 'u', 'y' and 'to' are variables of the study and ' ϵ ' is a "well-behaved" random "disturbance" term, i.e. is serially independent, homoscedastic and normally distributed.

In equation (5), the first four terms with summation signs represent the error correction dynamics, and the second term (terms with θ s) corresponds to the long-run relationship (Rahman and Kashem 2017).

Model Stability Test

The model's stability is tested using Recursive CUSUM and CUSUM of squares (Brown et al. 1975). It is also suggested by Pesaran and Pesaran (1997) for measuring parameter stability. Ramsey RESET test is also conducted to identify the functional misspecification.

Causality Test

Rahman and Kashem (2017) opined that only correlation is insufficient to understand the relationship between the variables. The relationship might be spurious, or any other third variable might exist. Moreover, correlation does not mean causation. As a result, granger causality following Toda-Yamamoto (1995) procedure is estimated.

TY procedure is selected as in this process, there is no chance of losing information from differencing. Because the TY procedure considers vector autoregression (VAR) in levels (Soytas et al. 2007), it can also be applied to any arbitrary level of integration (Toda and Yamamoto 1995). This procedure can also capture the feedback effects through several lags; thus, pre-testing the series' co-integration properties is not mandatory (Peng and Sun 2010; Zapata and Rambaldi 1997).

4.4 Results and Discussion

Descriptive Statistic

Table 4.2 concentrates on the properties of the variables and the correlation matrix. The results showed that the mean and median of each of the variables differ from each other. Their standard deviation is not remarkably high. There is also a strong correlation among the underlying variables.

Table 4.2 Descriptive statistics and correlation matrix				
Descriptive Statistics				
	LEF	LU	LGDP	LTO
Mean	-0.543	1.581	6.439	2.9227
Median	-0.628	1.452	6.321	---
Maximum	-0.124	2.390	7.247	3.8707
Minimum	-0.749	1.180	5.995	2.1327
Std. dev	0.182	0.367	0.357	0.6159
Observations	47	47	47	47
Correlation Matrix				
LEF	1			
LU	0.689	1		
LGDP	0.929	0.871	1	
LTO	0.804	0.363	0.707	1
Source: Author's computation				

Unit Root Analysis

Unit root analysis is a preliminary step to check the level of stationarity to avoid spurious regression results and to determine the order of integration of the variables. To do so, I have used the Kwiatkowski Phillips Schmidt Shin (KPSS), Augmented Dickey-Fuller (ADF), Augmented Dickey-Fuller Generalized Least Squares (ADF-GLS) and Phillips-Perron (PP) unit root tests. Unlike other tests, the KPSS test has the null hypothesis of stationary. The results of the tests are reported in Table 4.3. The results show that all variables are stationary at $I(0)$ or $I(1)$. For example, ADF, ADF-GLS, and PP tests of LEF reveal that the null hypothesis of non-stationary at level is accepted as the calculated values are smaller than 95% simulated critical values. It means that LEF has a unit root at levels. However, the null hypothesis of non-stationary at the first difference is rejected, meaning that LEF is stationary at the first difference, i.e. $I(1)$. The KPSS test indicates that the null hypothesis of stationary at the level and first difference is accepted. Therefore, under the KPSS test, we can say that LEF is stationary at the level and first difference, i.e. $I(0)$ and $I(1)$. The results of other variables also reported that variables are either $I(0)$ or $I(1)$, and none of them is integrated at order 2, i.e. $I(2)$.

Table 4.3 Results of the ADF, ADF-GLS, PP and KPSS unit root tests.

Variables	Name of the Test	At level				At 1 st difference				Comments
		With intercept only		With trend and intercept		With intercept only		With trend and intercept		
		Calculated	Critical	Calculated	Critical	Calculated	Critical	Calculated	Critical	
LEF	ADF	1.31	2.92	0.18	3.57	8.54	2.92	6.52	3.51	I(1)
	ADF-GLS	1.50	2.33	0.71	3.22	4.38	2.25	5.30	3.17	I(1)
	PP	0.72	2.92	0.77	3.50	8.37	2.92	9.97	3.51	I(1)
	KPSS	0.37	0.38	0.13	0.17	0.27	0.38	0.11	0.17	I(0), I(1)
LGDP	ADF	5.48	2.92	1.10	3.51	4.89	2.93	11.43	3.51	I(0), I(1)
	ADF-GLS	2.40	2.33	0.84	3.22	0.48	2.25	2.21	3.17	I(0)
	PP	5.71	2.92	1.7	3.50	8.01	2.92	15.18	3.53	I(0), I(1)
	KPSS	0.44	0.38	0.14	0.17	0.48	0.38	0.14	0.17	I(0), I(1)
LU	ADF	1.44	2.92	3.29	3.51	4.34	2.92	4.33	3.51	I(1)
	ADF-GLS	1.38	2.33	2.94	3.22	4.25	2.25	4.33	3.17	I(1)
	PP	0.80	2.92	2.16	3.50	3.91	2.92	3.90	3.51	I(1)
	KPSS	0.38	0.38	0.11	0.17	0.14	0.38	0.13	0.17	I(0), I(1)
LTO	ADF	1.51	2.92	3.80	3.51	4.81	2.92	4.94	3.51	I(0), I(1)
	ADF-GLS	1.18	2.33	1.82	3.22	4.66	2.25	4.92	3.17	I(1)
	PP	1.17	2.92	3.05	3.50	6.44	2.86	6.68	3.53	I(1)
	KPSS	0.25	0.38	0.13	0.17	0.28	0.38	0.15	0.17	I(0), I(1)

Source: Author's computation

However, as mentioned earlier, the traditional unit root test is unreliable if there is a structural break in the data series. As a result, I applied Zivot and Andrews structural break unit root test. This test result provides the structural break year along with the stationarity property. The test result presented in Table 4.4 reveals that, despite having a structural break, all the variables are stationary at first difference. The overall result is similar to the traditional unit root test result.

Table 4.4 Outcome of Zivot and Andrews unit root test				
	Levels		1 st Difference	
Variables	t-stat	Structural Break Year	t-stat	Structural Break Year
LEF	2.39	2005	9.36***	1977
LU	4.96	1998	8.52***	1989
LGDP	2.61	1981	13.70***	1980
LTO	9.66***	1975	34.63***	2001
*** Significance at 1% level				
Source: Author's computation				

The ARDL Estimation

The Schwarz Bayesian Criterion has been used to determine the optimal lag length of the variables. The selected ARDL is (1,0,2,2). Therefore, the optimum lag length of the EF, U, GDP and TO variables are 1, 0, 2 and 2, respectively.

Diagnostic Tests

The result presented in Table 4.5 shows that the ARDL estimate is well-fitted and passes through all diagnostic tests. The ARDL estimates gives a high R-squared value of 0.98. The model captures almost 98% of the variations of dependent variables, and the rest are error terms. It is also noted that though the model contains the lagged value of the regressand, the DW statistics is around 2, suggesting that there is no (first order) autocorrelation in the model (Gujarati and Porter 2009). The computed F-statistic = 265.90 (Prob. 0.000) rejects the null hypothesis that the regressors have zero coefficients. The model also passes the diagnostic test of serial correlation/autocorrelation, normality, heteroscedasticity and functional misspecification.

Table 4.5 Model diagnostic tests result		
R Squared: 0.98 DW Statistics: 1.95 F-statistics: 265.90 (Prob. 0.000)		
	LM version [CHSQ(Prob.)]	F version F-ratio (Prob.)
A: Serial Correlation	0.026 (0.871)	0.023 (0.887)
B: Normality	2.254 (0.324)	Not applicable
C: Heteroscedasticity	0.048 (0.826)	0.046 (0.831)
D: Functional Form	0.189 (0.663)	0.148 (0.703)
Relevant tests:		
A: Lagrange multiplier test of residual serial correlation		
B: Based on a test of skewness and kurtosis of residuals		
C: Based on the regression of squared residuals on squared fitted values		
D: Ramesy's RESET test using the square of the fitted value		
Source: Author's computation (Appendix-9)		

ARDL Bounds Test

The result of all diagnostic tests suggested no problem in the model. Therefore, we can now move to the bounds test. The decision rule of this bound test is taken based on the position of calculated F-statistics; if the calculated F-statistics value is greater than the critical value of the upper bound (here shown as the value of $I(1)$) then we can conclude that there is co-integration among the variables. On the contrary, if the calculated F-statistics value is lower than the critical value of the lower bound (here shown as a value of $I(0)$), it indicates no co-integration among the variables. On the other hand, if the calculated F-statistics value lies between the lower and upper bound values, we cannot decide whether there is any co-integration. I relied on the lagged error correction term (ECMt-1) in such a situation. Here I have used the critical value of both Pesaran et al. (2001) and Narayan (2005) critical values. The result is presented in Table 4.6. The result shows that the value of the computed F-statistics (9.39) exceeds the upper bound even at a 1% significance level in both the Pesaran and Narayan relevant table of critical values. Therefore, we can conclude that there is evidence of a long-run relationship between the variables of my model.

Table 4.6 ARDL bounds test result					
F-statistic		Pesaran		Narayan	
Calculated	*Critical Values	Lower Bound I(0)	Upper bound I(1)	Lower bound I(0)	Upper bound I(1)
9.39	1%	5.17	6.36	6.053	7.458
	5%	4.01	5.07	4.45	5.56
	10%	3.47	4.45	3.74	4.78
Source: Author's computation (Appendix-10), Pesaran et al. (2001) and Narayan (2005) Critical values: For K=3 (number of independent variables), the relevant critical values with unrestricted intercept and unrestricted trend from table C1(v) on p. 301 of Pesaran et al. (2001) and for K=3, n=45 the table case(v) on p. 1990 of Narayan (2005)					

Cross-checking for cointegration

In addition to F statistics, I used t-statistics to cross-check the presence of cointegration. When I look at Table CII(v) on p. 304 of Pesarn et al. (2001), I have found that the I(0) and I(1) bounds for the t-statistic at the 1%, 5% and 10% significance levels are [-3.96, -4.73], [-3.41, -4.16] and [-3.13, -3.84] respectively. It is found that the computed t-statistic [-4.4274] is greater than that upper bound value [4.16] at the 5% level, reinforcing that my variables are cointegrated, and there is a long-run relationship among the variables.

The long-run and short-run results

The ARDL bound test confirms that the variables are co-integrated. Therefore, we can now proceed to see the long-run and short-run dynamics. To see the long-run and short-run relationship, I have used the ARDL approach. ARDL approach uses a single equation in a reduced form to measure the long-run and short-run results.

Table 4.7 Long-run relationship from ARDL (1,0,2,2) approach				
Dependent Variable LEF				
Variables	Coefficient	Standard error	T-statistic	P value
LU	0.002	0.127	0.022	0.982
LGDP	0.438 ***	0.158	2.764	0.009
LTO	0.172 ***	0.056	3.033	0.004
*** denotes significance at a 1% level				
Source: Author's computation (Appendix-9)				

The result presented in Table 4.7 shows that GDP significantly positively affects EF. The intuition here is that a 1% increase in GDP will trigger a rise in EF by 0.43%. This might be due to the consistent economic growth of Bangladesh over the past decades. This continuous growth has increased energy consumption, food, transportation, infrastructure development, and other activities that stimulate EF. The results are consistent with the findings of Belaid and Youssef (2017) and Amri (2017) for Algeria, Alshehry and Belloumi (2017) for Saudi Arabia, Khan et al. (2019) for Pakistan, Nathaniel et al. (2019) for South Africa, Mikayilov et al. (2018) for Azerbaijan.

It is also noticeable that a 1% increase in trade openness will also increase EF by 0.17%. This relationship suggests that Bangladesh imports outdated, dirty technologies, creating environmental pressure.

Conversely, the urbanisation coefficient is insignificant, meaning that urbanization has no significant impact on the EF of Bangladesh in the long run. This outcome suggests that the urban development of Bangladesh has not yet reached such a level that it could influence the EF of this country; it may be the outcome of taking an environment-friendly policy of setting up industries, National industry policy and taking legal action against industrial pollution. Bello et al. (2018) also found this kind of relationship between EF and urbanization of Malaysia. Similarly, Nathaniel et al. (2020a) used the quantile regression method and found that urbanization reduces the EF of coastal Mediterranean countries. Ahmed and Wang (2019) found a negative relation between EF and urbanization for India, which suggests that urbanization reduces EF in India. On the contrary, Ahmed et al. (2020a) found that urbanization increases the EF of G7 countries.

The Short-run results

Table 4.8 Relationship among the variables in the short run from ARDL (1,0,2,2) approach.				
Dependent Variable dLEF				
Variables	Coefficient	Standard error	T-statistic	P value
dLU	0.0012	0.0564	0.0229	0.982
dLGDP	-0.792 ***	0.241	-3.274	0.002
dLGDP1	-0.455 ***	0.148	-3.077	0.004
dLTO	0.058 ***	0.021	2.746	0.009
dLTO1	-0.066 ***	0.023	-2.839	0.007
ecm(-1)	-0.443 ****	0.101	-4.376	0.000
List of additional temporary variables created:				
dLEF= LEF-LEF (-1) dLU= LU-LU(-1) dLGD= LGDP-LGDP(-1) dLGDP1= LGDP(-1)-LGDP (-2) dLTO= LTO-LTO(-1) dLTO1= LTO(-1)-LTO(-2)				
*** denotes significance at a 1% level ****44% error will be corrected or adjusted towards the long-run equilibrium. Source: Author's Calculation (Appendix-9)				

The outcome of the ARDL (1,0,2, 2) approach presented in Table 4.8 shows that the coefficient [-0.443] of lagged Error term [ecm(-1)] is significant and negative, as expected. It suggests that there is a short-term dynamic along with a long-run relationship. Furthermore, the coefficient of ECM [-0.44] indicates a robust and faster speed of adjustment to equilibrium. It suggests that nearly 44% of the disequilibrium converges back to the long-term equilibrium within one period (one year).

The short-run result also indicates that urbanization has no significant effect on the EF in the short run, similar to long-run dynamics. On the other hand, trade openness increases EF in both the long and short run. However, the first lagged value of the first difference of trade openness significantly and negatively affects the EF. Similarly, the first difference and lag of the first difference of GDP significantly and negatively affect the EF.

Stability of the model

After finding the long-run relationship among the variables, it is necessary to confirm the robustness of the estimated parameters. As a result, the structure of the model should be stable. According to Pesaran and Pesaran (1997), the cumulative sum of recursive residuals (CUSUM) and cumulative sum of recursive squares (CUSUMSQ) tests are widely used to see the structural stability of the model. Accordingly, CUSUM and CUSUMSQ tests are used to check the stability of the ARDL coefficients.

The decision rule of these two tests is that the model is stable if the plots lie within the critical boundaries at a 5% significance level. Figures 4.1 and 4.2 represent the result of the CUSUM and CUSUMSQ tests, respectively. Both figures indicate that no straight lines (red and green lines drawn at the 5% level) are crossed by CUSUM and CUSUMSQ, i.e., the plots of both the CUSUM and CUSUMSQ are within the boundaries. Therefore, these tests confirm that the model is stable, and no systematic change is identified in the coefficients at a 5% significance level over the study period.

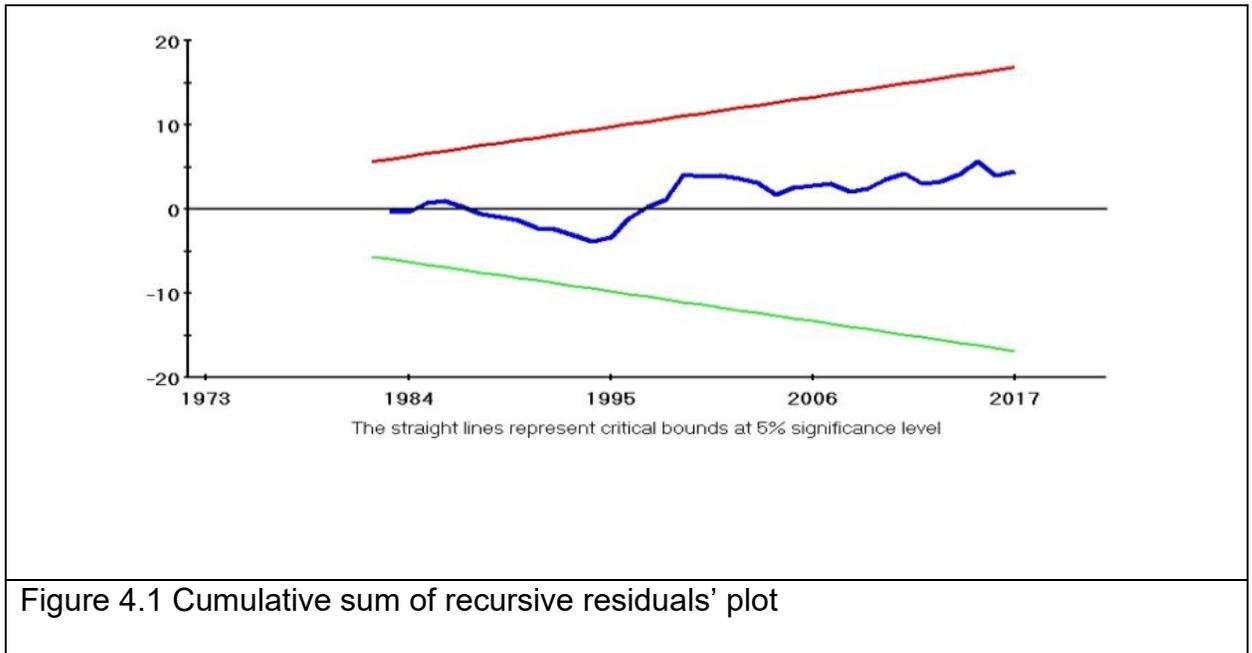


Figure 4.1 Cumulative sum of recursive residuals' plot

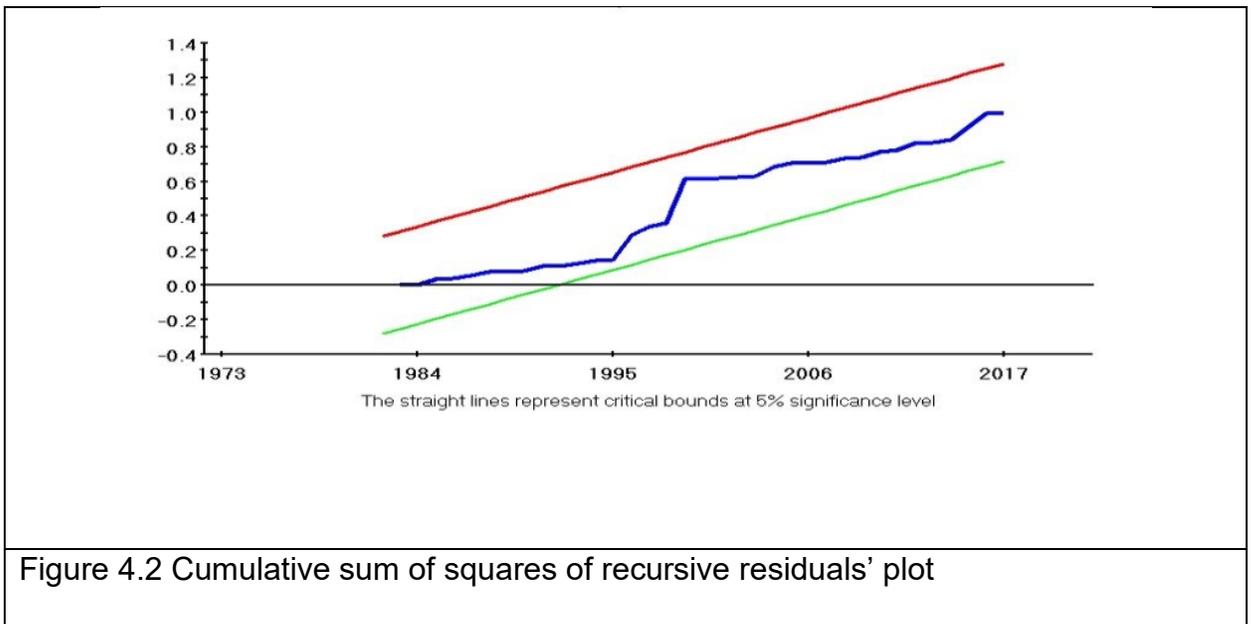


Figure 4.2 Cumulative sum of squares of recursive residuals' plot

Causality Analysis

As I obtained the co-integration, long-run and short-run relationship among the variables, I can now explore the direction of causality. As mentioned earlier, as there are some advantages to using the TY procedure, I use this process to identify the direction of causality.

Soytas et al. (2007) opined that the TY procedure is a modified Wald test that tests restrictions on the parameters of the VAR(k) model. The statistic follows an asymptotic chi-square distribution with k degrees of freedom [chi-square(k)]. The procedure requires augmenting the VAR (K) in levels (Where k is the optimum lag length) with 'd'. If the resulting VAR (k+d) passes some diagnostic tests, a Wald test is conducted on the first k parameters. If the first k parameters are statistically significant, then the null hypothesis of non-causality is rejected (Soytas et al. 2007).

According to Table 4.3, the order of integration of LEF, LU, LGDP and LTO does not appear to exceed 1. Now I evaluate several lag length criteria to determine the optimum lag length, k. Too many lags lead to a loss of degrees of freedom and can cause multicollinearity, serial autocorrelation in error terms and misspecification error (Gujarati and Porter 2010). Therefore, the selection of lag length is critical. There is no hard-and-fast rule on the choice of lag length. It is an empirical issue. In annual data,

the number of lags is typically small, 1 or 2, whereas, for quarterly data, 1 to 8 lags are appropriate. Given sufficient data points, 6, 12 or 24 lags can be used in monthly data. The easiest way out of this dilemma is to decide using a criterion like Akaike or Schwarz Information Criteria (SIC) and choose the model that gives the lowest values of this criterion. Econometrics packages efficiently compute these optimal lag lengths. In my case, SIC gives the lowest values. As a result, I have chosen SIC for lag length selection. This criterion points to an optimum lag length of (k=2). Hence, I estimate a VAR (2+1), i.e. VAR (3) in levels. I have found the results (Chi-square values of variables) displayed in Table 4.9.

Dependent variables	Independent variables				Direction of causality
	LEF	LU	LGDP	LTO	
LEF	-	0.06	6.54**	5.73**	GDP → EF TO → EF
LU	0.63	-	13.96***	11.26***	GDP → U TO → U
LGDP	6.53**	0.64	-	6.46**	EF → GDP TO → GDP
LTO	2.19	0.45	4.97	-	
significance at 5% level, * significance at 1% level					
Source: Author's computation (Appendix-10)					

Table 4.9 indicates that the EF granger causes GDP, the GDP granger causes EF and U, and the TO granger causes EF, U and GDP in Bangladesh. It is noteworthy to mention that there is no causality from urbanization to EF, GDP, and trade openness.

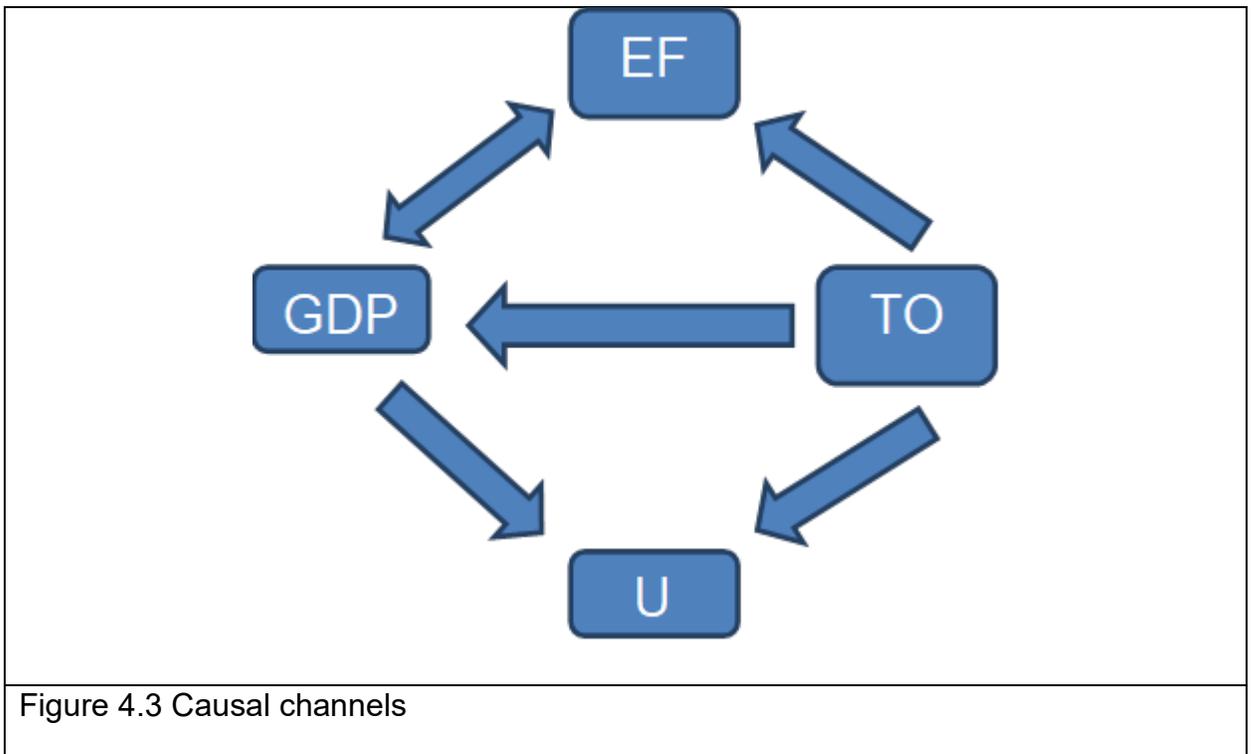


Figure 4.3 Causal channels

Figure 4.3 shows the graphical direction of causal channels. I have observed the unidirectional causality of trade openness with EF, urbanization and GDP, and bidirectional causal relationships between GDP and EF. No causal relationship between EF and urbanization is found.

4.5 Summary

In this chapter, I have attempted to dig out the long-run and short-run dynamics and causal relationship among EF, urbanization, GDP and trade openness in Bangladesh from 1971 to 2017 using the STIRPAT model. I have applied various time series econometric techniques, including the Augmented Dickey-Fuller (ADF), ADF-GLS, Phillips-Perron, Kwiatkowski-Philips-Schmidtshin (KPSS) unit root tests, Zivot and Andrew Structural Break Unit Root Test, the ARDL bounds test, the Error Correction Mechanism (ECM) and the Toda and Yamamoto (1995) granger causality test. Based on the STIRPAT model, urbanization might have a significant positive impact on EF. However, I have found no significant effect of urbanization on the EF of Bangladesh.

The bidirectional causal relationship to and from GDP and EF implies that GDP and EF are the cause and effect of each other, i.e. increase in GDP causes an increase in EF

and vice versa, which indicates that with the increase of EF, the environment degraded more, affecting human health. As a result, the productivity of human beings has been deteriorating in the long run, which affects economic growth. Therefore, Bangladesh should emphasise green technology in its economic growth.

A unidirectional causal relationship between trade openness and EF is also found, which signals that Bangladesh is importing more outdated technologies, creating more pressure on its environment. Therefore, Bangladesh must ensure it engages in a "green" trade by importing cleaner technologies. At the same time, efforts must be made to encourage industries to adopt new technologies to minimize pollution since economic activities and trade openness are essential to achieve better economic development; sacrificing them is not a good policy, specifically in a densely populated country like Bangladesh. Nonetheless, cleaner technology, new technology absorption capacity of local industries, and environmentally friendly government policy will intensify the recent urban development of BD in a sustainable way.

From the ARDL bounds test I have found that both long-run and short-run urbanization does not significantly affect EF in Bangladesh. The Toda-Yamamoto Granger causality test has also supported my findings. Since there does not appear to be a causal relation between EF and urbanization, Bangladesh might have the capacity to afford more urbanization that will not increase EF and ultimately not cause environmental degradation. There may be several reasons. Firstly, the government is now adopting more environmentally friendly policies and the private sector, especially the industry sector, also supports following the policies. Secondly, Bangladesh's urbanisation process promotes innovation, advanced technology, and environmentally friendly equipment such as vehicles, communication systems, machines, and utilities. Finally, it might assume that people are now more aware of cleaner urban development, and voices of environmental activities are working. Overall, my results are consistent with Bangladesh's policies toward more urbanization as the most effective and immediate way to increase economic growth.

Like other studies, this study is also not above limitations. I could not include other variables (e.g., government policy, foreign direct investment, human capital, industrialization, air pollution, transportation, and food consumption) that may affect the

EF of Bangladesh. Moreover, disaggregate studies to examine the relationship between urbanization and EF of a city in Bangladesh would be helpful for more specific policies. The present study also discloses the impacts of GDP and trade, which presents a vital gap for future studies to examine the effect of each element of GDP and trade on EF.

Having this kind of result, the following chapter will measure the EF of NC to get an indication of the EF of a city in Bangladesh.

Chapter Five

Ecological Footprint of Narayanganj City

5.1 Introduction

The empirical study in chapter four revealed that urban development in Bangladesh is still happening in a way that has no significant impact on her EF. This finding suggests that despite enormous problems, Bangladesh can still afford more urbanization which will not affect her EF. Bangladesh's urban area is a hub of economic activities, and more than 60% of GDP comes from urban areas (GoB 2020a). However, it is claimed that urban areas are the source of environmental degradation, biodiversity losses and a significant contributor to greenhouse gases. Despite this, globally more people are moving to urban areas, and it is estimated that sixty per cent of the total population will live in urban areas by 2030 (UNDESA 2018).

Similar to all other countries, Bangladesh have also experienced rapid urbanization. In 2019, 37.40% of the total population lived in urban areas, whereas in 2010, it was only 30.46% (World Bank 2023). So, urbanization cannot be stopped, but its sustainability is essential for continuous growth and development. This issue raises the question of what the EF of a city in Bangladesh is. Is the EF of a city higher than the country's biocapacity? What would the consequences be if a city's EF exceeded the country's biocapacity? In this paradox, this chapter measures the EF of NC. The comparison of EF among the different regions of NC and with Bangladesh's EF and Biocapacity is also presented. In addition to this, the main drivers of EF are also explored.

Following this introductory section, section 5.2 discusses why NC? A detailed discussion of the sample is presented in section 5.3. Section 5.4 comes up with EF of NC. A comparative study of EF and the major driving forces of EF is discussed in sections 5.5 and 5.6, respectively. Finally, section 5.7 presents the summary of this chapter.

5.2 Why NC?

Narayanganj is one of the prime cities of Bangladesh, located at 23° 33' and 23° 57' north latitudes and 90°26' and 90°45' east longitude. Narayanganj Municipality was formed on 8 September 1876 and upgraded to a city corporation in 2011 through the merger of Narayanganj, Siddhirganj and Kadamrasul Municipalities. It covers an area of 72.43 sq. km and is divided into three zones with an equal number of wards: Siddhangana (ward 1-9), Narayanganj (ward no 10-18) and Kadam Rasul (Ward no 19-27). This city, located at the heart of the country, only 17 kilometers (about 10.56 miles) southeast of the capital city Dhaka, is one of Bangladesh's oldest, most prominent and busiest river ports.

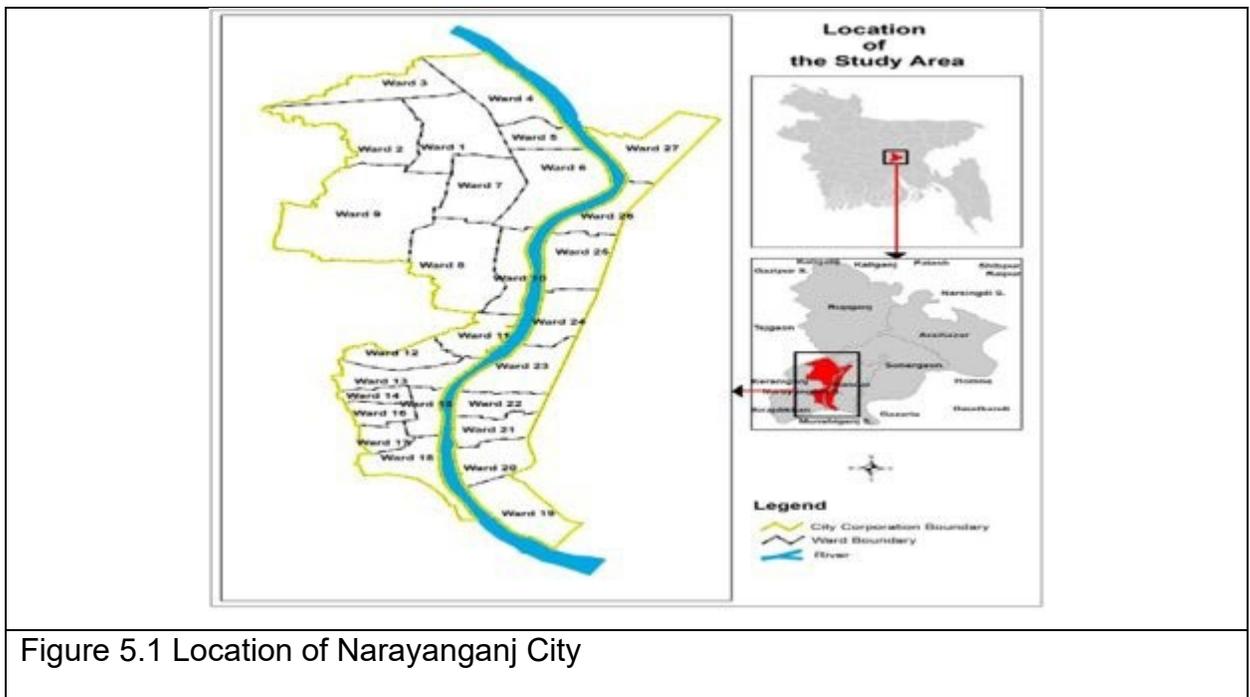


Figure 5.1 Location of Narayanganj City

NC is selected as it has a fascinating merger of east and west and has been historically known as the “Dundee of East” from the mid-19th century. Since then, NC has been an important industrial hub for Bangladesh for its strategic location, business-friendly environment and competitive attraction in terms of communication as it is surrounded by Shitalakshya and Buriganga. Having excellent connectivity with the rest of the country and port cities of neighbouring countries, such as Myanmar (Rangoon and Akyab), India (Kolkata, Asam and Kachar) and some other Asian countries through

waterways, NC has been made more attractive for import and export (Noman et al. 2016).

This city is also famous for its knitwear garment industries, producing hosiery products and jamdani saris. It accounts for 55% of the country's total Knitwear manufacturing and 33% of its total textile mills (Ahmed and Tareq 2008). The textile and garments industries in Narayanganj generated employment of over 130,000 in 2011 (BBS 2013). In addition, The Adamjee Export Processing Zone, located in Narayanganj, has attracted 46 domestic and international entrepreneurs, contributed over \$1.6 billion in exports, and created over 40 000 jobs in 2014-15. Moreover, the river port contributed 52.4% of the total tax revenue from inland river ports' activities to the government exchequer in 2012-13 (Noman et al. 2016).

As a result, NC has attracted thousands of citizens and migrants from other districts, particularly neighbouring southern and northern districts of Bangladesh and experiencing rapid urbanization. According to BBS (2011) urbanization rate of Narayanganj was 33.54% against the national rate of 23.30%. Consequently, the population growth rate of NC also increased from 2.16% in 2001 to 3.05% in 2011. With this estimated annual growth rate, the projected population of NC is expected to be 3 million from only 0.709 million by 2051(Figure 5.2).

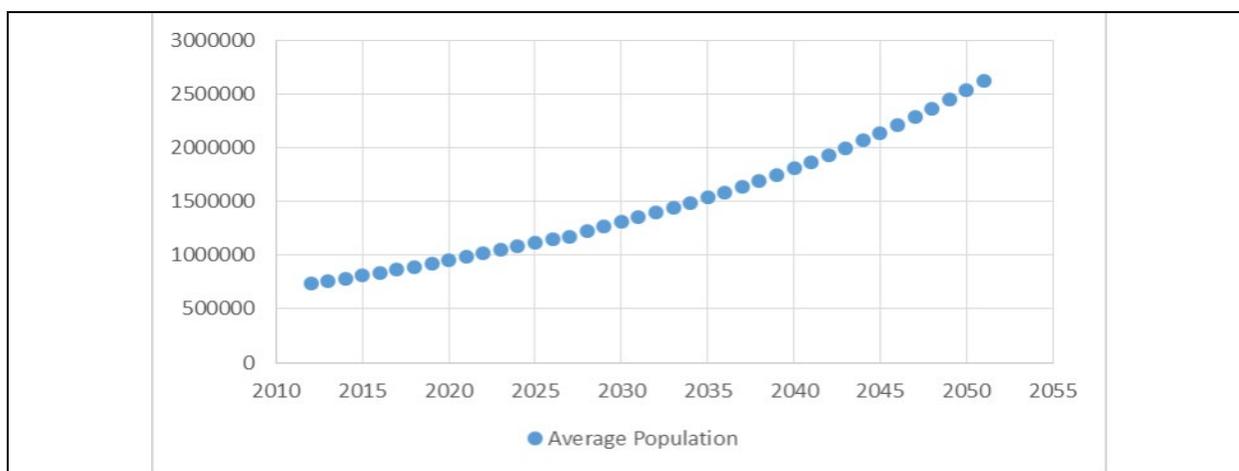


Figure 5.2 Population projection of NC (adopted from Mostahidul et al. 2020)

Therefore, like past contributions, NC's contributions to the national economy will also increase. Despite immense prosperity, the newly established NCC must face the

challenge of poor infrastructure, poor waste management, unplanned industrialization, and increased threat to environmental degradation (Noman et al. 2016). All these problems can cause further environmental, social, and economic sustainability issues. Therefore, this study selects this city to measure its EF, the first study ever for this city.

Note that there is no single index that can capture complex concepts of sustainability. As a result, it can be feasible to monitor and quantify various aspects of sustainability (such as environmental orientation) (Lee 2019). The growing trend of urban dwellers significantly impacts the urban environment. Thus, a systematic method is needed to analyze the multiple environmental pressures caused by people. EF can capture this human impact on the environment as it follows the Ehrlich and Holden (1971) concept, $I=PAT$ (Where I =impact, P = population, A =affluence and T = technology) (Delannoy et al. 2001). It also covers the strong sustainability view, which takes the environment more seriously (Skene and Murry 2015; Wu and Wu 2012). The global footprint network calculates the footprints of more than 200 countries, territories and regions from 1961 to the present, based on about 15,000 data points per country per year (GFN 2023). However, a fair share of criticism exists about the use of EF. Counterarguments also meet these criticisms. Nevertheless, footprint accounting practices are improving, and few alternative methodological approaches are yet to be offered (Galli et al. 2016).

5.3 Sample Overview

Identifying the survey sample's demographic composition is crucial to understand the quantitative data obtained in this study. Table 5.1 shows the cross-tabulation between age groups and gender.

Table 5.1 Age by gender					
			Gender		Total
			Male	Female	
Age group	18-35	Count	89	106	195
		% within Gender	33.7%	45.3%	39.2%
		% of Total	17.9%	21.3%	39.2%
	36-45	Count	81	82	163
		% within Gender	30.7%	35.0%	32.7%
		% of Total	16.3%	16.5%	32.7%
	46-60	Count	71	40	111
		% within Gender	26.9%	17.1%	22.3%
		% of Total	14.3%	8.0%	22.3%
	61+	Count	23	6	29
		% within Gender	8.7%	2.6%	5.8%
		% of Total	4.6%	1.2%	5.8%
Total		Count	264	234	498
		% within Gender	100.0%	100.0%	100.0%
		% of Total	53.0%	47.0%	100.0%

Table 5.1 presents that among 498 respondents, 47% are female, and 53% are male. It differed from the overall population, which comprised 50.46% females and 49.47% males in 2022 (BBS 2022). Most of those surveyed are young and fall in the age bracket of 18-35 (195 out of 498, or 39.2%), followed by people aged 36-45 (32.7%) and 46-60 years (22.3%). Although respondents are young, they represent households made up of residents of all ages.

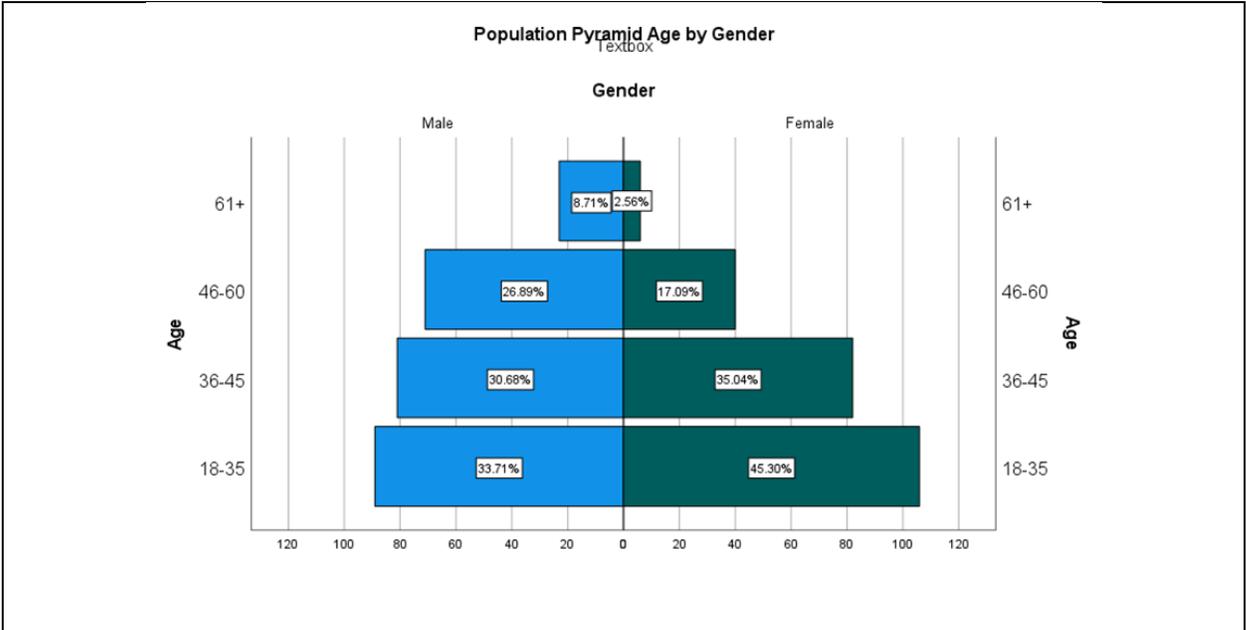
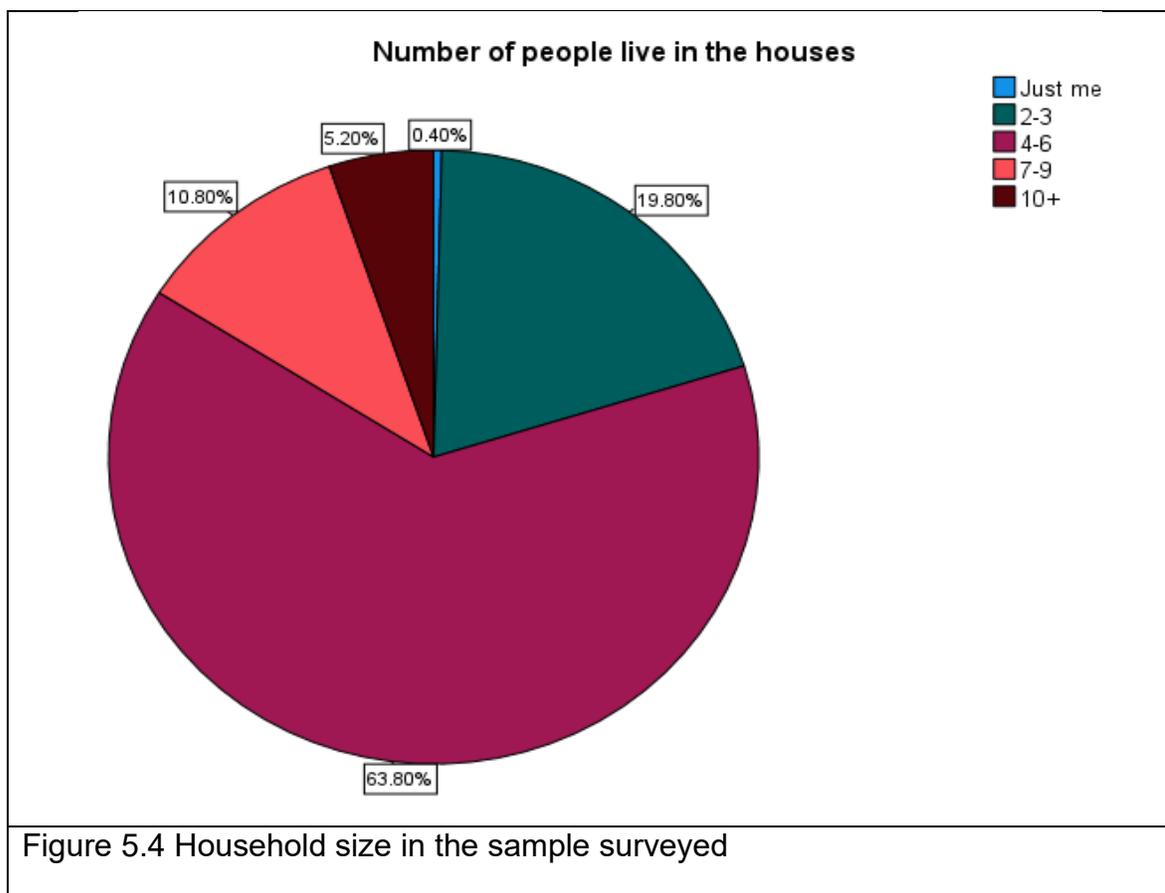


Figure 5.3 Age-sex composition of the survey

Figure 5.3 (the population pyramid) presents the age-sex composition of the survey population in NC areas in 2022. The age group of 18-35 is highest among males and females. The pyramid's shape confirms that it is a typical pattern in most developing countries that have started to stabilize. The pyramid presents a wider base at the bottom than the top and gradually narrows towards the older population.

The third type of demographic information collected was household sizes (number of people living in a house). Most respondents belonged to the 4-6 (63.80%), while the 2-3 and 7-9 accounted for 19.8% and 10.8%, respectively (Figure 5.4). This is similar to the Urban Socio-economic Assessment Survey of BBS (2019), where the average household size of urban areas (except Dhaka and Chattogram) is 4.11.



The fourth category of demographic information was collected, the household's income. Bangladesh Bureau of Statistics (BBS) provides household income data. They published their latest Household Income and Economic Survey (HIES) report in 2016, where the national average monthly household income is BDT 15945.00. However, this report does not give city-level data. Another survey report conducted by a reported private organization, the Power and Participation Research Centre (PPRC), in collaboration with UNDP, provides the city-level household income figure of Dhaka and other urban areas in Bangladesh. The PPRC- UNDP's Governance and Economic Survey in 2015 states that the average household income in other urban (except Dhaka and Chattagram) areas are BDT 24031. For this study, this figure is used as indicative when referring to the average monthly household income in NC. Respondents were asked to provide information on whether they belong to a below-average, average or above-average income group.

Table 5.2 Household income level of the survey respondent					
		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Below Average	146	29.3%	29.3%	29.3%
	Average	142	28.5%	28.5%	57.8%
	Above Average	210	42.2%	42.2%	100%
	Total	498	100%	100%	

Table 5.2 represents that out of 498 valid responses, the largest group belongs to the above-average income group, 42.2% (or 210 in number). In contrast, below average and average income groups are 29.5% and 28.5%, respectively.

The respondents were also asked to provide their occupation information. Respondents often did not give the specific titles of their job or business. As a result, the occupation level was categorized into two major sectors: business and service. It has been found that a considerable fraction of respondents, 51% worked in the business sector; the second largest fraction, 32.6%, worked in the service sector (Table 5.3). Notably, a significant portion of respondents are housewives (10.6%). Although they do many household activities, the economy does not recognise their contribution. If their work is recognized, it would be valued at BDT 30 403 per month (Trust-HealthBridge 2007).

			Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Business Sector	Business	253	51.0	51.0	51.0
	Service Sector	Job	150	30.0	30.0	83.6
		Day labourer	8	1.6	1.6	
		Expatriate	2	0.4	0.4	
		Retired	3	0.6	0.6	
	Sub-total Service Sector		163	32.6	32.6	
	Income from house rent		24	4.8	4.8	88.4
	Housewife		53	10.6	10.6	99.0
	Student		5	1.0	1.0	100.0
	Total		498	100.0	100.0	

The most common educational level of the head of the household was a primary school (30.6%), followed by High school (25.8%). It is observed that a significant number of household heads are illiterate (21.20%) (Figure 5.5).

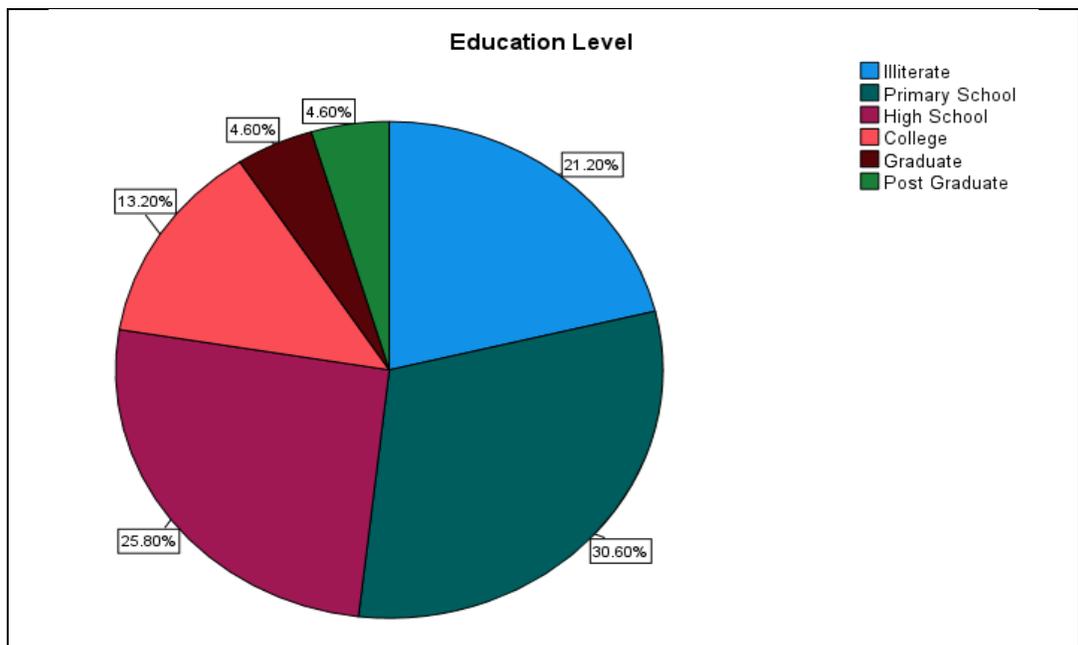


Figure 5.5 Educational level of head of household

5.4 Ecological Footprint of Narayanganj City

The idea of EF was introduced in the 1990s (Rees, 1992, Rees and Wackernagel, 1994; Wackernagel and Rees, 1996), which is used as a tool to track human impact on the environment concerning six different footprint land types expressed in a unit called global hectare (gha) per capita. These land types include carbon, cropland, grazing land, fishing grounds, forest products and built-up land. EF shows unsustainability by comparing it with that area's biocapacity. Unsustainability occurs if the area's ecological footprint exceeds its biocapacity. Biocapacity represents the earth's biologically productive land, including forests, pastures, arable land and fishing grounds (Rashid et al. 2018).

EF measurement is carried out using different techniques worldwide, including in Bangladesh. Most studies use secondary data at the national or local level and apply a top-down approach to measuring the EF of a city. On the other hand, this study measures EFs using a bottom-up approach with primary data collected by the household survey. A limited number of studies use primary data collected by household surveys (e.g., Holden 2004, Lee et al. 2019, Rashid et al. 2018; Khan and Uddin 2018). The uses of primary data are relevant for Bangladesh. Because, in Bangladesh, city-level data to measure EF is not available. In addition, in a top-down approach, there would be a chance of information loss (Aall and Norland 2005; Wilson and Grant 2009). A new but effective EF measurement calculator is also now available online.

As discussed in Chapter 2, different government agencies or private organizations have developed online calculators for measuring EF over the last few years. For instance, WWF, Global Footprint Network (GFN), the Austrian Ministry of Agriculture, Forestry, Environment and Water Management and the Environment Protection Authority of the State Government of Victoria in Australia have introduced online EF Calculators. Lee (2019) used the carbon reduction behaviour calculator and water footprint calculator of Taiwan's Environmental Protection Administration (EPA) to measure the carbon footprint and water footprint sub-component of EF. Rashid et al. (2018) measured the

EF of two cities in Pakistan, Bahria Town and Gulriaz Colony, using the online calculator of GFN.

This study also uses the online calculator of GFN to measure the EF of NC. Consequently, the questionnaire of this study was based on this online calculator. Some other relevant information, for example, demographic data, electricity and cooking fuel cost, mode of transportation, household waste generation tendency, recycling habit, and house construction material, were also collected to visualize their relationship with EF (Questionnaire- Appendix-1).

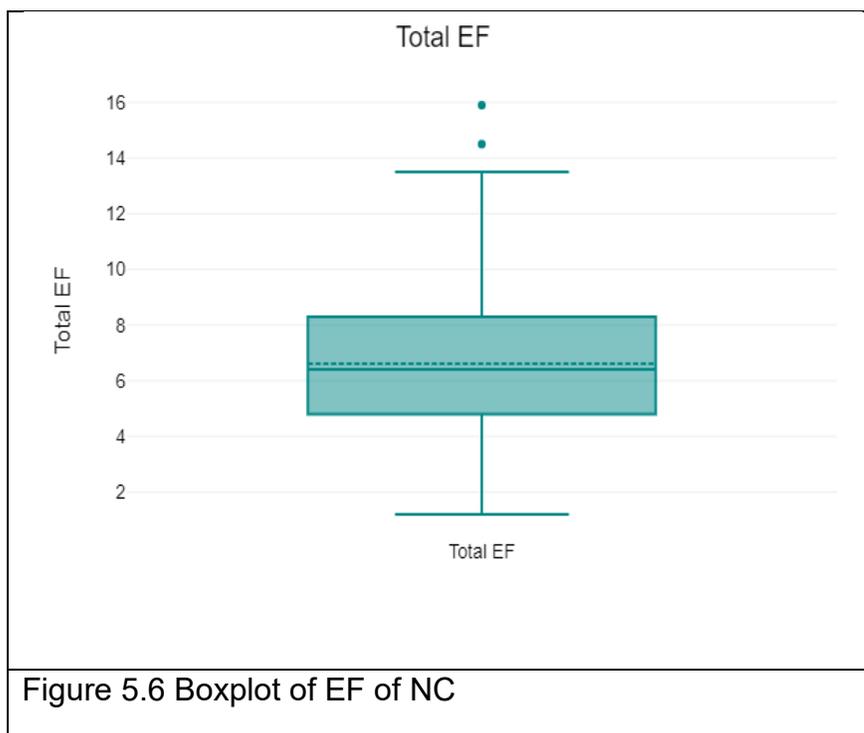
Table 5.4 presents the descriptive statistics of the EF of 498 respondents.

Table 5.4 Descriptive statistics of the EF of NC	
	EF
Mean	6.54
Median	6.40
Mode	7
Sum	3,305.2
Std. Deviation	2.48
Minimum	1.2
Maximum	15.9
Range	14.7
Skew	0.48
Kurtosis	-0.09
95% Confidence interval of Mean	6.39; 6.83
Mean \pm Std.	6.54 \pm 2.48

Table 5.4 shows that the mean value of EF is **6.54** gha. The median value of 6.40 gha indicates half of the respondents have EF above 6.4 and half have the below. Note that the mean value is higher than the median value, which tells us that some 498 respondents must have a higher EF than 6.4. It is also observed that the most frequently occurring EF is 7. However, the frequency of 7 is only 3.2% of the total sample, i.e. only 16 respondents have the EF of 7gha (due to space limit frequency

table is not presented here). The data also showed that the lowest value of EF is 1.2, and the highest is 15.9, for a range of 14.7.

One of the main shortcomings of the mean is that it is not resistant. That is, it is disproportionately affected by extreme values in the distribution. In terms of dispersion, we can see a standard deviation of 2.48. It is essential to be aware that a few extreme values can distort the central values like mean, mode, and median. Therefore, checking the data for unusually high or low values is advisable before employing these statistics (Acton et al. 2009).



The box plot (Figure 5.6) shows the dataset's two extreme values (usually called outliers). Including or excluding such an observation, especially if the small sample size, can substantially alter the results (Gujarati and Porter 2009). However, this study has a large sample size of 498 respondents. On the other hand, outlying observations can provide important information by increasing variation in the explanatory variables (which reduces standard errors) (Wooldridge 2013). Therefore, deciding to keep or drop such observations in a regression analysis can be difficult, and the statistical properties of the resulting estimators are complicated.

In such circumstances, it would be preferable to use other tools to conclude whether to keep outliers in this dataset, for example, the sample distribution. The histogram of the EF (Figure 5.7) indicates that the estimated EF is normally distributed, i.e. the data is symmetrical around its midpoint, the mean. To confirm this normal distribution, we can also consider the value of “skewness” (i.e. lack of symmetry) and “Kurtosis” (tallness or flatness). As a general rule of thumb, the smaller the absolute value of skew, the better, as this shows a more symmetrical batch of data. Also, if the absolute value of skew is below two, this is generally considered acceptable (Acton et al. 2009). In this survey sample, it is observed that the skewness value of EF is 0.48 (Table 5.4), which is pretty much less than two. Therefore, we can say that the distribution of EF is approximately symmetrical; that is, the EF is normally distributed.

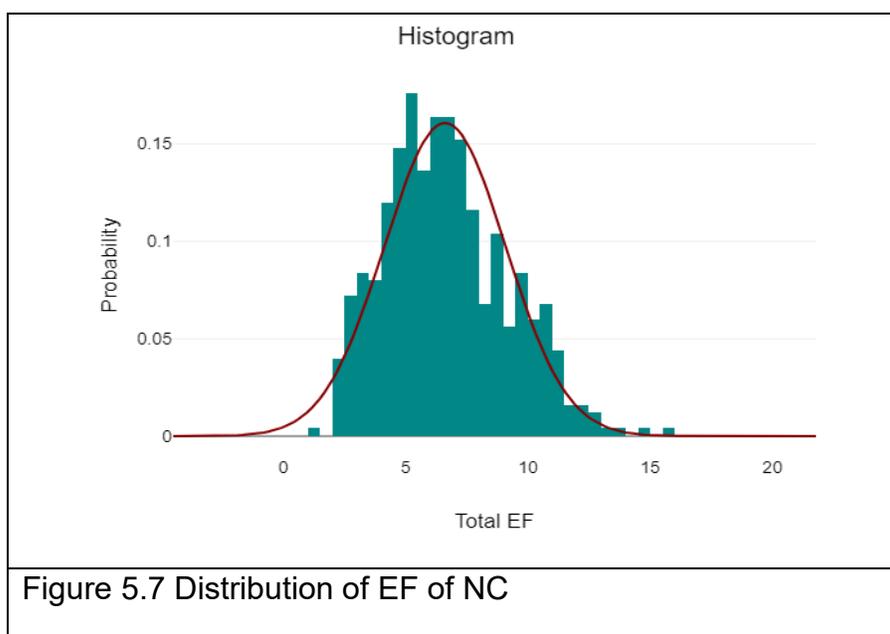


Figure 5.7 Distribution of EF of NC

On the other hand, Kurtosis refers to the extent to which the shape of the data distribution conforms precisely to the bell-shaped of a normal distribution. If kurtosis is zero, its shape of it is exactly normal. If kurtosis is a positive figure, the shape is more ‘humped’ than a normal distribution, with values tending to pile up or cluster in the middle. If kurtosis is negative, the shape tends towards being ‘flatter’ than a classic normal distribution. Here, the kurtosis value is negative, -0.09 (Table 5.4). Looking back at Figure 5.7, the histogram of EF, we can see that the distribution is slightly ‘flatter’

than the normal curve that is superimposed on it. So, we might not confirm that the distribution of EF follows a normal distribution.

To be more confirmed, some formal tests, for instance, Kolmogorov-Smirnov, Kolmogorov-Smirnov (Lilliefors Corr.), Shapiro-Wilk, and Anderson-Darling tests of normality, were applied. Table 5.5 shows that all the test results are significant at the 1% level. So, we can reject the null hypothesis of the data that is not normally distributed and accept the alternative hypothesis that the data is normally distributed.

	Statistics	p
Kolmogorov-Smirnov	0.07	.019
Kolmogorov-Smirnov (Lilliefors Corr.)	0.07	<.001
Shapiro-Wilk	0.98	<.001
Anderson-Darling	2.53	<.001

Moreover, the confidence interval of the mean (6.39 to 6.83) (Table 5.4) indicates that we are 95 per cent confident of the actual difference in the mean of the EF of the population from which we drew this particular sample lies within the range of 6.39 to 6.83 (Nardi 2018). In addition, the margin of error expresses the amount of random sampling errors in the survey results. The greater the margin of errors, the less confident we are that the results reported by the data are close to the actual figures, i.e., the figure for the entire population. The margin of error of EF of NC is +/- 0.217. It means that out of every 100 samples, on average, 95 of them will contain the population mean within 0.217 below or above the sample mean.

Therefore, it can be concluded that despite having two extreme EF values (outliers) in the sample survey, as the sample size is big (N=498), they have no significant influence over the mean. Furthermore, the data set is normally distributed, and the mean value of EF indicates the EF of NC is 6.54 gha, which is acceptable. However, it is essential to remember that there are different methods to measure the EF, and using the online calculator also has some limitations. Most importantly, one limitation is that entering the

same information several times does not give the same result (though very close). Moreover, social research might not have uncovered some data due to the method used. Some information might be out of reach. Perhaps top-down methods would have led to additional findings or contradictions (Nardi 2018). Simons et al. (2000) and Rashid et al. (2018) also consider the mean value of EF as the EF of the Island of Guernsey, UK and two cities in Pakistan, respectively. Inasmuch, it can be assumed that the per capita EF of **NC is 6.54 gha for 2022**.

5.5 Comparative Study of EF

5.5.1 Comparison with Bangladesh's EF

A comparison of the EF of NC with per capita EF and Biocapacity of Bangladesh reveals that the sustainability concern of NC is under threat (Figure 5.8). The data on Bangladesh's EF and Biocapacity were collected from GFN. It should be noted that GFN does not **provide** city-level EF and biocapacity of Bangladesh. As a result, the estimated EF of NC is compared with Bangladesh's per capita EF and Biocapacity.

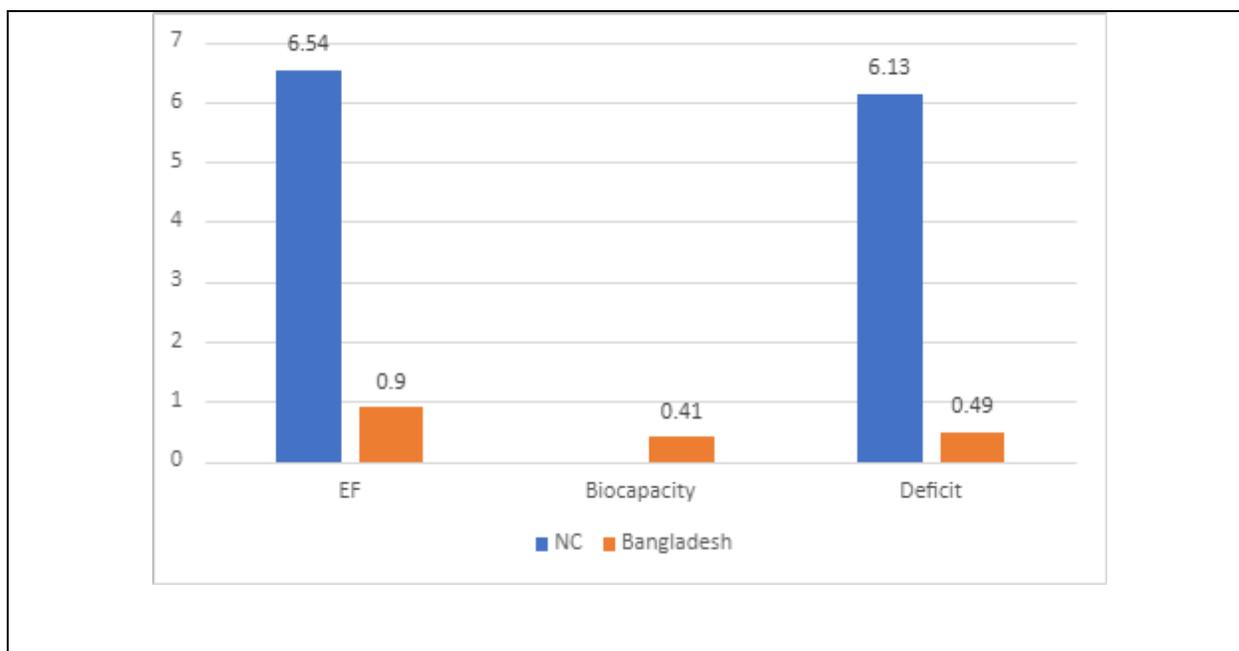


Figure 5.8 NC and Bangladesh's EF and ecological deficit (data source household survey and GFN)

Figure 5.8 shows that the EF of NC is sixteen times higher than the Biocapacity of Bangladesh. The higher the value of the EF (gha/capita), the higher the demand for resources and services and vice versa (Galli et al. 2015). The per capita ecological deficit of NC and Bangladesh is 6.13gha and 0.49gha, respectively. The per capita deficit (6.13gha) of NC is much greater (12.51-fold) than that of Bangladesh's deficit (0.49gha). This deficiency is signalling the overconsumption and unplanned materials flow in different sectors of the study area. The people of NC consume much more resources than the biocapacity of Bangladesh.

According to the working guidebook to the national footprint accounts by Lin et al. (2018), the six components of EF indicate six different productive land areas needed for each human activity. Table 5.6 shows the representation of each component of EF.

Table 5.6 Representations of the component of EF		
SL. No	Component of EF	Representation
1	Built-Up land	Bio-productive land that human activities have physically occupied.
2	Forest Products	The area of average forest land needed to supply wood for fuel, construction and paper.
3	Cropland	Land necessary to grow all crops consumed by humans and livestock.
4	Grazing Land	Demand for grazing land to feed livestock and the embodied demand for grazing land in traded goods.
5	Fishing Grounds	The demands of fisheries on aquatic ecosystems as the equivalent surface area required to sustainability support of an area.
6	Carbon Footprint	The area of forest land required to sequester anthropogenic carbon dioxide emissions.
Source: Author's creation based on Lin et al. (2018)		

This study also discloses that the components of EF of NC are much higher than those of Bangladesh (Figure 5.9). Specifically, the grazing land (0.13) of NC is thirteen-fold

higher than that of Bangladesh (0.01). According to GFN, grazing land calculation is the most complicated part of EF. It assesses the demand for grazing land to feed livestock and the embodied demand for grazing land in traded goods. Therefore, it can be inferred that the **people of NC consume thirteen times more livestock than an average Bangladeshi consumes**. Similarly, carbon footprint, forest products, fishing grounds, cropland and built-up land are 12.5, 7.75, 7, 3.51, and 2.62 times higher than the average Bangladeshi.

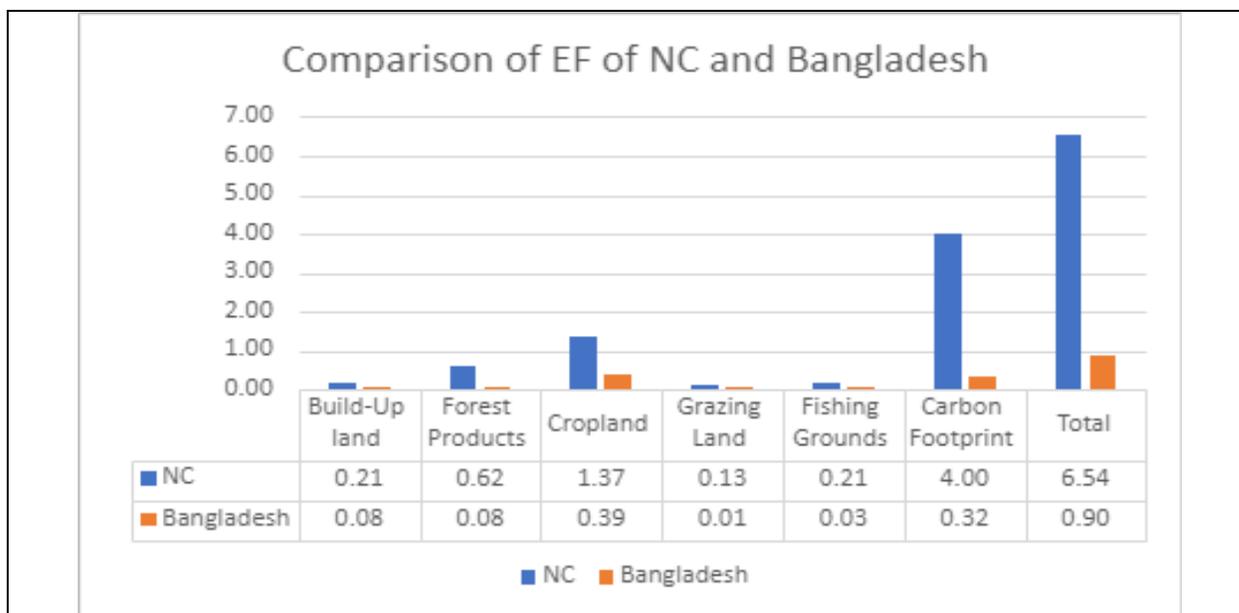
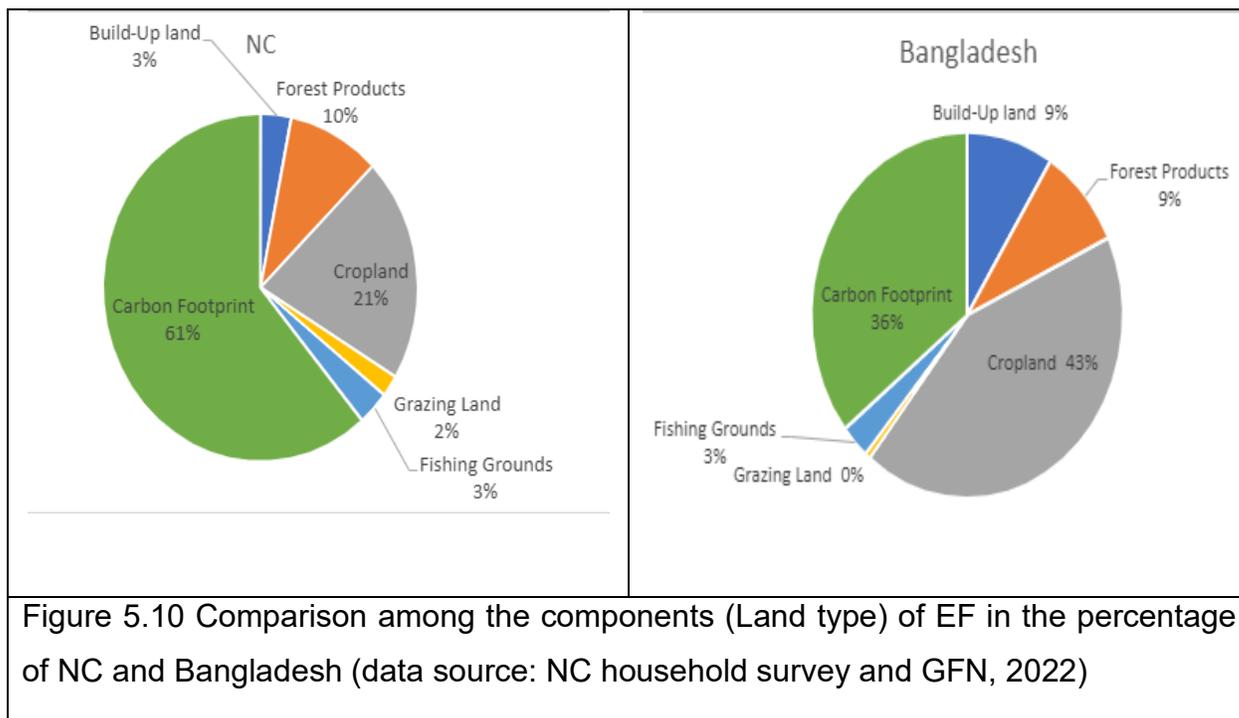


Figure 5.9 Comparison of the different components of EF of NC and Bangladesh (source Author's calculation)

In percentage terms, this study also found that more than sixty per cent of EF comprised carbon footprint, cropland and forest products constitute above twenty and ten, respectively (Figure 5.10). It is also noticeable that the carbon footprint of NC (61%) is much higher than that of Bangladesh **carbon footprint (36%), which reflects that people of NC have been using more fuels and transport that directly release carbon dioxide**. They also consume more energy like electricity, natural gas, water, food, and transport and generate more waste than the average country's people, which causes indirect effects on GHG emissions. Moreover, emissions related to household consumption largely depend on the living standards of the area; higher living standards

lead to more emissions. **Therefore, the EF results indicate people of NC consume much more resources than Bangladesh overall.**



EF by consumption type also exhibit (Table 5.7) that shelter accounted for more than thirty-eight per cent of EF. The other two major contributors are food (25.23%) and goods (17.89%). It indicates that proper policy interventions should be taken to reduce the emissions from household-level energy consumption through electricity, cooking fuel, water, and waste generation. However, reducing consumption has some interrelated effects. As a result, policy options or interventions for reducing consumption could not bring a linear result.

Sl. No.	Footprint Category	Footprint (gha)	Percentage
1	Shelter	2.51	38.38%
2	Food	1.65	25.23%
3	Goods	1.17	17.89%
4	Services	0.91	13.91%
5	Mobility	0.30	4.59%
Total Footprints		6.54	100%
Source: Authors calculation.			

Moreover, as household income increases, consumption levels will also increase. For example, with the increase in living standards, household energy consumption will also increase. Similarly, as NC is an industrial hub of the country, more people rush to this city. As a result, there is no alternative to sheltering them. They also have no proper knowledge of urban life. For instance, they do not know the culture of urban waste management and other things. There is a lack of urbanism. These things cannot be achieved by taking policy only. Apart from policy formulation, some indirect policy interventions to reduce or regulate consumption patterns should be taken to address the sustainability concern of urban life.

Comprehensive city-level EF calculations for the other city of Bangladesh are very scarce. More specifically, no other study uses EF calculators for measuring the EF of a city in Bangladesh. Sameen and Feroze (2020) measure the EF of all districts of Bangladesh for 2016 by using secondary data. They also found that the Narayanganj district has the highest EF (**1.31 gha**) among all districts of Bangladesh, even more than the other four major industrial districts viz Narasingdhi, Tangail, Gazipur, Chattogram and Dhaka (Figure 5.11). However, their measurement area includes suburban and rural areas rather than urban ones. In another study, Khan and Uddin (2018) estimate the EF of a ward of Khulna City Corporation, another major city in Bangladesh, following the component and direct method. They have found that the EF of this ward is 0.7161gha/capita for 2015. Rashid et al. (2018) quantify the EF of two urban areas of Rawalpindi, Pakistan (Bahria Town and Gluraiz Colony) using the online calculator of GFN. They reported that the EF of Bahria Town and Gluriaz Colony is 8.6gha and 6.9gha, respectively. It reflects that the urban dwellers of these two areas lead more luxurious lives and consume more resources than in NC.

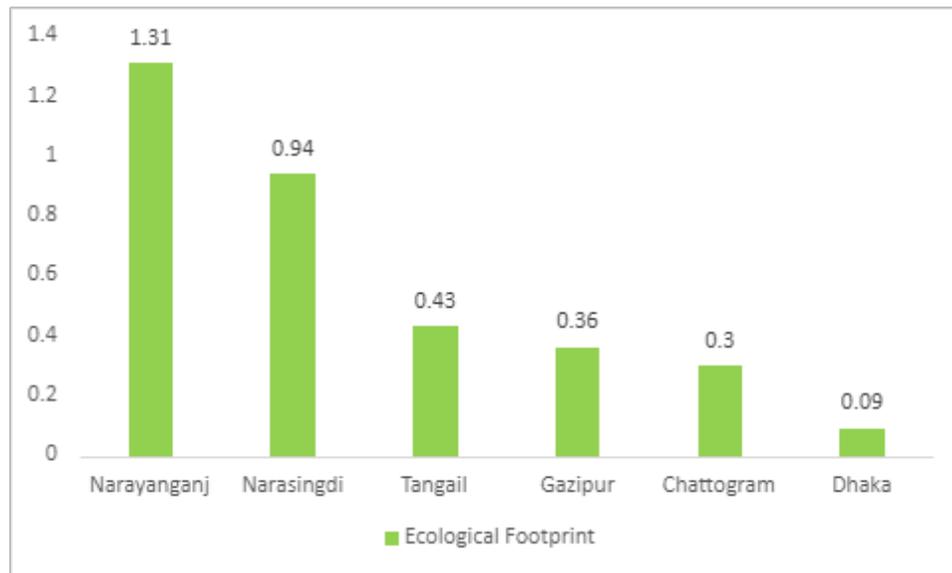


Figure 5.11 EF of different districts of Bangladesh (computed by Sameen and Feroze 2020)

Therefore, it is found that the result of my study is consistent with the results of Sameen and Feroze (2020) and Rashid et al. (2018) in that the EF of NC is much higher than that of Bangladesh. The people of NC consume more resources and also create more pressure on its environment. This result also indicates that NC is not growing sustainably from EF's viewpoint. As a result, BD will soon be unable to afford more urbanization.

5.5.2 Comparison of EF among Different Regions of NC

Apart from the comparison with Bangladesh, the EF of NC is compared among the three regions of NC. As mentioned earlier, NC is constituted by the merger of three former municipalities, viz Narayanganj, Shiddhirganj and Kadamrasul, NC is also divided into three regions with an equal number of wards (the small administrative wing of the city corporation), i.e. nine wards in each region. These three regions are different from each other. For instance, in terms of the population, almost thirty-six per cent of people live in Shiddhirganj (region-1), whereas Narayanganj region (region-2) covers almost forty per cent, and 23.44% in Kadamrasul (region-3) (BBS 2011). The survey data also discloses that these three regions differ regarding income level (Figure 5.12) and household size (Figure 5.12).

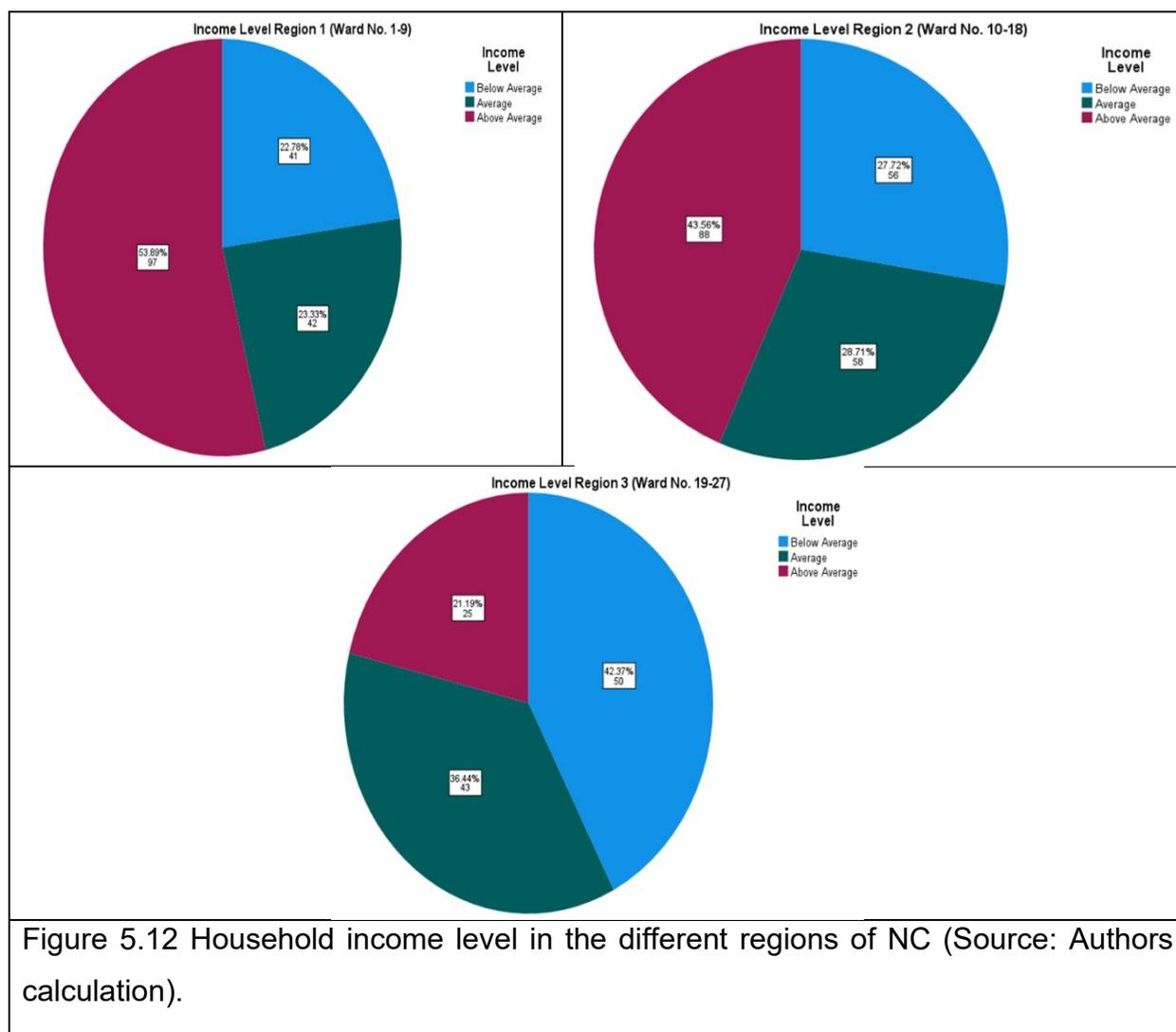
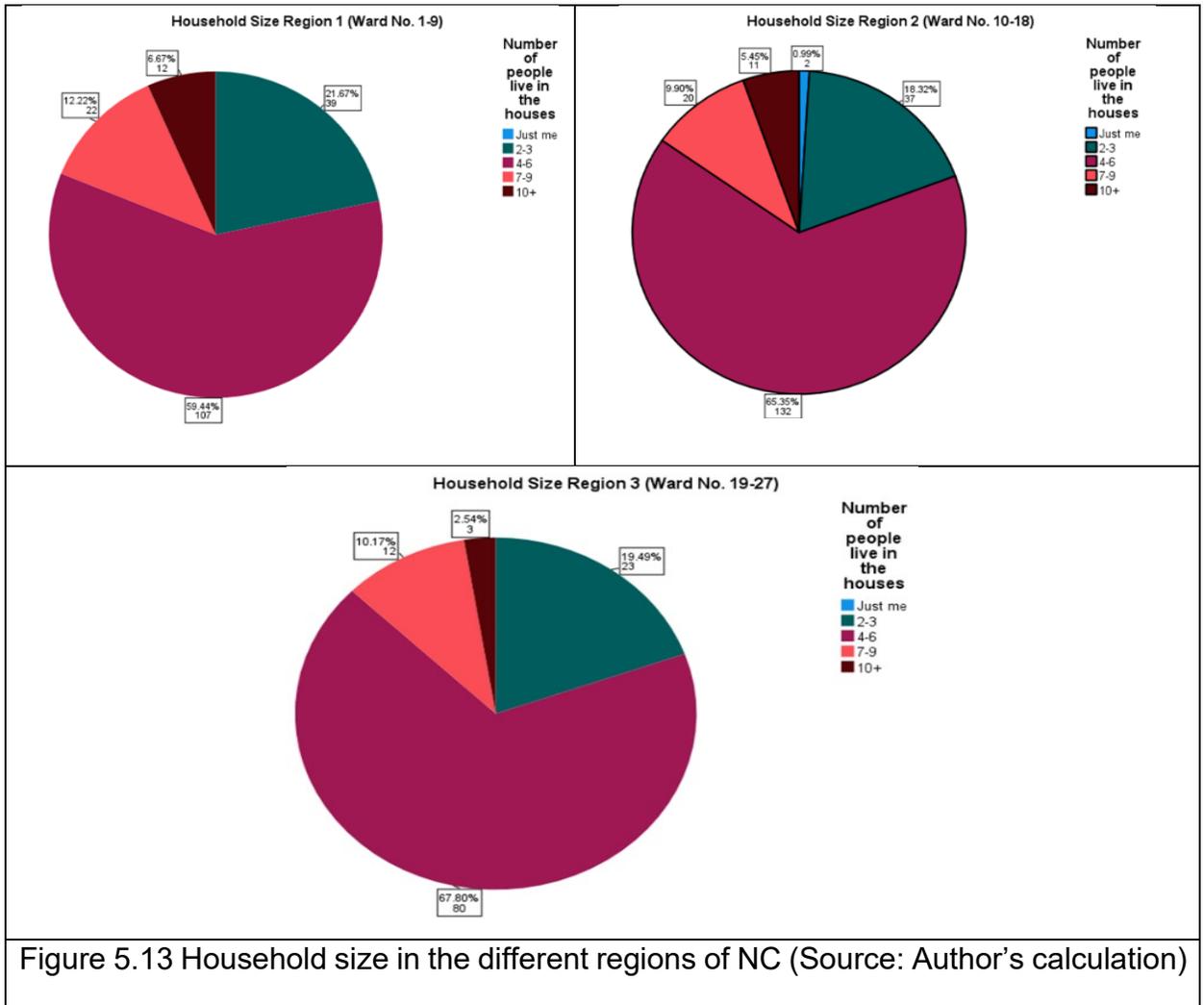


Figure 5.12 presents the most above-average income level people (53.89%) living in region-1, whereas region-3 has the lowest (21.19%). Similarly, figure 5.13 shows that most people in all regions have household sizes (number of people living in a house) of 4-6. However, region-1 has a more household size of 7-9 (12.22%) and 10+ (6.67%) than the other two regions.



These three regions also differ in house size (square feet). Table 5.8 shows that among the three regions, region-3 has the highest percentage of people (29.7%) who have a larger size of houses (above 1500 sqft.).

Category		Region-1	Region- 2	Region-3	NC
	Small (120-500)	79 (43.9%)	67 (33.2%)	16 (13.6%)	162 (32.4%)
	Medium (500-1500)	62 (34.4%)	106 (52.5%)	67 (56.8%)	235 (47%)
	Large (1500<)	37 (21.7%)	29 (14.4%)	35 (29.7%)	101 (20.6%)
	Total	178 (100%)	202 (100%)	118 (100%)	498 (100%)

Source: Author's calculation.

These differences are also reflected in the EF of these regions (Figure 5.14). People with high-income levels are generally expected to have a high EF. As more high-income people live in region -1, this region has the highest EF of **6.82gha**. This indicates that the NC authorities should pay more attention to region -1. Although more high-income people live in region 1, during the survey, it was visible that this region is lagging in terms of road, drainage and waste management infrastructure. One of the data enumerators was about to get sick because of the foul smell of roadside waste dumping.

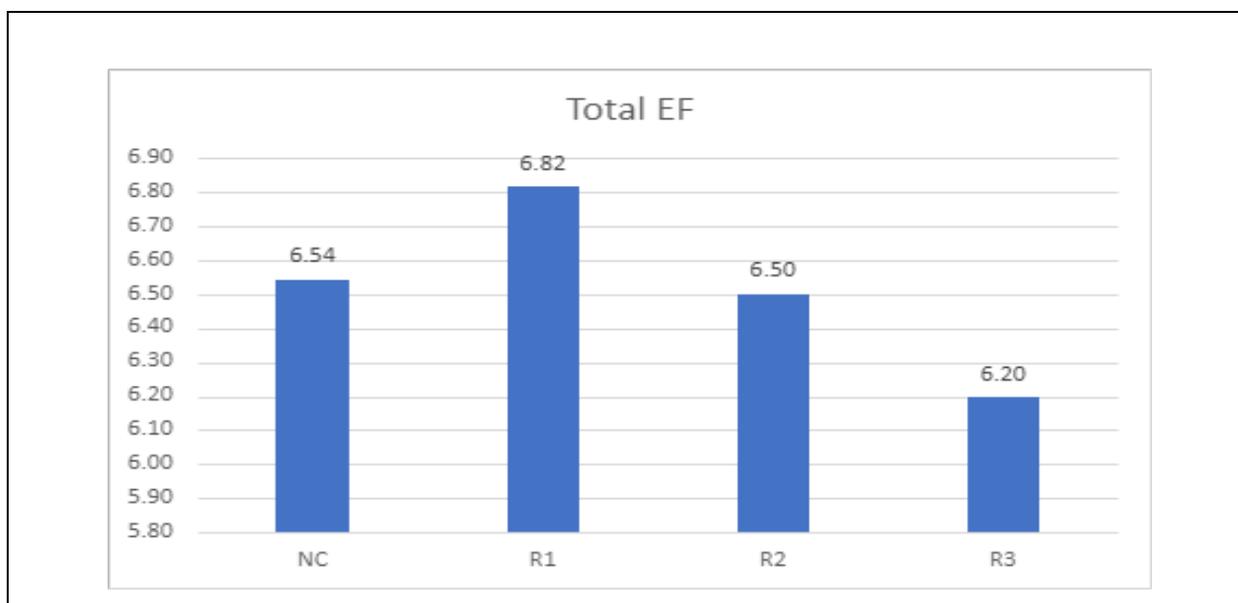


Figure 5.14 EF of different regions of NC (Source: Author's calculation)

5.6 Major Driving Forces of EF of NC

Major driving forces of EF have been searched in different studies. Rashid et al. (2018) found household income as the major driving force of EF in two cities in Pakistan. With regression analysis, they observed that with the increase in household income, EF also increased. One-way ANOVA analysis of Lee (2019) posit that gender, occupation, age, educational level and personal annual income have no correlation with EF in the 12 districts of Taipei, one of Taiwan's most densely populated cities. Using the STIRPAT model, Wang et al. (2010) identified urbanisation and GDP as the fundamental driving force of EF of West Jilin Province, Northeast China, from 1986 to 2006. Dietz et al. (2007) suggested that population, GDP, and land area significantly impact the EF of countries with populations over one million globally. Marquar-Pyatt (2015) investigated the major driving forces of EF by using Prais-Winsten (PW) regression model with panel-corrected standard errors.

Instead of using Prais-Winsten (PW) and STIRPAT model, this study uses MLR (Multiple Linear Regression) to explore the driving forces of EF of NC. Because the PW and STIRPAT model needs time series data (Marill 2004), the EF of NC could only measure for 2022. MLR also provides a better understanding of individual factors' association with outcome and independent variables. In addition to MLR, ANOVA, and crosstabulation, correlations were also used to search the driving forces of EF of NC.

5.6.1 Cross Tabulation

Frequency distribution and other descriptive statistics, such as measuring central tendency and dispersion, are insufficient to represent the relationship between two or more variables. To verify the existence and strength of any relations among variables, cross-tabulation or contingency table is the main tabular method (Rea and Parker 2014).

Since to explore the driving forces of EF, the cross-tabulation between household income, EF and gender of NC was carried out. Firstly, the results were tested against the household income of the respondents, and secondly, gender was included. The ANOVA test shows (Table 5.10 and 5.12) that the relationship is significant for both

cases. Moreover, to measure the strength, the spearman correlation technique was also used (Table 5.13).

The cross-tabulation of EF by household income (Table 5.9) reveals an apparent difference in EF among the income groups, reflecting the finding that the people who belong to the **above-average income group** have the highest EF of 7.63 gha. This reflects a relationship between household income and EF; higher-income people have a higher EF. It also reflects a positive linear relationship, and the average value is steadily reduced as we pass through the EF line.

Table 5.9 EF by household income					
	Household Income				Total
		Above Average	Average	Below Average	
Frequency (%)		210 (42.08%)	142 (28.46%)	146 (29.46%)	498 (100%)
EF	Mean	7.63	6.26	5.46	
	Median	7.1	5.9	5.3	
	Modal	5.2	5.4	5.5	
	Sum	1,601.6	888.6	803.3	
	Std. Deviation	2.26	2.46	2.29	
	Minimum	2.9	2	0.3	
	Maximum	13.4	15.9	12	
	Number of valid values	210	142	146	498
Source: Author's calculation.					

A one-factor analysis of variance (ANOVA) in Table 5.10 shows a significant difference between household income and EF, $F= 42.799$, $p<.001$ (Table 5.10). Therefore, I have rejected the null hypothesis of no difference and concluded that EF difference could be attributed to the difference in household income, not by chance.

	Sum of Squares	df	Mean Square	F	Sig
Between Groups (Combined)	430.706	2	215.353	42.789	<.001
Within Groups	2501.347	496	5.033		
Total	2932.053	497			

Source: Author's calculation

It is also possible to add a third variable to a contingency table analysis by constructing a contingency table that cross-tabulates the dependent and independent variables while holding the third (control) variable constant (Rea and Parker 2014).

								Total
	Household Income	Above Average		Average		Below Average		
	Gender	Male	Female	Male	Female	Male	Female	
	Frequency (%)	108 (21.73%)	102 (20.52%)	84 (16.9%)	58 (11.47%)	71 (14.29%)	75 (15.09%)	498 (100%)
EF	Mean	7.75	7.49	6.56	5.8	5.64	5.25	
	Median	7.55	7	6.3	5	5.3	5.1	
	Modal	9	5.2	6.1	4.8	5.5	2.6	
	Sum	837.2	764.4	551.1	330.5	400.7	393.9	
	Std. Deviation	2.24	2.29	2.21	2.76	2.33	2.23	
	Minimum	3.3	2.9	2.6	2	2.2	0.3	
	Maximum	12.6	13.4	11.1	15.9	11	12	
	Number of valid values	108	102	84	58	71	75	100

Source: Authors Calculation.

Table 5.11 shows such a cross-table where the EF of NC was cross-tabled against household income and gender. This is ordinarily referred to as a three-way cross-

tabulation because I suspect that there could be an additional variable that could be involved in the relationship between EF and household income. Male seems to have more EF in all income groups. Figure 5.15 also reveals that males of all income groups have a higher EF than females. For instance, above-average-income males have an EF of 7.75gha, whereas females of the same income group have an EF of 7.49gha.

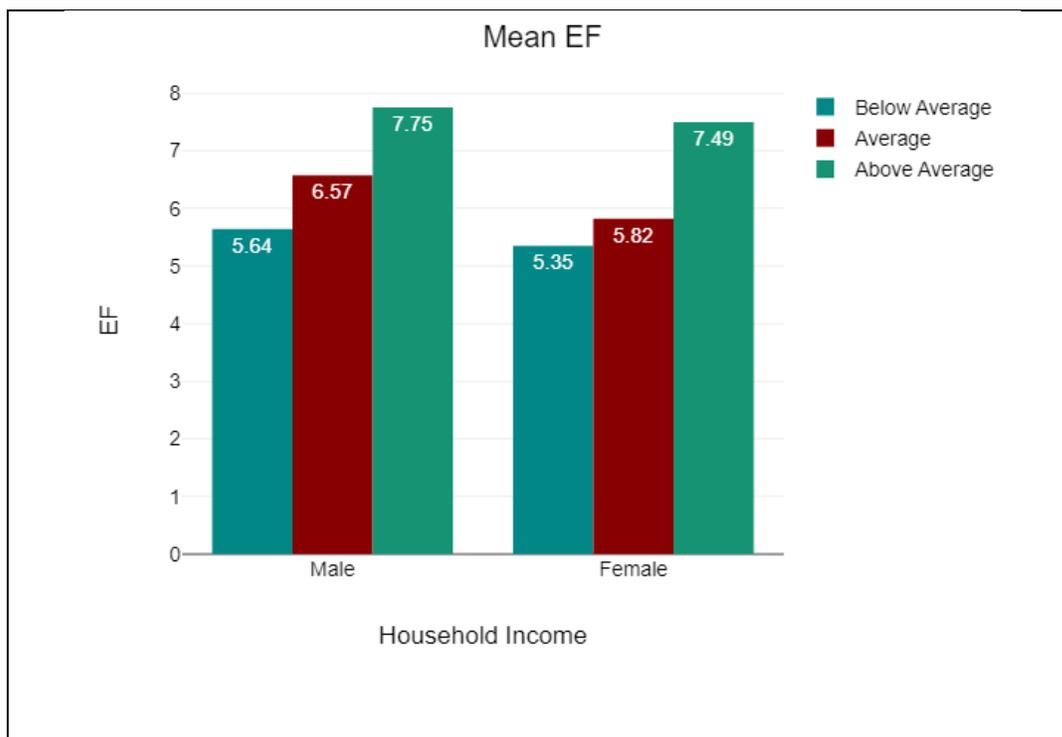


Figure 5.15 EF by gender and household income (Source: Author's calculation)

A two-factor analysis of variance (ANOVA) in Table 5.12 without repeated measures was conducted to test whether there is a difference between the groups of the independent variable household income to the dependent variable EF and whether there is an interaction between the two variables Gender and Household Income concerning the dependent variable EF.

Table 5.12 Two-factor ANOVA without repeated measures					
	Type III Sum of Squares	df	Mean Squares	F	p
Corrected Model	443.52	5	88.7	16.62	<.001
Intercept	21,849.62	1	21,849.62	4,093.1	<.001
Gender	21.27	1	21.27	3.99	.046
Household Income	417.28	2	208.64	39.08	<.001
Gender x Household Income	4.97	2	2.48	0.47	.628
Error	2,637.05	494	5.34		
Total	24,930.19	498			
Corrected total variation	3,080.57	497			
Source: Authors calculation.					

The two-factor analysis of variance without repeated measures (Table 5.12) confirmed that there is a significant difference between the groups of the independent variable gender concerning the dependent variable EF [$p=.046$], and there is also a significant difference between the groups of the independent variable Household Income with the dependent variable EF [$p<.001$]. It means the differences did not happen by chance. It is a finding due to the actual influence of **household income and gender on EF**. It has also shown no interaction between the two variables Gender and Household Income with the dependent variable EF, [$p=.628$]. One possible explanation for this could be that, unlike men, women are usually responsible for doing all household

activities, including preparing meals, childcaring and others. As a result, most of the time, they stay at home.

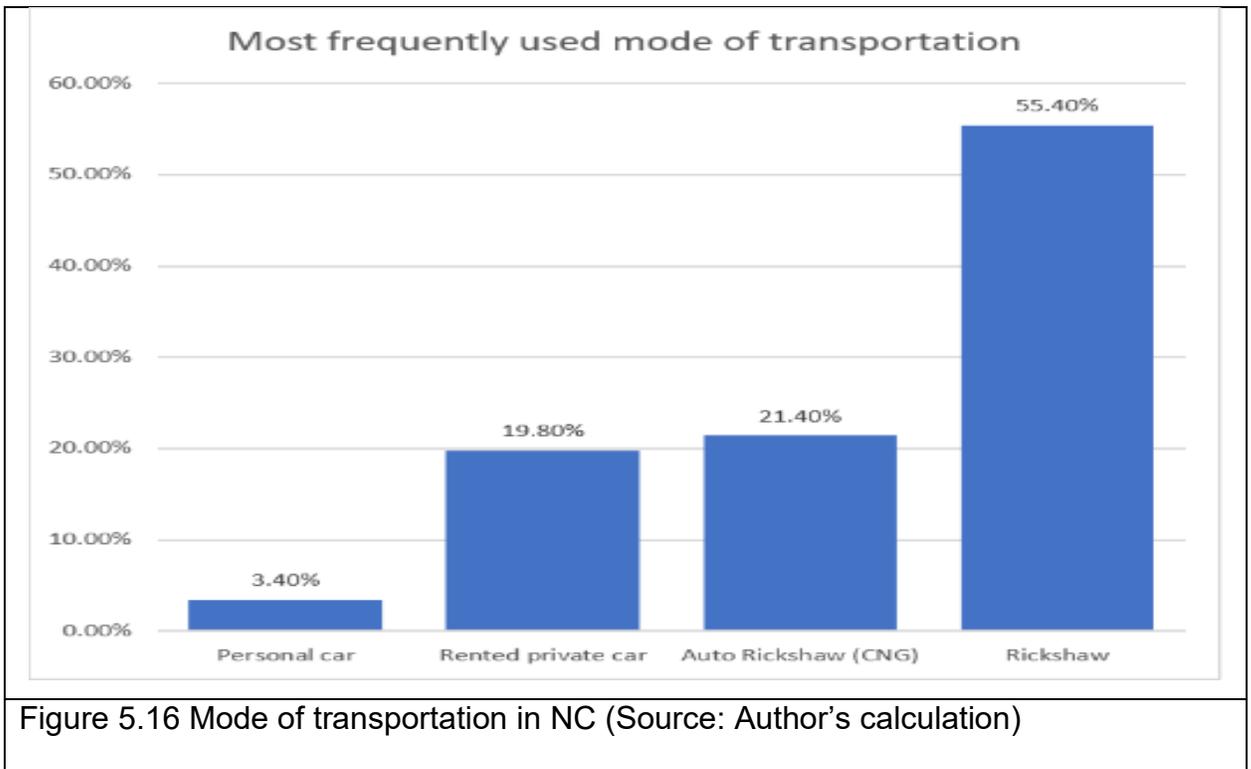
Statistical significance tests are insufficient because they only determine whether a relationship exists between variables. However, it does not measure the strength of the relationship. As a result, the measurement of strength is an essential tool that reflects the intensity of the relationship and deserves reporting (Rea and Parker 2014). Fortunately, several statistical tools are available to measure the strength of association, for example, correlation analysis.

Therefore, a spearman correlation was performed to measure the strength of relationship among EF, Gender and Household income.

Table 5.13 Spearman correlation analysis between EF, household income and gender			
	Gender	Household Income	EF
Gender	1		
Household Income	0.01 (.766)	1	
EF	0.1 (.02)	0.37 (<.001)	1
Source: Author's calculation			

The Spearman correlation result presented in Table 5.13 revealed that there was a significant low positive association between EF and Gender ($r = 0.1, p = .02.$) and a significant medium positive association between household income and EF ($r=0.37, p<.001$).

Another important finding of this research is that most of the survey respondents (55.40%) use rickshaws (three-wheeler peddled carriers) as a mode of transportation (Figure 5.16).



As a result, cross-tabulation between the mode of transportation and EF of NC was also conducted. This cross-tabulation shows that people who use privately rented cars have the highest EF of 7.97 gha (Table 5.14). This indicates a relationship between the **mode of transportation** and EF of the people who use rented private cars; they have high EF. It also reflects a positive linear relationship; as we move across the EF row, the mean value steadily increases from rickshaw to rented private car (6.13 → 6.39 → 7.85 → 7.97).

		Transportation Mode			
		Rickshaw	Auto Rickshaw (CNG)	Personal car	Rented private car
EF	Frequency	277	107	17	99
	%	55.4%	21.4%	3.4%	19.8%
	Valid %	55.4%	21.4%	3.4%	19.8%
	Mean	6.13	6.39	7.85	7.97
	Std. Deviation	2.34	2.48	2.52	2.33
	Minimum	1.2	2.2	3.3	3
	Maximum	14.5	15.9	11.6	12.7
Source: Author's calculation					

A one-factor analysis of variance result of Table 5.15 confirmed that this significant difference between the mode of transportation and EF is not by chance ($F = 16.37$, $p = <.001$). A Spearman correlation result is also presented in table 5.15, which measures the strength of association among these variables. The result shows that there is a significant positive association ($r=0.28$) between the mode of transportation and EF ($r = 0.28$, $p = <.001$).

Table 5.15 ANOVA and spearman correlation between mode of transportation and EF						
ANOVA						
	Sum of Squares	df	Mean Squares	F	p	Critical F-Value
Between Groups	277.62	3	92.54	16.37	<.001	2.62
Within Groups	2,803.57	496	5.65			
Total	3,081.19	497				
Spearman Correlation Analysis						
	r	0.28	$p = <.001.$			
Source: Author's calculation						

5.6.2 Multiple Linear Regression (MLR)

So far, it has been established that household income, gender and mode of transport are the driving forces of EF of NC. Apart from these, it might also be assumed that some other things, for example, respondents' age, electricity bill, cooking fuel cost, the energy efficiency level of the house, housing type, educational level, waste generation habit, and recycling practice have a significant effect on EF. Cross-tabulation, ANOVA and correlation analysis can also be done among these variables. However, MLR analysis can capture all variables in a single equation (Rea and Parker 2014). As a result, MLR was done to unveil the effects of all variables.

Moreover, Rea and Parker (2014) argued that tests of significance with cross tabulation and measurement of association with correlation study are not enough to predict the exact value of dependent variables based on the value of the independent variables. However, the exact value prediction is possible by applying regression analysis. Therefore, instead of using cross-tabulation and correlation analysis, an attempt is also made for regression analysis.

While analysis is focused on such prediction types, examining the overall impact of a set of variables and their collective impact on the dependent variables is common. When the joint impact of variables is examined, it is usually done by constructing a model (De Vaus 2014). As a result, a multiple linear regression model (MLR) is constructed for this study.

Model Construction:

The MLR model is based on the idea of a straight line that has the formula of

$$Y=a+bX$$

Where,

- Y = The value of the predicted dependent variable is sometimes called the criterion and, in some formulas, represented as Y' to indicate Y-predicted;
- X = Value of independent variable or predictor;
- a = Constant or the value of Y when X is unknown that is zero. It is the point on the Y axis where the line crosses when X is zero;
- b = It is the slope or angle of the line, and because not all the independent variables contribute equally to explaining the dependent variable, b represents the unstandardized weight by which the value of X is adjusted. For each unit of X, Y is predicted to go up or down by the amount of b.

Linear regression analysis calculates the constant (a), the coefficient weights for each independent variable (b), and the overall multiple correlations (R). The formula for the estimation of a multiple linear regression model is (Nardi 2018):

$$Y = a+ bX_1+ bX_2+bX_3+bX_4.....b_nX_n +e$$

Multiple linear regression is a powerful means of carrying out a causal analysis. However, this powerful means have a severe limitation that it only considers the interval/numerical variables. Despite this, the advantage of using MLR is that it could tolerate some violation of its assumption. If there is a large sample size (100 cases or more), categorical variables in regression can be introduced, particularly as independent variables. This is possible by converting categorical variables into a series of dummy variables (indicator or binary) with just two categories coded 0 and 1. It can be used to discriminate between the categories of a predictor. The values of dummy variables can be directly compared even when not standardized (De Vaus 2014, Acton et al. 2009, Von Eye and Schuster 1998).

The number of dummy variables must always be one less than the number of categories of the original variable, i.e. $K-1$ categories, to avoid technical problems with multiple regression-multicollinearity. For instance, if gender is variable, then the two categories ($k=2$)-male and female-can be accommodated by creating one new dummy variable ($k-1=1$), where a code of 1 would indicate male and 0 would indicate female. If there are five categories, then four dummy variables would be created. The category for which a dummy variable is not created, i.e. the omitted category, becomes a baseline for which the regression coefficient is compared to other categories. In dummy regression, the estimate for the omitted category is obtained using the intercept. Given that the intercept represents the regression estimate for the omitted category, the coefficient (b) figures for the groups represented by the dummy variables can be interpreted as being that much higher (or lower) than the omitted category. If one equation uses more than one set of dummy variables, the interception value will represent the value for the combination of omitted categories (De Vaus 2014, Rea and Parker 2014).

In summary, by converting categorical variables into a series of dummy variables or dichotomous variables coded 0 and 1, it is possible to extend the power of multiple regression to problems where not all variables are measured at the interval level (De Vaus 2014). Given that, while exploring the driving force of EF of NC, 30 dummy variables were created (Table 5.16).

Table 5.16 Variables used in the MLR

Dependent Variable: EF					Expected effect (+/-)
Independent Variables	Category	Reference Category	S.N	Dummy variables	
Household Income	Below Average	Below Average	1	Average Income	+
	Average		2	Above Average Income	+
	Above Average				
Gender	Male	Female	3	Male	+
	Female				
Mode of Transportation	Rickshaw	Private Car	4	Rickshaw	-
	Auto-rickshaw (CNG)				
	Rented Private Car		5	Auto-rickshaw (CNG)	-
	Private Car		6	Rented Private Car	-
Level of Education	Illiterate	Illiterate	7	Primary School	-
	Primary School		8	High School	-
	High School		9	College	-
	College		10	Graduate	-
	Graduate		11	Post-graduate	-
	Post-graduate				
Energy Consumption	Electricity Bill (EB)		12	Interval variable. As a result, dummy variables are not needed.	+
	Cooking Fuel Cost (CFC)		13		+
Housing Type	Free-standing no, running water	Luxury Condominium	14	Free-standing no, running water	-
	Free-standing running water		15	Free-standing running water	-
	Duplex row house or building with 2-4		16	Duplex row house or building with 2-4	-
	Multistory Apartment		17	Multistory Apartment	-
	Luxury Condominium				
Number of people living in the house	Just me	10+	18	Just me	+
	2-3		19	2-3	+
	4-6		20	4-6	+
	7-9		21	7-9	+
	10+				

Dependent Variable: EF					Expected effect (+/-)	
Independent Variables	Category	Reference Category	S.N	Dummy variables		
Household waste generation tendency compared to neighbor	Much less	Much less	22	Less	+	
	Less		23	Same	+	
	Same			More	+	
	More			24	More	+
	Much More			25	Much More	+
Practicing recycling	Bottles	Nothing	26	Bottles	-	
	Old/used unwanted cloth		27	Old/used unwanted clothes	-	
	Old Newspapers		28	Old Newspapers	-	
	Unwanted Metal Items		29	Unwanted Metal Items	-	
	Nothing					
Housing construction materials	Brick/Concrete	Steel/Other	30	Brick/Concrete	-	
	Steel/Other					

In SPSS, different options exist, e.g., 'enter', 'stepwise', 'removed', and 'forward' for conducting MLR. Among these options, stepwise is helpful if there are many independent variables since those that are initially most significant will get the first shot at explaining the variance in the dependent variable (Acton et al. 2009). I have 30 independent variables, so MLR was done by following this option.

The stepwise procedure goes through thirteen steps, adding a new variable each time and hence produces thirteen models. Variables are only dropped if their coefficients become non-significant. Therefore, if we look at the final model thirteen, it is revealed that variables listed as excluded variables in Table 5.20 have no significant effect on the dependent variable EF (SPSS Output- Appendix-12).

The model summary in Table 5.17 shows how the general fit of the regression improves with each step from Model 1 to 13. Note that 'Adjusted R square' gradually rises from 14.1 to 45.6 per cent of explained variance in the dependent variable EF. The Durbin-Watson statistic at the final stage indicates the overall extent of multicollinearity between the variables. If it is less than 1.0, there may be problems. If tolerance is

greater than 0.4 and VIF is less than 10, we are on safe grounds (Acton et al. 2009). I have found that DW is well above one at 1.87, and so as tolerance and VIF values (Table 5.19). So, models are safe from multicollinearity problems (Table 5.19).

Table 5.17 Model summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
Dependent Variable: EF					
1	.375 ^a	.141	.139	2.28204	
2	.429 ^b	.184	.180	2.22675	
3	.487 ^c	.237	.232	2.15513	
4	.537 ^d	.288	.282	2.08361	
5	.573 ^e	.328	.321	2.02679	
6	.603 ^f	.364	.356	1.97316	
7	.635 ^g	.404	.395	1.91274	
8	.649 ^h	.422	.412	1.88554	
9	.655 ⁱ	.429	.419	1.87505	
10	.661 ^j	.438	.426	1.86339	
11	.667 ^k	.445	.432	1.85343	
12	.672 ^l	.451	.438	1.84434	
13	.675 ^m	.456	.441	1.83835	1.870
a. Predictors: (Constant), Electricity Bill					
b. Predictors: (Constant), Electricity Bill, Free Standing no Running Water					
c. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average					
d. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment					
e. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water					

f. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water, More trash
g. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water, more trash, Mush more trash
h. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water, more trash, Mush more trash, Average Income
i. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water, more trash, Mush more trash, Average Income, Rickshaw
j. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water, more trash, much more trash, Average Income, Rickshaw, Old Newspapers
k. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water, more trash, much more trash, Average Income, Rickshaw, Old Newspapers, Same trash
l. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average, Multistory Apartment, Free Standing Running Water, more trash, much more trash, Average Income, Rickshaw, Old Newspapers, Same trash, just me
m. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average (household energy efficiency level), Multistory Apartment, Free Standing Running Water, more trash, much more trash, Average Income, Rickshaw, Old Newspapers, Same trash, just me, Unwanted Metal

The ANOVA Table 5.18 reflects all variables in the thirteen models showing significant differences [$p < 0.01$]. The core consideration among these models is the output of final model thirteen.

Table 5.18 ANOVA of all models

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	425.375	1	425.375	81.682	<.001
	Residual	2593.441	497	5.208		
	Total	3018.816	498			
2	Regression	554.486	2	277.243	55.914	<.001
	Residual	2464.329	497	4.958		
	Total	3018.816	498			
3	Regression	715.096	3	238.365	51.321	<.001
	Residual	2303.720	496	4.645		
	Total	3018.816	498			
4	Regression	869.815	4	217.454	50.088	<.001
	Residual	2149.001	495	4.341		
	Total	3018.816	498			
5	Regression	989.521	5	197.904	48.177	<.001
	Residual	2029.295	494	4.108		
	Total	3018.816	498			
6	Regression	1099.392	6	183.232	47.063	<.001
	Residual	1919.424	493	3.893		
	Total	3018.816	498			
7	Regression	1218.793	7	174.113	47.590	<.001
	Residual	1800.023	492	3.659		
	Total	3018.816	498			
8	Regression	1273.182	8	159.148	44.764	<.001
	Residual	1745.634	491	3.555		
	Total	3018.816	498			

Model		Sum of Squares	df	Mean Square	F	Sig.
9	Regression	1296.068	9	144.008	40.960	<.001
	Residual	1722.748	490	3.516		
	Total	3018.816	498			
10	Regression	1320.904	10	132.090	38.042	<.001
	Residual	1697.912	489	3.472		
	Total	3018.816	498			
11	Regression	1342.437	11	122.040	35.526	<.001
	Residual	1676.379	488	3.435		
	Total	3018.816	498			
12	Regression	1362.234	12	113.520	33.372	<.001
	Residual	1656.581	487	3.402		
	Total	3018.816	498			
13	Regression	1376.361	13	105.874	31.328	<.001
	Residual	1642.454	486	3.380		
	Total	3018.816	498			

The R square value of the final model-13 (Table 5.17), **0.456** representing 45.6 per cent of the variance of EF, can be explained by the independent variables. In a study with categorical social variables, this percentage is considered very high.

As mentioned above, the interpretation of the coefficient of dummy variables differs from the traditional interpretation. Here, the interpretation is made with reference to the omitted variable, i.e. the variable for which dummy variables were not created. The constant value represents the combined effects of all omitted variables (De Vaus 2014). Therefore, a constant value of 7.795 means if a person with above average income lives in a luxury house, has a household size of 10+, has no electricity, uses a private car, produces much less household waste and bears no recycling habits, he/she would have an EF of 7.795gha. We can calculate the EF of other people with different social classes using this constant value. For example, if a person of below average income group has family members of 10+, lives in a free-standing house with no running water,

has electricity, uses a rickshaw, produces more household waste, recycles unwanted metal items then his/her EF would be 4.358 gha (7.795 -1.324 -2.547+000 - 0.510+1.780-0.836). For simplicity and easy understanding, the coefficients are interpreted here by comparing omitted variables for each category, subject to all other things, remaining constant as reference categories.

Table 5.19 Coefficients from Model-13

Model-13	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics		
	B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF	
Dependent Variable: EF										
R square value: .456										
	(Constant)	7.795	.282		27.667	<.001	7.241	8.349		
	Electricity Bill	.000	.000	.109	2.748	.006	.000	.000	.711	1.407
	Free Standing no Running Water	-2.547	.294	-.364	-8.674	<.001	-3.124	-1.970	.636	1.573
	Below Average	-1.324	.233	-.245	-5.673	<.001	-1.782	-.865	.598	1.672
	Multistorey Apartment	-1.902	.277	-.307	-6.874	<.001	-2.445	-1.358	.560	1.785
	Free Standing Running Water	-.931	.246	-.187	-3.785	<.001	-1.414	-.448	.458	2.185
	More trash	1.780	.238	.288	7.482	<.001	1.313	2.248	.758	1.320
	Much more trash	2.451	.360	.248	6.809	<.001	1.744	3.159	.846	1.182
	Average Income	-.857	.219	-.158	-3.903	<.001	-1.288	-.425	.687	1.455
	Rickshaw	-.510	.176	-.103	-2.893	.004	-.856	-.164	.880	1.136
	Old Newspapers	-.944	.347	-.095	-2.719	.007	-1.626	-.262	.910	1.099
	Same trash	.479	.200	.094	2.390	.017	.085	.873	.718	1.393
	Just me	3.130	1.310	.080	2.390	.017	.557	5.703	.989	1.011
	Unwanted Metal	-.836	.409	-.070	-2.045	.041	-1.640	-.033	.961	1.041

Model 13		Beta	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
	Male	.057	1.639	.102	.074	.936	1.068	.457
	Auto Rickshaw (CNG)	.000	-.001	.999	.000	.461	2.171	.440
	Rented private car	.004	.090	.928	.004	.540	1.852	.447
	Primary School	.019	.538	.591	.024	.946	1.057	.457
	High School	.038	1.111	.267	.050	.948	1.054	.456
	College	.058	1.687	.092	.076	.944	1.059	.455
	Graduate	.062	1.816	.070	.082	.951	1.051	.455
	Postgraduate	-.061	-1.777	.076	-.080	.961	1.040	.455
	House construction material	.010	.231	.818	.010	.661	1.514	.430
	Bottle	-.003	-.070	.944	-.003	.602	1.662	.457
	Old, used, unwanted clothes	.039	1.130	.259	.051	.950	1.053	.457
	Less Trash	.087	1.366	.173	.062	.273	3.666	.240
	2-3	.059	1.638	.102	.074	.867	1.154	.457
	4-6	.000	.006	.995	.000	.915	1.093	.457
	7-9	.007	.195	.846	.009	.906	1.104	.458
	Duplex row house with 2-4	-.049	-1.047	.296	-.047	.512	1.953	.266
	Cost of cooking	.061	1.676	.094	.076	.847	1.181	.457

The results presented in Table 5.19 meet the general expectations. Regarding living standards, we expect EF to be positively linked to high living standards. Similarly, low-income people may have less EF than high-income groups. Here, I have found that the people who are living in free-standing houses with no running water, with running water and multistoried apartments have statistically significant less EF than the people who live in the luxury condominium. For example, the people living in a house with no running water have an EF of 2.547 units less than those living in the luxury condominium subject to all other things remaining constant as reference categories. Similarly, subject to all other things constant as reference categories, the people living

in multistoried apartments and houses with running water have comparatively 1.902 units less EF than those of luxury condominiums. However, the people living in the duplex row house with 2-4 units have no significant effect on EF (Table 5.20).

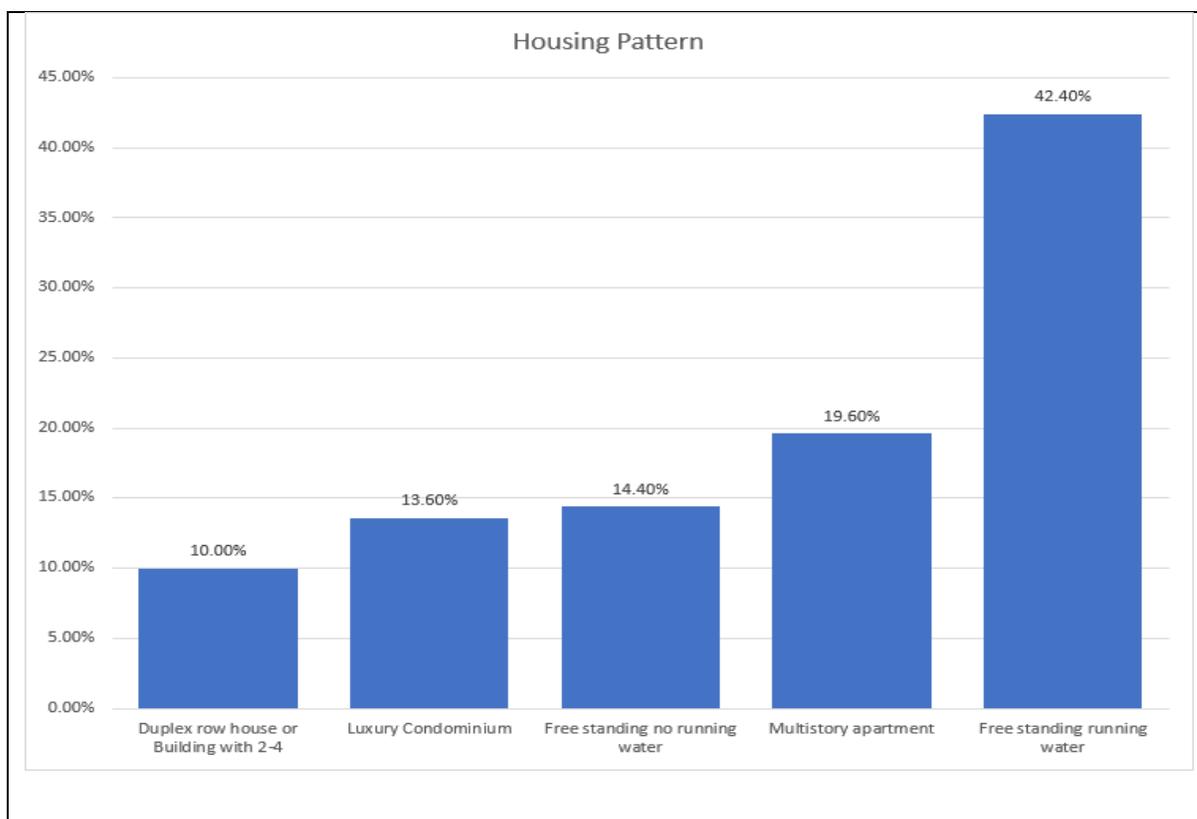


Figure 5.17 Housing pattern of NC (Source: Household Survey of NC/2022 by Author)

Figure 5.17 from the survey finding reveals that only 13.60 per cent people in NC live in luxury condominiums, and the remaining 86.40 per cent of people live in other types of housing. Therefore, it could be suggested that NC have a considerable scope to convert these houses into multistory apartments, which ultimately decreases the EF of NC. There is a hope that NC already has the experience to build some multistory apartments on their land. Several private companies, with the partnership of the landowner, are now building apartment complexes in different areas of the city. Sometimes, a conflict of interest arises between the developer company and the landowner. In these circumstances, NC can build these multistoried apartment complexes, and there is still much underdeveloped bare land in the city area. Noman

et al. (2016) also suggested that instead of individual housing ownership, an apartment-style condominium would accommodate large amounts of families, simultaneously decreasing the pressure on the highly demanded land of NC. Moreover, these apartments will temporarily shelter many migrant workers, especially in the garments sector.

It is also found that the people of below average and average income levels have statistically significant low EF than those of above average income levels with the coefficient of -1.327 and -0.857 , respectively, subject to all other things remaining constant. Additionally, with all other things remaining constant, the people who frequently used rickshaws as a mode of transportation have 0.521 units less EF than those who use the private car. The people using other modes of transportation like auto rickshaws (CNG) and rented private cars have no statistically significant difference in EF than those using a private car. Therefore, we can conclude that the people who lead a luxury lifestyle consume more resources making their ecological footprint much higher than the other group. Interestingly, Rashid et al. (2018) also reported similar findings in a study of two urban areas in Pakistan.

The fascinating thing is that these results provide deep insight that the theory on the hierarchy of human needs, also known as **Maslow's Pyramid**, is not fully working in NC. This theory assumes that human beings are motivated by unsatisfied needs. Certain basic needs (physiological, survival, safety, love and esteem) must be fulfilled before a person can act unselfishly (Maslow, 1968, 1999). This foundation for unselfish behaviour could be seen as one of the most critical factors for sustainable development (Moldan et al. 2012). However, these findings suggest that people who can meet their all-basic needs have self-esteem, consume more resources, and create more pressure on the environment, resulting in higher EF. However, it would not be practical to impose something against the human right to lead a luxurious lifestyle if they can do so. Instead, environmental education can enhance public awareness and the willingness to protect the environment to avoid risks and achieve sustainability.

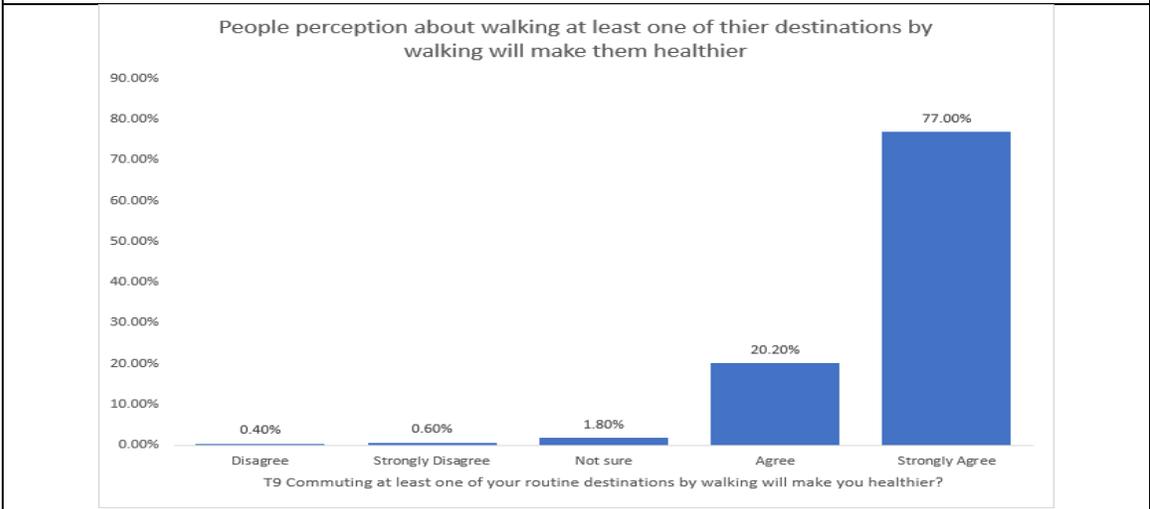
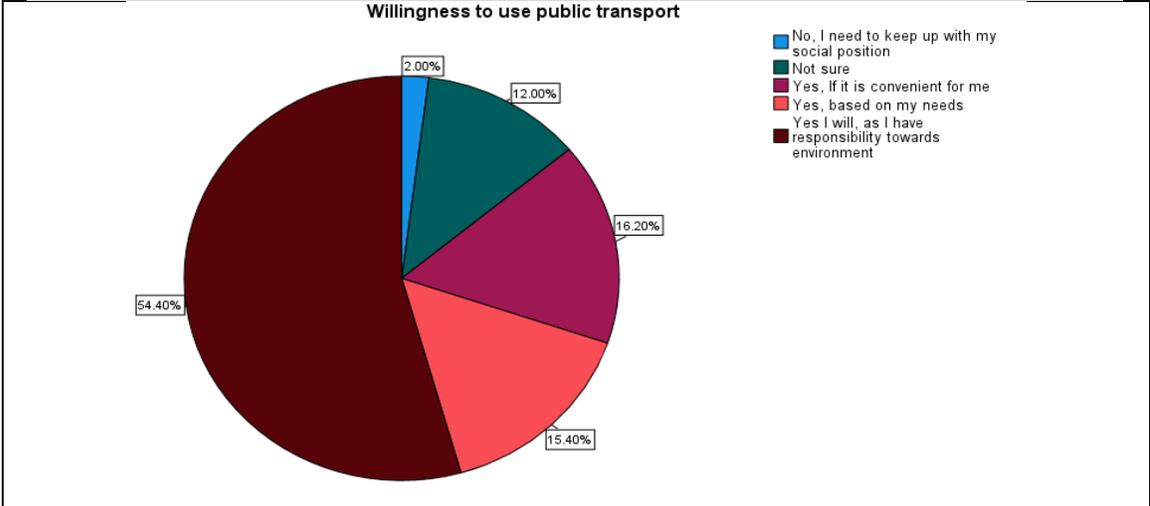
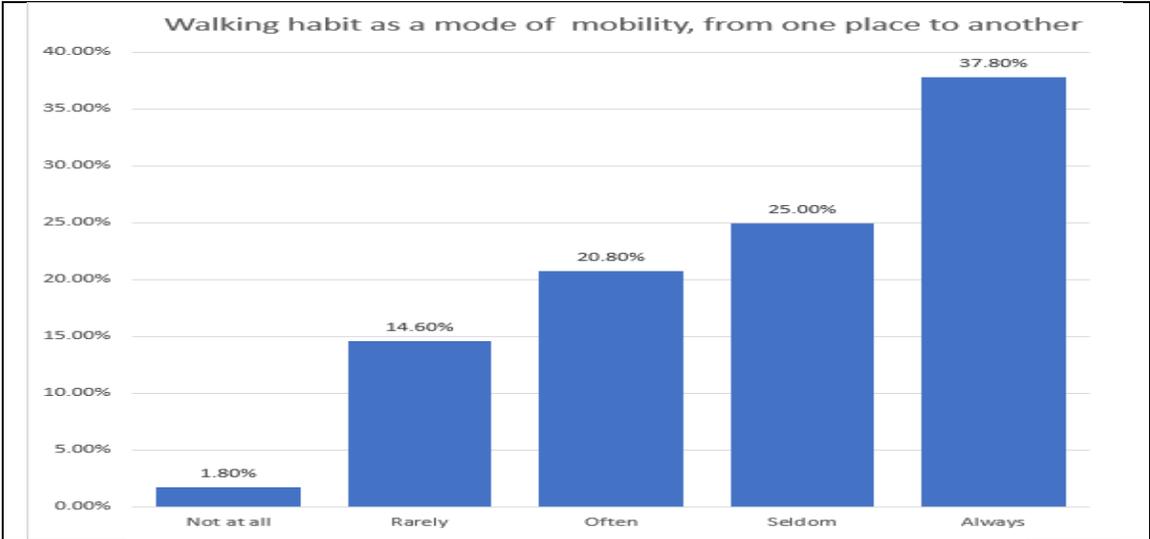


Figure 5.18 Walking habits and perception of walking is good for health and willingness to use public transport of the people of NC (Source: Household Survey of NC/2022 by Author)

However, Figure 5.16 shows that it is an opportunity for NC that many people still use rickshaws (55.40%) for their daily movement, and only 3.40 per cent of people use personal vehicles. Moreover, figure 5.18 shows that the highest number of people (37.80%) always walk for their local needs. In addition, people's perception of walking and using quality public transport is also favorable for NC. Because 77% of people think walking to at least one of their destinations can make them healthier, and 54.50 per cent of people will use the public transport system if it is convenient.

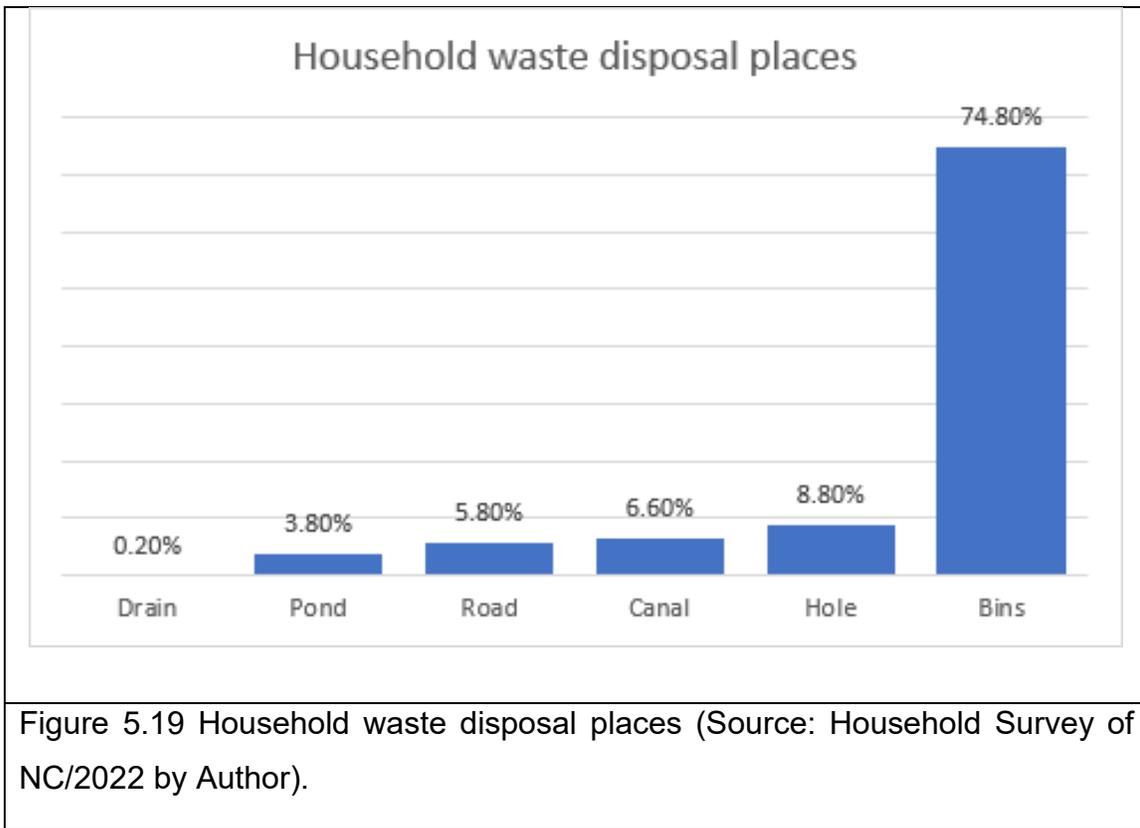
NCC can use this opportunity by declaring some areas only for pedestrians, i.e. pedestrian zone and making the footpath more pedestrian friendly. NCC can also declare some roads as one-way roads, especially in residential areas, which are very narrow. NCC can easily demarcate the entry and exit points of the road, and the people will easily accept it. Moreover, NCC can introduce a circular bus system on the major road with a minimum fare and a specific stoppage, drastically reducing traffic gridlocks, especially during pick hours. NCC can also set up some bus stations for the inter-district buses outside the main city center. The circular bus system, rickshaws and walking-friendly footpath will link these bus stations and the city center. All these things will reduce the existing private car, rented private cars, and auto rickshaws use tendency of the people, which will reduce the traffic congestions, CO₂ emissions, ultimately decreasing the high EF of NC, which in turn will facilitate the sustainability of the city. However, intensive community consultation, engagement and piloting of projects will be required before implementing this proposal. Community engagement can be implemented with the leadership of ward commissioners with the help of honorable local personnel.

The co-efficient of electricity bill '000' in Table 5.19 might make anyone puzzled, but if we think that the electricity bill unit is in BDT. While an increase in the electricity bill does have the effect of raising the EF, one BDT is a minuscule amount, so the effect of 1 BDT on the dependent variable EF will be tiny. However, if we consider the standardized coefficient, there would be a significant increase of 0.109 units.

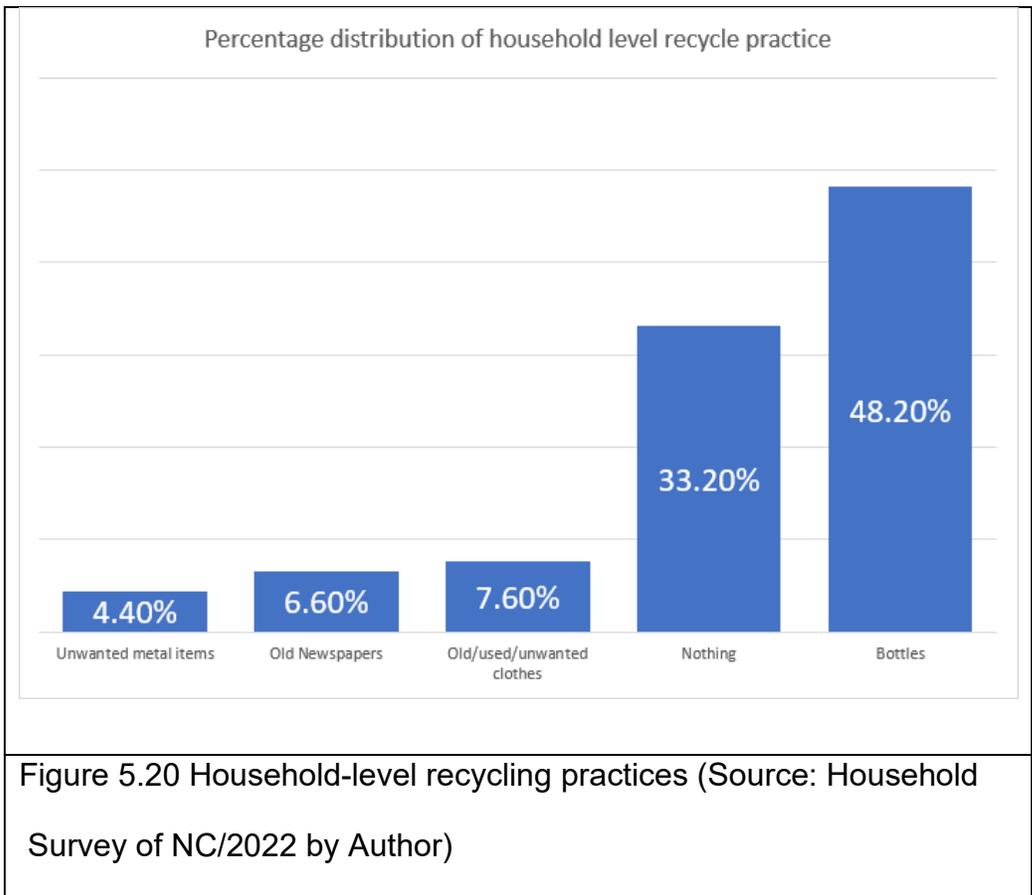
Generally, household size should have a negative sign in relation to the EF because more people living in a house share common facilities like electricity, water, cooking fuel, and floor area. It means the higher number of people living in a house should have less EF than the smaller number of people living in a house. This expected relationship is found in this study. MLR output in Table 5.19 shows that the houses where only one person lives have 3.130 units more EF than the 10+ people living in the same house, subject to all other things remaining constant. Liu et al. (2017) also reported that the number of households is a crucial predictor of resource use and biodiversity loss.

Regarding household waste generation tendency, we expect households generating more trash than their neighbours to have more EF. I have also found that the coefficient of 'Much More', 'More' and 'Same' trash-generating households is positive and highly significant (Table 5.19).

Households residing in NC are not using uniform size Bin. While conducting the survey, it was also observed that people are unaware of the size of their Bin, and more than twenty-five per cent of respondents are not using it. They usually dispose of household waste in nearby ponds, canals, holes, and roads (Figure 5.19). People are also very reluctant about the quantity of waste. Therefore, it was not possible to collect the exact amount of waste. Consequently, as a proxy for the amount of waste, respondents were asked to give the garbage generation quantity compared to their neighbors.



Some evidence supports that people with some sort of recycling habit tend to have less EF. From the findings, I confirm that the people who recycle old newspapers and unwanted metal items have significantly -0.944 and -0.836 units less EF, respectively, than those who do not recycle. In general, this sort of recycling practice is very informal in NC. The local vendors are buying this sort of recyclable material from door to door and sell it to recyclable shops (Vangari). These shops then sell it to recycling industries. The survey data shows that 33.20 per cent of people recycle nothing, whereas 48.20 per cent recycle different types of bottles, including plastic and glass (Figure 5.20). Therefore, NC can formalize this informal recyclable material collection and reward the people presently recycling the materials. To encourage the 33.20 per cent of people who are not practicing recycling, NC can provide separate bags to all households to store the recyclable items. For collecting these items, NC can employ some casual workers who can collect them once every two weeks/ month.



De Vaus (2014) claimed that information provided by unstandardized coefficients is valid but has one important limitation. They cannot be compared with one another. Therefore, they cannot be used to determine which variables have the most significant effect. This is because each independent variable is measured on a different scale. We should consider the standardized regression coefficient whenever we want to compare the relative importance of independent variables.

Table 5.21 Standardized coefficients of different variables from Model-13 in descending order		
Sl. N.	Categories	Standardized Coefficients
1	Free Standing no Running Water	-.364
2	Multistorey Apartment	-.307
3	More trash	.288
4	Much more trash	.248
5	Below Average	-.245
6	Free Standing Running Water	-.187
7	Average Income	.158
8	Electricity Bill	.109
9	Rickshaw	-.103
10	Old Newspapers	-.095
11	Same trash	.094
12	Just me	.080
13	Unwanted Metal	-.070

Tables 5.21 represent the descending order (from highest to lowest) of the effect of independent variables on EF. For instance, people living in free-standing houses with no running water have a 0.364 unit less EF than those living in luxury houses. It suggests that the shelter sector has the highest effect on the EF of NC. This is probably the biggest part of EF by consumption type (38.38%) (Table 5.7).

McBain et al. (2018) also reported that the increase in urbanization, increase in housing size, and decrease in the number of people living in the house mean that the impact of the urban housing sector on the environment is likely to increase significantly. Therefore, reducing the EF of the housing sector is urgent for NC. Barker et al. (2007) pointed out that building energy use can significantly reduce CO₂ emissions over the next few decades. As a result, the city authority of NC can take the initiative to introduce a star rating of the energy demand of the new houses. If a house has a high star rating, that house owner could get some incentives in the form of a tax cut or declaration as a

celebrity of NC and be provided with some extra facilities from the NCC authority. However, a strong and dedicated monitoring team is needed to implement this plan. To do this, NC can easily outsource a highly technical team.

In summary, it can be suggested that housing type, household waste generation, household income, household size, energy use, mode of transportation and recycling practices are the main driving force of the high EF of NC.

5.7 Conclusion

EF is a strong sustainability indicator reflecting human demand for natural resources. This chapter measures EF by adopting a bottom-up approach with a household survey. Extensive information was collected from the people of NC, and the EF was measured using the EF Calculator of the global footprint network. The result indicates that the EF of NC (**6.54gha per capita**) is sixteen times higher than the Biocapacity of Bangladesh(0.41gha), signaling the overconsumption and unplanned materials flow in different sectors of the study area. Consequently, the gap between the EF and biocapacity is widening. The findings highlight that carbon footprint comprised the most prominent exponent of EF of NC because of the high consumption of natural resources in terms of shelter and household energy consumption. The city is moving away from sustainability.

Comparing the EF of the three different regions of NC showed that Region 1 has the highest EF of 6.82gha/capita. Therefore, NC authorities should pay more attention to this region, especially to the major driving forces of EF, which are identified by multiple linear regression modelling. It was found that the major driving forces of EF of NC are housing type, household waste generation, household income, household size, energy use, mode of transportation and recycling practices. This study also proposes some guidelines to formulate policy and plan for NC that needs to address these driving forces. Besides, from EF's judgement, the findings of this study can be applicable in negotiations to develop an appropriate policy for ensuring sustainability in the urbanization process.

This study has not freed from limitations as well. Firstly, regarding the use of the personal EF measurement calculator of the global footprint network. Due to pinpointing

button errors in different positions in the calculator, the same input provides a slightly different output at different times. Moreover, the Biocapacity of NC was not possible to measure with this calculator. Therefore, it was not possible to find out the exact ecological overshoot of NC. The correction of this limitation would demand rigorous data for the production capacity of NC, which might need a mixture of secondary and primary data, which can be done in a future study. Also, due to the COVID-19 pandemic, respondents were reluctant to talk to the data enumerator and tried to provide information without taking enough time. Most surveys were conducted during the day, so housewives, retirees and the elderly were more likely to be surveyed than low- and working-class residents. Although relatively few young respondents were sampled, the proportions of other respondents were broadly representative of the residents of NC. Furthermore, the respondents were asked to provide their consumption for the preceding week or month. Some respondents could not easily and clearly remember the sought consumption data.

Secondly, the methodology of this research is not limited to further improvement, as yearly basis data at the city level is yet available in Bangladesh on such issues. Thirdly, other methods of data collection, viz focus group discussion with public representatives, local environmental workers, and journalists, might provide more intensive information for the policy formulation of NC. However, this research has a greater potential to provide a deeper incitement from human consumption behavioral perspective, which will facilitate the community movement for the sustainability of NC.

Chapter six

Urbanization: Opportunities for Sustainability

6.1 Introduction

The findings of chapter four suggest that Bangladesh's urban development is still happening in a way that has no significant impact on its ecological footprint. It indicates that Bangladesh still has enormous potential to ensure urban development in a sustainable way. It is also revealed that as a country, Bangladesh can cope with many challenges, including adverse effects of climate change, political instability, social chaos, poverty, education, corruption, environmental degradation and so on. In recent years Bangladesh's success has been a matter of high discussion in different international forums as Bangladesh's position is different from the position of her birth. Fifty years ago, Bangladesh was called an international basket case entangled with poverty, famine & natural disasters. Now globally known as a development superstar, hoping to graduate to an upper middle-income country by 2031 (The Economist 2023). It was possible through the hard struggle of the people to pull themselves up from poverty and through innovative actions unique to Bangladesh (Tanveer 2021). However, findings in chapter five reveal that the ecological footprint of NC is much higher than that of Bangladesh. The same higher EF might be found for the other urban areas. Therefore, sustainable urban development with low EF is vital for Bangladesh's continuous growth and development.

In this backdrop, this chapter aims to develop a sustainable urban development framework (SUDF) for Bangladesh, which is the third objective of this thesis. To achieve this, this chapter accumulates the key issues and interventions required for the sustainable urbanization of Bangladesh from twenty in-depth semi-structured interviews conducted with the academia, NGO (non-governmental organizations), Government representatives, political leaders, Independent Research Organizations, and voluntary organization.

The interviews were analyzed by following the **theoretical thematic analysis**, where themes are always guided by an existing theory and theoretical concepts (as well as by the researcher's standpoint, disciplinary knowledge, and epistemology) (Braun and

Clarke 2013). The themes were chosen from well-established four dimensions of sustainable development concepts: social, economic, environmental, and institutions. The subthemes evolved from interviews and were discussed based on interviewees' opinions and relevant literature. These subthemes were then assigned to different dimensions of sustainability by following United Nations Sustainable Development Goals-11 (SDG-11) and Shen et al. (2011). In summary, this analysis follows the following process:

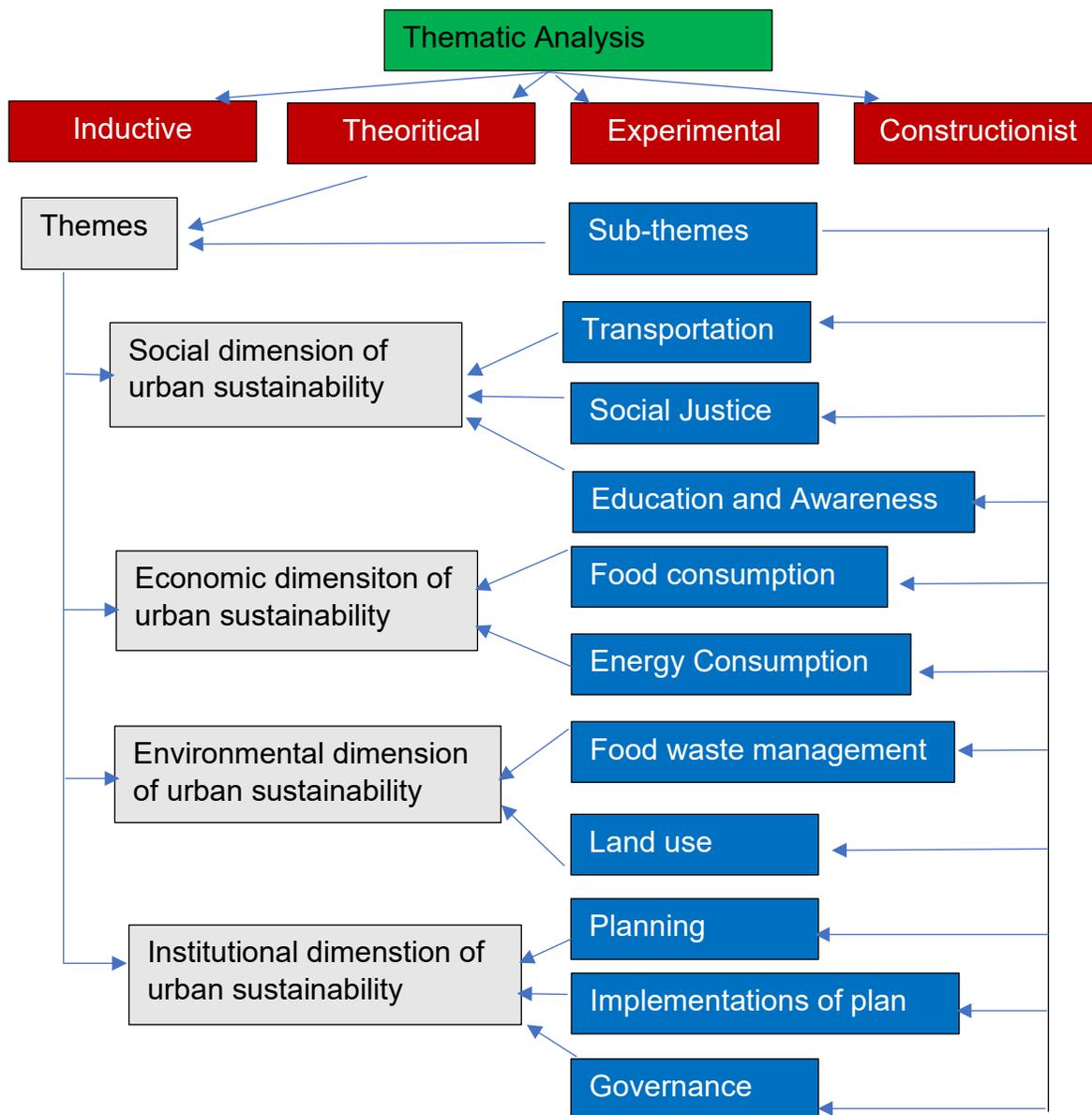


Figure 6.1 Interview data analysis process (Author's creation Based on Braun and Clarke 2013).

Following this introductory section, section 6.2 will present the social, economic, environmental and institutional dimensions-based results and discussions on the urban sustainability of Bangladesh, respectively. Based on these discussions, the SUDF is presented in section 6.3. Section 6.4 presents a series of policy recommendations linked to this SUDF. Finally, section 6.5 concludes this chapter.

6.2 Results and Discussions

6.2.1 Social Dimension of Urban Sustainability

6.2.1.1 Transportation

Sustainable transport systems play a crucial role in minimizing traffic congestion and improving air quality and acting as a catalyst for a country's sustainable development. It also has a tremendous effect on poverty reduction and economic prosperity. However, developing countries constantly struggle to meet economic and other social demands. As a result, this sector has not always been given priority. Bangladesh is not an exception to this. In general, sustainable transportation system refers to a safe system that operates fairly and efficiently, provides different choices, minimizes impact on land use, is consistent with human and ecosystem, limits emissions, uses renewable resources, and is affordable for all (Abu-Eisheh et al. 2019). Realistically, every city will be uninhabitable without a functioning transportation network. In this regard, the respondents were requested to express their opinion about sustainable transportation for the urban area of Bangladesh (Questionnaire Appendix-4). Different opinions and suggestions were found.

The traffic lane operation is notorious in every prime city of Bangladesh. Although the segregation of transport lines dramatically improves the traffic on existing roads, all transport modes, including buses, cars, and rickshaws, play on the same road or even park. It looks like contact sports racing because vehicle positions are so close that they compete to overtake each other (Bird et al. 2018). However, there is a high demand for public transport in all cities of Bangladesh, their quality, security and safety are not up to the mark. As one of the interviewees -A1, commented:

“There is high demand of public transport in Dhaka city (p) but very poor quality, poor services of public transport.”

Despite the high demand for public transport, private cars occupy more than sixty per cent of the road space of Dhaka city, whereas they carry only eight per cent of total commuters. On the other hand, public transport in Dhaka city carries three million passengers a day, occupying only seven per cent of the total road space (Abu 2020). A sign of frustration was also found in one of the interviewees- A5, as he said:

“Public transport could be a very good option. But so far, we have not been successful in very rapidly providing public transport services in our big cities.”

It is also found that the number of public buses is minimal. The management of this limited number of buses is also very messy. As a result, the crisis of public buses during peak hours is a common feature. For example, one of the interviewees-v1, expressed his opinion as follows:

“We also found that there are not enough buses, especially in office time. In this time man cannot go even standing on the buses. Sometimes we also find that some buses are waiting for passengers. It means the number of buses is not a problem. The problem is the pressure of people, especially in office starting and ending time. And how many buses there are in this route is not important, the important thing is that how many buses run at office starting and closing time.”

Another quite common features of the transportation of city area of Bangladesh are traffic congestion. Dhaka city's average traffic speed has dropped seven kmph from twenty-one kmph in the last ten years; by 2035, the speed might drop to four kmph less than walking speed. Another BRAC study reported that traffic congestion loss is twelve billion USD annually and eats up around five million working hours yearly (Haider 2018). Interview I2 suggested continuing the covid-19 practices of working from home to relieve traffic congestion.

One reason for the vast traffic congestion in the city area of Bangladesh could be rapid urbanization without proper planning. All of the interviewees agreed that urbanization of Bangladesh is happening in an unplanned way; some termed it “organic development.” For example, one of the interviewees V1 opined that:

“Major challenges of our urbanization are most of the cases it is developed in an unplanned way. As it is developing in an unplanned manner, public transport and road networks are also developing in a haphazard way. Construction of housing was not happen in a planed way or not happening in a planed way. At first stage, when there are less people, less congestion, less traffic, then road are constructed narrowly. Afterwards, when population increase by three or four folds, then expansion of those roads become more difficult because we need to break our houses to expand those roads. The major challenge, in an urban area, how much it will expand, where would be the residential area, where would be the bazaar, how the transport system will be managed, these are not developed in a planned way. IN MY VIEW THESE ARE THE MAJOR CHALLENGE OF OUR URBANIZATION”.

Urbanization in Bangladesh is also happening with the line of development work of the government. Bangladesh is mainly a flood-prone area; all the land is used for agriculture and kept as usual until a government infrastructure, e.g. embankments, roads, and highways, is constructed. The most prominent example is DND (Dhaka Narayanganj Demra) embankment. DND area was the kitchen garden of Dhaka in the 1960s. When a bypass through Sanirakhra and a bridge on Shitalakha were constructed, the DND area gradually transformed into an urban area from an intense agricultural area. It was happening informally, and now this area is an extension of Dhaka city. Dhaka and Narayanganj were separate municipalities. Nevertheless, now these two municipalities are amalgamated (interviewee-G5).

Interviewee G5 added that “ On the other hand when a new EPZ (Export Processing Zone) was created in Savar, a huge demand of houses was created and informal urbanization process started there. To meet this housing demand, the large area of Turang flood plain land was filled up. In the mean time, the first satellite town in Purbachal was constructed by RAJUK. As soon as the Purbachal project was started, private sector also start their development activities to the surrounding twenty km area. As a result, we have started to loss our agricultural land. Now a days, the development trend is found in the Kamrangichar to Mowa, Sreenagar area due to the construction of Padma Bridge. Again due to the construction of four lane road from Gazipur to Mymensigh, it takes only 2 hours to reach Mymensigh from Dhaka. I guess,

when the mass bus transit system will operate, Mymensingh will be a perfect satellite town of Dhaka. There are lots of tyles, dying, chemical industries have developed beside the Dhaka-Mymensingh corridor. Because this area is flooding free zone and a part of Madhupur tilla and lots of water is available here. As a result, this area is becoming an industrial zone.”

After independence, the growth of Dhaka was confined to the north. Between 1975 to 1998, Dhaka city was further extended to the northwest and west, followed by the construction of roads and bridges on the river. As a result, many water bodies and agricultural lands have been transformed into urban areas (Ahmed et al. 2012). World Bank also reported that after the devastating flood of 1988, when the government constructed the western embankment of the Buriganga river, private real estate companies and individual households started to construct various infrastructures by filling the water bodies (Bird et al. 2018). Once, Dhaka city was crisscrossed by 45 natural canals (locally known as ‘khals’) covering 142 km (DWASA 2016). Due to rapid urbanization and unplanned development, many of these canals have been filled up (Iftekhar and Islam 2022). Once known as an Island city, Dhaka is now popularly known as a city of congestion. One reason is that construction work around the government infrastructure area was started before social and transportation services were developed. As a result, traffic congestion in Dhaka spirals out of control and becomes one of the least livable cities in the world.

It is also a common feature of city transportation that they do not maintain the stoppage rule. Mass transport, especially buses, tries to stop anywhere. Both drivers and commuters are responsible for this. From the driver’s side, they want to maximize their income by picking up more passengers. On the other hand, commuters also tend to get down near their own house. As interviewee V1 stated:

“Specific stoppages should be strictly maintained. For example, if a bus pass my house, it do not stop there, have to stop in the stoppage. We have to bring this types of things. We have enough laws and policies. The only problem is the proper implementation. We need to be strict in implementation and make our citizen as a conscious citizen.”

He also added that “The bus route or bus stop is not suitable for me and they take more time, the bus driver reluctantly use that route where there are more traffic, can get more passengers but my time will waste. If we can bring the bus network into a system, that the number of buses of a specific bus would be the same, which was a thought of ex-mayor Anisul Hoque, now we can see a route as a piloting project, started from Mohammadpur to Kaspur, only one or two buses are now on road, not all the buses of the co-operatives join there, the bus co-operative people did not join here.”

Besides, there are also quality, safety, and gender responsiveness issues in the public transport system. The frustration about gender responsiveness in public transportation systems was found in the voice of interviewees A5, I3, V1, A4, N2, G1, G4. Their voices produce the consensus that the present public transport system is not clean, there are no arrangements for the elderly and disabled people, and the women and young girls do not feel safe.

The government has already taken some good initiatives to improve the mass transport system. For instance, the government has a time-bound action plan to build a 128.74 km (about 80 mi) metro rail network under six lines (MRT-1,2, 3,4,5 and 6) comprising elevated and underground lines in Dhaka and its adjacent areas. Among these lines, the first line would be MRT-06. With 16 stations, this line will carry 60,000 people an hour, reducing travel time between Uttara and Motijheel to around 40 minutes. Travelling the same distance takes about two hours (Shubhra 2021). Part of this MRT-6 started operation on 28th December 2022. It will eventually expand to cut through the city to the financial district of Motijheel in the south (Heather, 2022). However, the success of these MRT Lines depends on several issues (interviewees A1, A2, I2, G2, I3, N2, P1, N3). As interviewee N2, illustrates:

“ You know, government has already taken some good initiatives for our cases. For example, developing the metro rail across the Dhaka city. So, that you know, I think it is taking too long for building the whole project. I think this should be the priority project. Developing the mass transport system let us say Metro rail or BRT. You have to ensure the safety of these that people will feel safe for using those public transport. If they do not Again, you know, you are building the infrastructure, but if people are not feeling safe, so then I would say that will not

achieve our objectives using more mass public transport. So, there are a quite few issues. You know, how we are making the system pro-people, or safe or gender responsive again I would say you know. So, If our female members of our family do not feel that the using metro rail or using BRT is not safe, then you know again they will use the private transport. You see if we are not feeling safe, that our kids are using public transport then you we will not use those facilities. So we have to build the infrastructure first and in a short time and second thing we have to take the program that it is also safe, convenient and also definitely less time consuming. So, these are issues I think need to focus on. Yah, I think then the people will automatically be using those public transport. If they see this is convenient for them.”

Interviewee I3 also opined that Bangladesh always thinks about project-based solutions with little interest in low cost solutions. ten to fifteen per cent of people might use the metro rail, but for the remaining eighty to eighty-five per cent, people quality public bus and quality para transit is essential for Dhaka. However, the current paratransit neither has the required quality nor maintains road safety issues. In this paradox, the main weakness of BD’s present government vision is only Metro-based. It should be metro, bus transit, paratransit, NMV based. Nevertheless, thinking of one and being reluctant to others will not develop a system. As a result, if we do not highlight the other supporting public transport of Metro, the existing car dependency will prevail.

Therefore, to gain hundred percent benefit from MRT, the position of MRT station should be fixed by considering the city area's demographic structure. For example, where more people live, the number of stations would be greater than that of a less populous area. The station should have access for all, including the disabled, older people, and pregnant women. A supportive transport network like a footpath, bike/rickshaw lane, and bike stand should be ensured, i.e., the stations should be multimodal accessibility. So that as Bangladesh people are more likely to use bikes/rickshaws for short-distance travel, they can quickly leave their bikes at the MRT station and will be able to go to their workplace. It is also positive that most of our commuters are low-income and will quickly shift to using the MRT or any other quality mass transport system. In this way, MRT will dramatically change urban traffic.

Lack of quality public transport systems and safety and security are also seen as the cause of the increasing number of private car users in the cities of Bangladesh. However, the number of users of private cars is comparatively low, but it is gradually increasing (interviewee- I3, A1, A2, A4, A5, G2, G4). Private cars are one of the leading causes of severe traffic congestion in Dhaka city. For example, interviewee G4 opined that:

“Definitely, if there are a quality and efficient public transport system people will use them. Due to poor public transport system, even many general people try to buy a car. There is no tension about parking fees or parking spaces like developed countries. Because developed countries have quality and efficient public transport systems. -----Due to this, the number of private cars has increased dramatically. As a result, there is no control over it. Some families might have 3 or 4 cars.”

Another participant (Interviewee A4) also noted that, due to the lack of safety and security, families who could maintain a car always try to buy a car rather than other things. Especially the people of the middle class. According to her voice:

“From my general experience, I can say whenever we see that a young couple have sent their baby to school, then they (who can afford) buy car despite their other priorities. Because they think that this is the safest mode for their baby.”

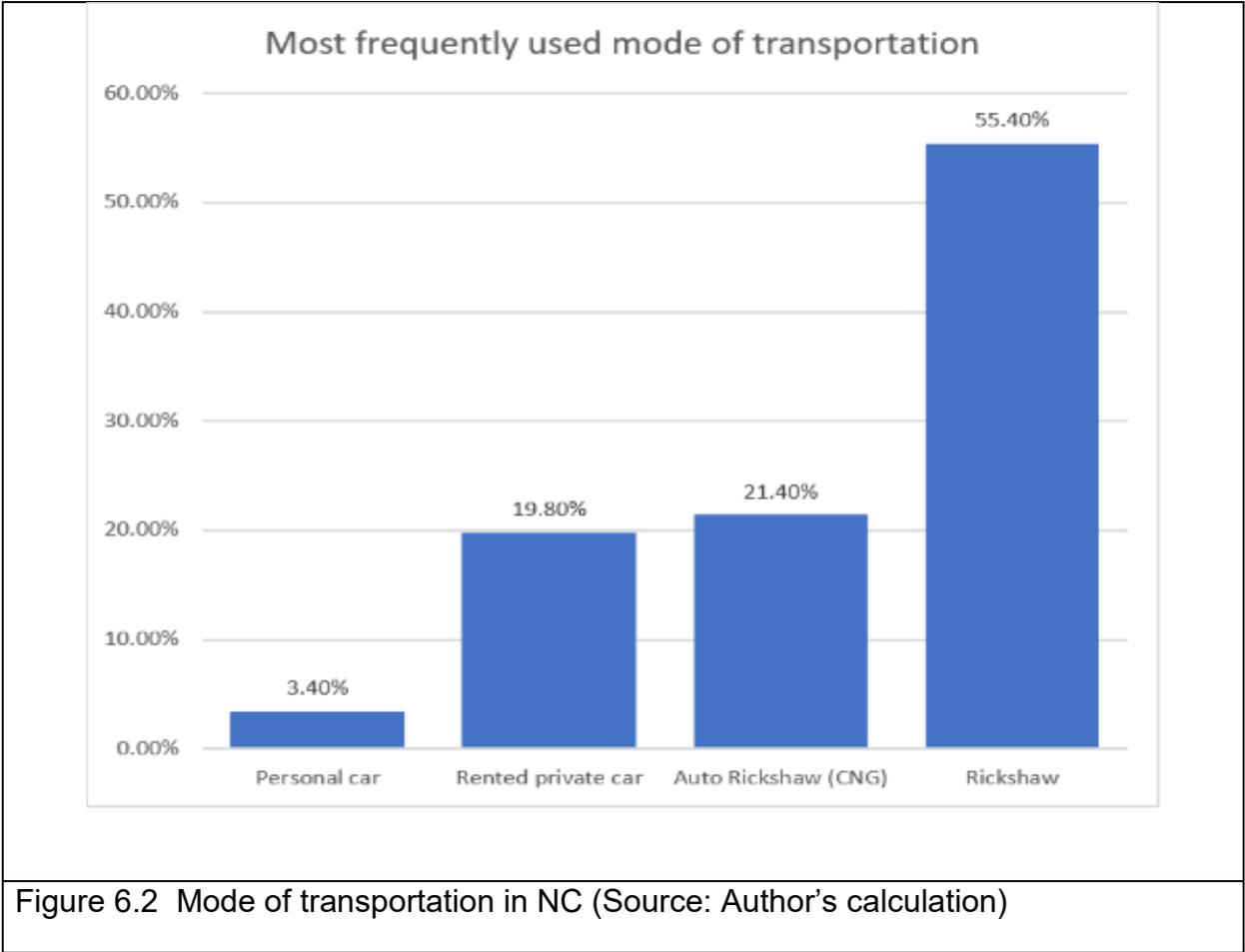
The present transport policy of the government is very supportive of achieving sustainability in urban transport. The multimodal transport policy favors public and active transport (AT) by keeping the “Pedestrian First” program. It prioritizes pedestrians at traffic signals, widens footpaths, ensures short walking distances to shops and services in rural areas, provides separate bicycle lanes in urban areas, and promotes road safety measures (Jamal and Mohiuddin 2020).

However, a substantial gap is found between the policy direction and implementation. For example, though sixty three percent of travel mode is walking and twenty percent of travel mode is rickshaw, and one percent by bicycles (Hossain and Susilo 2011), the transport infrastructure is not favorable for walking and other AT. So-called hawkers occupy the footpath, rickshaw is always considered the leading cause of traffic congestion, and

marked bike lane (in some areas of the city) is taken as a safe place for car parking is a prevalent scenario in the city areas (Interviewee A1, A5, I2, N1, N2, N3, I3, P1, V1, G3, G5, G6,). On the contrary, the scenario should be the opposite; from a sustainability perspective, we should acknowledge the naturally grown transport mode in our city area. As expressed by participant A5:

“Globally non motorized transport or active transport like walking or cycling is highly acceptable for low emission. But we have better option or better advantage in our country that is we have rickshaw. YOU KNOW SOME OF THE EXPERTS USED TO SAY CYCLE OR RICKSHAW AS NON-MOTORIZED PUBLIC TRANSPORT (int: hmm, right). So , I mean we do have this benefit, Off course, there have some problems, their drivers, rickshawalla, they are lack of I mean training. In many cases they do not understand the traffic rules, signals . But this is said to be one of the many reasons to impose restrictions on rickshaw. But if we compare or acknowledge the benefits of rickshaw, from environmental sustainability or emission perspective, we should train them how to ride a rickshaw in more discipline way on the urban routs rather than restricting them. Fortunately we have the technology, this is a kind of local technology, we have human resource. And, this is not a private rickshaw, this is serving us like public transport. So that one thing is just acknowledge this benefit.”

Urban planners of Bangladesh prioritize including NMV, like rickshaw, which is the heart of Dhaka city, in the mainstream public transport system. The NMV produces low or zero emissions; conversely, they also generate employment. They talk about planning that could include NMV and how to integrate them by considering the local context. They also articulate that modern cities cannot be run by rickshaws. However, the rickshaw is Dhaka's beauty, is Dhaka's tradition, and should integrate with the mainstream system (interviewee-I3). The survey findings of NC also reveal that 55.40 per cent of people use rickshaws as their primary mode of transportation (Figure 6.2).

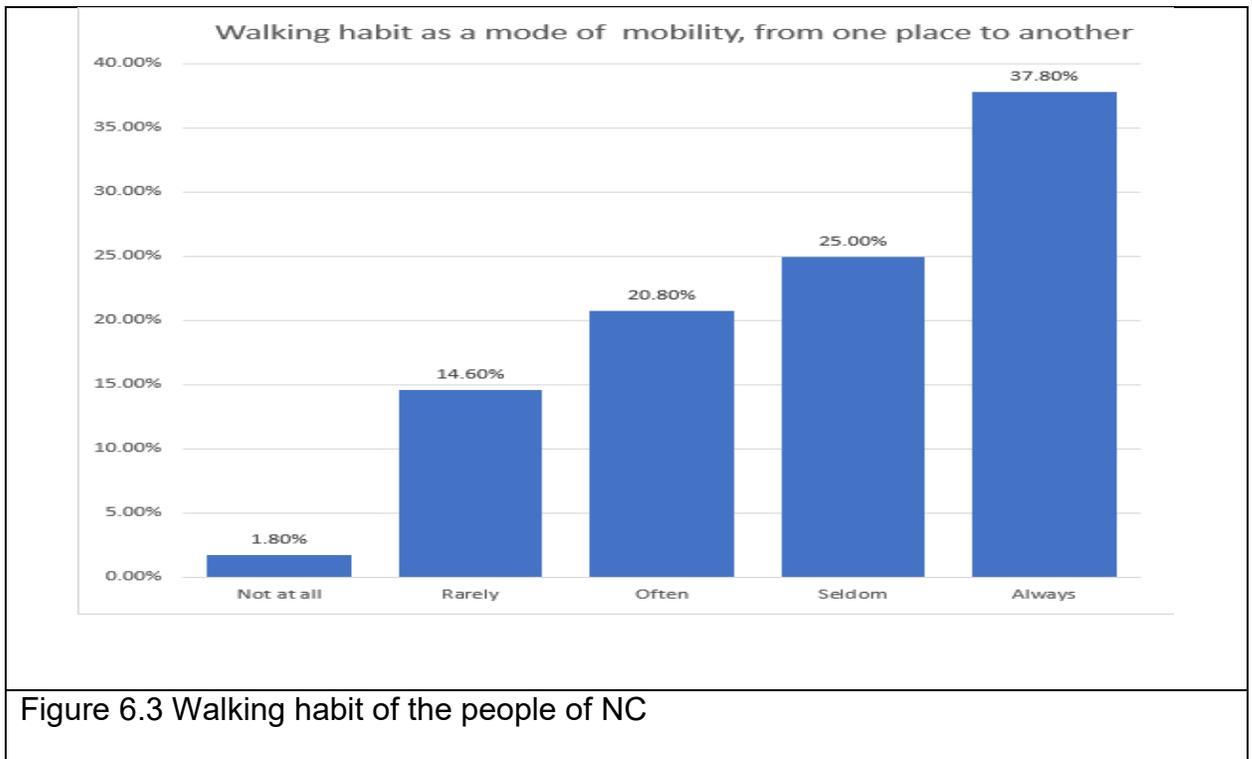


Further to this, the road infrastructure of the city area is not bicycle-friendly at all. It was found that city corporations of Dhaka have made some well-painted cycle lanes. Due to ignorance, the car driver thinks these painted lanes are for parking. As a result, they always park in these areas (interviewee N3). Bangladeshi culture is not also supportive of flourishing the use of a bike. The young generation has taken motorized two-wheelers as an attractive and status symbol compared to walking and cycling (Jamal et al. 2022). One participant (interviewee-N2) also articulates that Bangladesh weather is unfavorable for cycling.

In contrast, all the academics, two NGO representatives, Government Officials, and the Political Leader of this interview advocate using bicycles. Interestingly, one NGO participant (interviewee N3) said he had used a bike for seven years for his office commuting. Another NGO participant (interviewee - N1) and his wife continuously cycle on holidays.

Therefore, for sustainable transportation, the government of Bangladesh can take a long-term action plan to promote AT. There is no short-term solution. Because it always takes time to change a culture and mentality. For instance, it took over 20 years to make bicycles popular in Amsterdam, the Netherlands'. Now, this city is popularly known as the city of Bicycle. That was the result of Amsterdam city authority's 1975-1995 effort. They have taken the strategy of advocacy for social homogeneity. They utilized their political representatives, high-ranking government officials, and celebrities to promote active transportation modes (Giselinde 2013; Ruth and Adri 2011). For Bangladesh, local-level practices already exist; as Hossain and Susilo (2011) reported that in Bangladesh, sixty-three per cent of the total commuters are done by walking. If the infrastructure and mindset of the people change, it is expected that it will not take so long to popularize the use of active transport mode in the city area of Bangladesh.

There is also the view that everyone should not be able to use a bike. For instance, older people (falling can be quite severe) and pregnant women (not considered safe regarding fall risks). Bicycle use among female people is also limited due to the conservative nature of Bangladesh society (Shaila et al. 2020; Sarker et al. 2020). Some also argued that sometimes you have to have quite a lot of stuff with you, not making public transport ideal or there might not be a public transport system where you are living/going. So sometimes a car is necessary. However, the number of car users in Bangladesh is meagre. Many commuters are pedestrians and use AT mode, viz. walking, rickshaw (interviewee- 25, A5, 23-A4, 1-A1, 18-N3, 22-G5, 20-G4, 6-I1, 13-I3, 19-V1). A study in the Rajshahi city of Bangladesh reveals that people tend to walk when the distance is less than ten minutes. They also prefer walking on the local road instead of the main road for safety (Jamal and Mohiuddin 2020). The survey of this study also reveals that 37.80 per cent people of in NC always prefer to walk (Figure 6.3).



This indicates that more people will be inspired to walk if the infrastructure is walking-friendly and ensures safety. In a study of Chennai City, India Anand (2018) also found that people are willing to walk but walking facilities are not pedestrian friendly and very unsafe. In Bangladesh, pedestrian friendly initiative is taken during the specific year period when some active part of a city area is declared as pedestrian zone. For example, during the Eid festival, some shopping mall areas are declared pedestrian zones, and people from all walks of life enjoy the facilities. For instance, one participant noted (Interviewee- A4):

“ Man can walk. Our merit, our weather, permit to walk. But there should be facilities to walk. The most important thing is that there should be safety. BUET (Bangladesh University of Engineering and Technology) is not so far from my house. It is possible to go there on foot. But my way should be safe and comfortable. Some areas in some time automatically become pedestrian zone, for example New market area during Eid. We can think about some areas that all these types of areas are pedestrian zones. Perhaps car can move over this area.”

The unequal development of transport infrastructure is also found in city areas of Bangladesh. Most of the development budget is allocated to the infrastructure development of Dhaka city rather than any other city, attracting more people to Dhaka and inspiring people to use more private cars. As illustrated by one government official (interviewee-G6):

“You might find that our maximum investment is made in Dhaka or Chattagarm. And if you see our annual development budget of Public Works ministry, you might find that maximum budget is allocated for Dhaka and Chattagram. Dhaka and Chattagram are already full. You are developing more; it means you encouraging people to move to these cities. In 8th five-year plan, government is incorporating the satellite township in the urban peri-pheri. I think our investment should be made in this area. No development will be made in the existing city. Now you all must move out. Some days I ago I discovered that the headquarters of port is in Dhaka. It was strike in my head that why it is in Dhaka? It should be in Chattagram or in Khulna. It should be in Khulna, because Chattagram is already saturated. The main problem, once upon a time it was in Chattagram. But somehow, our high officials do not want to live in Chattagram. Because everyone should be in Dhaka. This is our main problem.”

Another government official (interviewee G5) also articulated that all development is Dhaka-centric. He quantitatively analyzed the infrastructure, amenities, and facilities of 480 growth centers and developed a weightage scale from 1 to 100. His results indicate that urbanization of Bangladesh is very skewed. It means all are in Dhaka; it has gotten about 79, then Chattagram scored 62, and the other 11 city corporations are in the 40 to 45. The rest growth centers scored in the range of 20 to 25. The quality of 332 municipalities is not good. As a result, it is found that much investment is in Dhaka city. More flyovers, infrastructure, facilities, and amenities are constructed in Dhaka city.

Therefore, it could be concluded that the present government policy is very favorable for sustainable urban transport systems. The 8th five-year plan of Bangladesh has the direction to introduce BRT, ITS (Intelligent Transportation System), Bus route rationalization and company-based bus operation. The government is also now building MRT lines. However, the progress of MRT construction is slow, and it will take more

time to get the actual benefit from it. In this regard, to get a quick result from existing facilities with low cost, the government can emphasize work from home, encouraging NMV, creating more walking facilities, systematic public bus and train network and finally can control private cars.

6.2.1.2 Social Justice

Equal opportunities can enhance productivity to gain more inclusive and sustainable development. Globally, it is found that the top countries that have the highest per capita income are more urbanized (Panday 2020). However, in the global south, the cities are overgrowing with an economic crisis and currency devaluations (Ahmed and Meenar 2018). As a result, urbanization does not significantly impact the reduction in urban poverty (Cohen 2001; Sangraula et al. 2007). Urban development in this region always happens unequally, favors top-class people, and limits the social and economic benefit of lower-class and homeless people.

Nevertheless, millions temporarily or permanently migrate to urban areas for better employment each year. In addition, various natural disasters and weather conditions act as a push factor to leave rural areas (Saunders 2011). Consequently, urban poverty has shown a growing trend.

In the case of Bangladesh, it is found that, over time, urban poverty is also increasing. Urban poverty has been the most common feature of the country's metropolitan cities over the past decade (Panday 2020). More than two million people (2232114) live in the slum area locally known as *bastee* (BBS 2015).

Table 6.1 Distribution of slums by locality (City Corporation, Municipalities and Other Urban Areas).

Locality	Slum census 2014		Slum census 1997	
	Number	Percentage	Number	Percentage
City Corporations (CC)				
Barisal	137	0.98	NA	NA
Chittagong	2216	15.90	186	6.22
Camilla	41	0.29	NA	NA
Dhaka (North)	1639	11.76	1579 ^a	52.79
Dhaka (South)	1755	12.59		
Gazipur	1285	9.22	NA	NA
Khulna	1134	8.14	202	6.75
Narayanganj	82	0.59	NA	NA
Rajshahi	104	0.75	84	2.81
Rangpur	49	0.35	NA	NA
Sylhet	671	4.82	NA	NA
Sub-total CC	9113	65.40	NA	NA
Municipalities	3357	24.04	940	31.43
Other urban areas	1465	10.51	NA	NA
National	13935	100	2991	100
Source: Census of Slum Areas and Floating Populations, 2014.				
^a During this time, Dhaka was not divided into two city corporations.				

The above table 6.1 represents the Census of Slum Areas and Floating Populations (2014). This census result reported 13935 slums in the country; 65.40 % are in the city corporation's area. Ahmed and Rahaman (2014) and Obeng-Odoom (2011) reported that people living in these slum areas significantly contribute to the urban informal economy and service sectors. They also play a vital role in shaping local politics by acting as a vote bank (Banks et al. 2011). Despite this, they do not have access to safe shelters, water, land, and basic services and always suffer from deprivation and threats of eviction. This type of discrimination and inequality plays a crucial role in urban livelihoods, and they can hamper local and regional sustainability (Agyeman 2014).

Moreover, it is common practice that most city sustainability planners do not consider them in their planning process (Ahmed and Meenar 2018). However, the sustainability of our urban development should consider this part of our population. As interviewee - A4 rightly raises the same issue:

“Regarding Social aspects, the major challenge of our city is that a large portion of our population are poor, around 30 to 40 percent people are ultra poor, we need a balance of it. It means when we developed a city, we think that development means there might some big flyovers, multistoried buildings, shopping malls etc. But this is not. Now sustainable development means leaving no one behind. Therefore, if we do not want to leave anyone, then we have to move with this 40 percent of people. Here social perspective, like distribution of cost and benefit should come.”

Ahmed et al. (2018) also argued that since sizable portions of our urban population live in slums and other informal settlements, current urban sustainability initiatives will not give a desirable result until current policy practices are reoriented to include equity and social justice objectives. Interviewee -G2 also pointed out that “city policy must be more inclusive, have to think about all the people from all income groups, from all age and also the future generation. So, if we consider all of them in our policy, only then can we make our city sustainable.”

On the other hand, urban development authorities have limited resources to provide essential services to most urban dwellers. As a result, economic and environmental factors are always a priority rather than social justice (Ahmed and Meenar 2018). In addition, sometimes slum dwellers are unwelcoming and considered the burden of the city. However, this should not always happen. Because some slum dwellers are involved in small businesses, have entrepreneurial capacities and contribute to the urban economy. Therefore, substantial political involvement and commitment are needed to ensure social justice and equality for the sustainability of urban development.

Moreover, sustainable development must consider the inclusiveness of all stakeholders in the development activities, whether women, informal workers, older people, or children. The innovative economy is always talking about gender equality. Studies found that women's inclusion in economic activity will add \$12 trillion to Global GDP by 2025. The world would be better off by utilizing the productive power of women (Mercy 2022). In Bangladesh, more than half of the urban population are women. Therefore, no sustainable initiative will lead to a positive result if we do not consider them in our planning process. As one participant illustrated (interviewee A4):

“Another things, that I always say that gender sensitivity. Because the half of the population of a city is women, different age grouped. Most of the time we forget it. When we make a plan, we always think that only able, rich, and male will be there. We are not thinking about other perspectives. If we do that, we can easily meet the anomalies that are seen now.”

Therefore, though urbanization has significantly contributed to Bangladesh’s economy, social justice and equality in the urban area are yet to be ensured. The current planning practices lack inclusion. As a result, poverty in the city has gradually increased. Even though many people migrate to urban areas with a dream of a better income and better life, in most cases, their dreams remain dreams. As cities are not ready to accept them, they are forced to live in slum areas/informal settlements. Although the people of these areas significantly contribute to the urban economy, they are always neglected in the urban planning process. However, GoB claimed that her present policy is inclusive; in the real sense, this policy does not bring any significant benefits to the people experiencing urban poverty, older people, women, children, and disabled people. If they are kept outside the planning process, no initiative on urban sustainability would be effective. To ensure this, strong political commitment and involvement are needed.

6.2.1.3 Education and Awareness

Education and human capital are closely related. In a real sense, education can transform a man from a liability to a resource of a country. A well-educated population can turn raw natural resources into capital goods and services. Education is, therefore, important for continuing a country's economic growth and development (Aida et al. 2021).

In contrast, it is also found that education does not significantly contribute to sustainable urban development. For instance, nearly eight million students graduate from different universities and colleges in China annually. Additionally, China has had the highest number of patent applications worldwide since 2017. However, China's urbanization does not have any reflection of this enormous number of educated people. One probable reason is that employers are not getting the skills they need, or graduates are not getting suitable jobs according to their qualifications (Guo et al. 2022). Another reason that may be the prominent driving force of urbanization in the global south is the

migration of rural people. These migrants enter mainly for lower-level jobs because they lack the skills required for better jobs (Kuhn & Shen 2015).

Like China, nearly two million youths in Bangladesh enter the job market yearly but are not getting suitable jobs. Though Bangladesh has tremendous success in universal primary education, literacy rate, the inclusion of female students in all levels of education, and dramatic progress in Goal 4 of SDGs (Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all), the education industry is not so much successful in job creation. One reason for this is that the current level of education discourages private investment in highly valued and diversified sectors. It should be noted here that the allocation for the education sector in Bangladesh is below the World average. When questions arise about the quality of teaching, vocational training, and skilled workforce, the available data keep Bangladesh below 100 among the 140 listed countries (Barai 2020). Therefore, to benefit from rapid urbanization, Bangladesh needs to increase the budgetary allocation in education to create a more skilled workforce by re-examining the present education system. One of the interviewees also rightly pointed out the same issue (interview G-5):

“We can say, our infrastructure is ready, if we can produce production oriented skilled manpower, not so called, BA, MA pass, if our university produce job oriented, it means focus should be industry, then skill manpower will be available, then the urbanization process will be tremendous, a boom in the next 10 or 15 or 20 years.”

Grosbeck et al. (2019) argued that sustainability-oriented teaching materials, content, and innovative curriculum are essential for Bangladesh. It is also noted that the people of Bangladesh are now experiencing many infrastructure development activities in the city areas. However, people are not well informed about the use or rules of using these infrastructures. Before starting any huge infrastructural development activities, a long-term plan to enlighten and train the general people is required. As interviewee v1 illustrated:

“---- So, road is not the solution, building and urban development in a very rapid way would not be a solution, we should start from the basic, from the core, we must address these are the things like after 20 years I want focus on these areas,

like, I like to focus on road and highways, I want to focus for a pollution free city, where, you do not see any pollution. So if you want to see after 10 years, so you have to work these 10 years academically. We have to train your people for these 10 years then start these. So once you started these things and once you have the whole infrastructure and the people started to using these and they are maintaining the whole norms and systems. They know the system, they know the policy. Because, the last ten years, people actually learn a lot about that these are the things are happening in our country and once it happens, we will have that mindset to accept this. ----- So definitely, enlightens first, knowledge sharing comes first, then the other things, then the infrastructural development should be.”

Similar things are also found in the voice of Interviewee-I1. He pays attention to youth education at school. If they are educated, they can change society. Because when the youth learn something, that will guarantee their future. Moreover, they also make their adult members follow the rules. Besides, education and training, Interviewee A2, I1, A3, I2, N3, VO, G4, G5 gives more emphasis on awareness of urban population. Awareness is also a much-discussed issue in the UN Agenda 21. For example, chapter 36 of Agenda 21 started with the statement -

“36.1 Education, raising of public awareness and training are linked to virtually all areas of Agenda 21-----.”

More emphasis on awareness building is also given in the 8th five-year plan of GoB, especially on awareness development in the youth of Bangladesh. The number of youths increased from twelve to forty-four million in 2017, continuing until 2026 (GoB 2020b). Sustainability knowledge can be disseminated to this group of people to benefit from this demographic dividend. It might give an outstanding result in sustainable urban development.

Another dimension of people's awareness is found in the voice of interviewee I1. He brings the opportunity of using the vast number of mosques in the city areas of Bangladesh. Many people go to the mosque, and colossal gatherings happen on Fridays. So, if somehow the imams (religious leaders) of these mosques, who give

speeches on Friday, can explain to the people that they should not do these things or they should do these, it will have a substantial impact and can contribute more.

Bangladesh has 164 million people, 90% Muslim (Fair and Patel 2022). It is also praiseworthy that Bangladesh already has over 250,000 mosques; Dhaka is home to 6,000 (Prapti 2017). Moreover, GoB is implementing different Mosque-based projects to enhance the child and mass literacy program and establishing 560 model mosques and Islamic cultural centres (one in each district and upazila) (GoB 2023). Additionally, like all other Islamic states across the Middle East and North Africa as well as Central, South and Southeast Asia, Bangladesh is also attempted to regulate the content of Khutba to align it with state goals (Fair and Patel 2022). Therefore, GoB already has enormous scope to make people aware of sustainability by using these mosques because Imams have more impact on the community than planners and government officials. They only need to sensitize the Imam about sustainability practices, and then they can help to sensitize the general public.

Therefore, GoB needs to concisely re-examine its education system to produce a skilled workforce, including sustainability practices and how to use the mega infrastructural projects in the national curriculum. Awareness and training program for schoolteachers, mosque imams and other people who have close interactions with a significant portion of productive/active citizen of the country is highly recommended for the sustainable urban development of Bangladesh. It is also essential to raise awareness of the people of semi-urban, suburban, or rural areas. Because every year, many people migrate to urban areas and do not know how to use urban facilities like parks, footbridges, public buses, and road crossings. Therefore, if we can enlighten them, they can quickly adapt to the urban environment when they move to urban areas.

6.2.2 Economic Dimension of Urban Sustainability

6.2.2.1 Food Consumption

Urban sustainability and household consumption patterns are closely related issues for developing and developed countries. A study by Holden and Norland (2005) indicates that household consumption, in terms of housing, food and transport, comprises eighty per cent of total consumption in Scandinavian cities. Among these, food consumption

is the most basic form of resource use. Despite this, minimal studies have been found regarding Bangladesh's household food consumption pattern, specifically for the city area. However, some related studies suggest that urbanisation changes household-level food consumption patterns. Due to urbanization, people's lifestyle is changing; people may consume more fat, protein, and Western-style foods to save time for preparing food in the house, especially female members who are in formal jobs (Clark et al. 1995; Huang and David 1993; Regmi & Dyck 2001). They also cannot employ house assistants to make food at home. As a result, they go shopping and have some processed food like cans and packed food (Interviewee N2).

The city dwellers are also gradually shifting to processed and packaged food like dairy products such as milk in various forms, ice cream, yoghurt and drinks, and potato-based fried snacks (Harun and Ahmed 2013). School children are becoming fond of fast-food and carbonated beverages as their tiffin (mid-day meal) (Saha et al. 2011). Islam et al. (2017) suggested that delight, variety, availability, and attractiveness are the major factors that attract the young generation to take more fast food. Besides, socialization in the city area is becoming food-based, especially among the young generation; corporate personnel think of having their meal in a branded franchise restaurant such as Nando's, KFC, or Pizza Hut as a fashion (Islam and Ullah 2010). Apart from this, the study of Husain et al. (2015) reveals that 250 thousand of street vendors are now selling diverse types of food, including fast food, tea, snacks, everyday groceries, and poultry, and also bring some sorts of fast food the doorstep of urban dwellers.

Despite the above fact, the interview data of this study suggested that most urban dwellers still prefer traditional homemade foods as their regular meals. Among 20 interviewees, 14 argued that the urban people of Bangladesh still take more unprocessed food than the developed countries. Rice based-food consumption is quite common practice. Though the agricultural land of Bangladesh is gradually decreasing, rice production increased four times than in 1972 or 73. Simultaneous production of vegetables, maize, and wheat also increased. As a result, there is no significant change in people's food habits, which usually happens in many other countries (interviewee G1). FAOSTAT (2016) data also reveals that Bangladesh is one of the largest rice-consuming countries in the world, consuming 172kg/year per capita.

Moore (2015) reported that residents' cultural backgrounds, socio-economic characteristics, and personal values significantly influence eating habits. Some changes in cultural background and personal values are also happening in Bangladesh. People are now more concerned about their health, especially diabetes and blood pressure (Interviewee G4). As a result, although rice is considered a staple food, many urban people now eat bread or eat fewer carbohydrates, more vegetables, and low-fat foods. Huang and David (1993) also reported that due to urbanization and an increase in income, the people of Bangladesh are now taking more wheat and less rice.

Increased connectivity to the rest of the world also brings some cultures of taking processed food to Bangladesh, but not so prominent. Some people also take processed food as a hobby (Interviewee G3). Some urban, exceptionally high and upper-middle-income people are gradually moving towards processed food. This trend of moving towards processed food is not advisable, considering the low quality of processing and preservation.

Food consumption patterns also vary according to the class of people. There is a far difference in food consumption habits among middle-class or lower-middle class or low-income people. However, one exciting thing is that a similar pattern of food consumption habits is found in the highest and lowest income group; both groups take unhealthy food from shops. For example, high-income people buy fast food, and low-income people buy street food. Both are unhealthy (Interviewee N3). Islam and Ullah (2010) provide considerable evidence that restaurant meals contain lower nutritional value than meals taken at home because they contain more fat and calories. Fast foods are also considered a significant factor in obesity.

In Bangladesh, it would be considered an opportunity that most people cannot afford the cost of processed food (Interviewee I3). Interviewee A5 also argued that the number of people in the class of society and the availability of processed food is also an issue for the low percentage of taking processed food. At least more than sixty per cent of urban people are poor, and they cannot buy processed food. Moreover, the processed food supply centre is extremely limited to high-income areas, and the number of high-income people is meagre. Interviewee G2 also agreed with him and added that

Bangladesh still produces sufficient food, and people are very fond of buying more fresh food directly from the kitchen market.

This tendency of the general people and the low affordability issue could be used as an opportunity for sustainable food consumption because promoting local traditional food intake helps foster social values that support sustainable food consumption (Solaiman 2019). One of the interviewees also claims it is a crucial factor for fewer COVID-19 incidents in Bangladesh. As he opined that (Interviewee-I1):

“As far as I saw, also as I saw that fortunately, Bangladesh has one of the lowest level of problems of covid-19 during this pandemic period. I ASSUME ONE ASPECT IS THAT MOST PEOPLE ARE RELAY ON FRESH FOOD, NOT ON THE FOR EXAMPLE, PACKED OR PROCESSED FOOD. This using fresh material I assume is an incredibly good habit and right now from this point of view, I assume generally, the habit regarding food consumption is very good.”

However, Bangladesh's primary concern for food consumption sustainability is using toxic chemicals and unethical practices are commonly known as food adulteration (Mottaleb and Mishra 2017). Another concern is that the ecological footprint of food is gradually increasing. As Interviewee A5 expressed his concern as follows:

“And, another thing um, in terms of what they are eating, most of the person here they do eat LOCALLY PRODUCED FOOD (int: hmm, hmm). But the issue is, these locally produced food, I mean, THE ECOLOGICAL FOOD PRINT for locally produced food is increasing day by day. I mean previously, at least back in 20 years or in 2005, you could have, or you could see, many of the carrots and potatoes, those could be or those were produced within the 40 kilometres area from the city centre of Dhaka city, in Manikganj, in part of Savar or all these areas. But now you will find those land uses, have been completely replaced by build environment. So, this green field or paddy or I mean the agricultural land are pushed further back or in some cases on the other bank of the river. And that is why as urbanization is increasing, the ECOLOGICAL FOOD PRINT IS also increasing. It is not good in any way. Neither any from sustainability perspective, nor of course from ECONOMIC SECURITY, or aa, aa, AGRICULTURAL SECURITY perspective.”

Therefore, it could be concluded that most of the urban dwellers of Bangladesh still are very fond of taking traditional food items. They prefer to buy fresh food from the kitchen market. This tendency can be used as an opportunity, and the government can promote this tendency by conducting more drive against food adulteration, both in the kitchen market and in the restaurant, to ensure chemicals and toxic substances free food for the citizen. However, existing legal norms capture some but not all aspects of adulteration (Ali 2013). For example, BSTI, Bangladesh Food Safety Authority, must be strengthened to enforce existing laws and strictly conduct more monitoring activities. The Directorate General of Food, directorate of agriculture extension, directorate of fisheries, and directorate of livestock can act together, whereas the Ministry of food can act as a coordinating authority. Government can also set up some open markets where farmers can directly sell their food items, and urban people can also be able to know information that on a particular day of the week, the farmers of a specific area (a nearby district of a city, for example, Manikganj, Narashingdi for Dhaka) will sell his/her products (Interviewee-V1). Another important thing is that, as the ecological footprint of food consumption is gradually increasing, proper planning for the semi-urban area to save agricultural land should also be taken.

6.2.2.2 Energy Consumption

Energy is considered the lifeblood of modern society and one of the utmost economic endowments (Zhihao et al. 2020, Muntasir 2020). It is very natural that with the increase of urbanization, energy consumption will also be increased (Cole and Neumayer 2004, Pariakh and Shukla 1995). Bangladesh is not the exception to this. Interview data revealed that the city area of Bangladesh is gradually becoming an energy-hungry city (Interviewee –I1, I3, A4, A5, G1, G2, G3, N2 and V1). The level of energy consumption also varies with the level of income. The high-income people are now using more energy-intensive household appliances than before. For example, high-income people are now using more A/C, refrigerators, and fridges and consuming more energy. They are not even thinking to spent a summer without an A/C. For instance, one of the interviewees-N2 said:

“Umm we need to actually, you know first of all I would say, the city is becoming more day by day more energy hungry city. Let us say, more people are using

the air condition system (int: hmm). Day by day more people are using elevators, lifts, and also the people I see they are also refrigerators and freezers everything. So, that is becoming day by day more energy consuming life style. So this is growing as a trend. But as I said that, as a city of Dhaka, so you know as a citizen, being a citizen of Dhaka city I I cannot even think of spending a summer without the air conditioning. Because of the climate change, the sweating situation, high humidity, and high temperatures situation. Even we do not have free space to go.”

The increase in energy use is also associated with the structure of the buildings. It is estimated that Buildings consume eighty per cent of energy in the operation stage and twenty per cent in the construction stage. During operation, buildings require massive amounts of energy for cooling, heating, and lighting (Ahmed 2022). However, in the city area of Bangladesh, the buildings were constructed so close to each other that air circulation or sunlight penetration is impossible. Shopping malls are also constructed in a way that obstructs the entry of sunlight (interviewee A4). Whereas in the developed countries, especially in Europe, sunlight is scarce, they are constructing their shopping malls and even some airports to use the sunlight. However, though sunlight is abundant in Bangladesh, it is always neglected. The city is becoming a concrete jungle.

One interviewee claimed this concrete jungle was a failure of planning (Interviewee-I3). Previously, the buildings were built close to each other, especially in the older part of the city area. However, now there is a rule to keep a certain amount of space between the two buildings, but this rule's implementation and monitoring activities are fragile. There is also a mindset problem from the property owner/developer side. They think they will lose square feet if they leave the space, which decreases their benefit. As a result, sometimes, they took the planners as their enemies.

Consequently, the general people are forced to use artificial lights and more A/C, transforming the city into a heat island. Now the temperature of the city area is always two or three degrees more than that of the outer city/rural area. Interviewee I3 describe it as follows:

“Household energy consumption issue is a very important question. Because energy consumption is a core thing for planning. You might notice that different

news media are now highlighting that heat island is now developing in urban areas. The temperatures are rising alarmingly. We are saying in different conference like CoP that temperature is rising for developed countries. But we should think that how much importance are given to our own country's temperature increasement specially in urban area. If we gave more importance, then the incidence of increasing 2 or 3 degrees of Dhaka city may not be happened. As a result, energy consumption matter is totally related to planning. -- in our rules for Building construction or in planning, there is no scope of ensuring using natural ventilation, natural sunlight.”

Besides the building construction planning, there is no proper planning for energy distribution in Bangladesh. One of the most common reasons of there is no energy data. It means there is no data about the household consumption that cover this house has this amount of electric point, the data of how many bulbs, fan, and A/C are in the house (interviewee V1). There are no building weighting mechanisms or energy labelling options. As a result, the government cannot regulate household energy uses (interviewee I1). Therefore, a household-level energy database is necessary for sustainable energy use and distribution mechanisms in the urban area.

It is also observed that energy generation capacity has increased from 4606 MW (2009-10) to 13792 MW (2020-21) over the past twelve years. Presently the energy generation system of Bangladesh is fueled by domestically available natural gas (60.19%). To meet the rising electricity demand, the government has permitted furnace oil and diesel-based plants as ‘Quick Rental Power Plants’ (QRPP). A small amount comes from coal (6.21%), hydropower (0.81%) and RE (0.20%) (GoB 2022b). The predominant reliance on such nonrenewable energy resources could never be a solution for the sustainability of the power supply (Muntasir 2020). Post covid-19 situation and then the Russain-Ukraine war have already proved that world's fossil fuel market is in turmoil, and it would be difficult to predict the future of this market. The only sustainable solution to this problem would be renewable energy, which is considered a vital element of any country's environmental quality and sustainable development (Usman et al. 2021).

However, the options for general urban dwellers for using renewable energy are minimal because utility services in an urban area come from institutional sources. The survey data of NC also revealed that more than ninety-five per cent of urban dwellers do not know whether their energy comes from renewable sources (Figure 6.4).

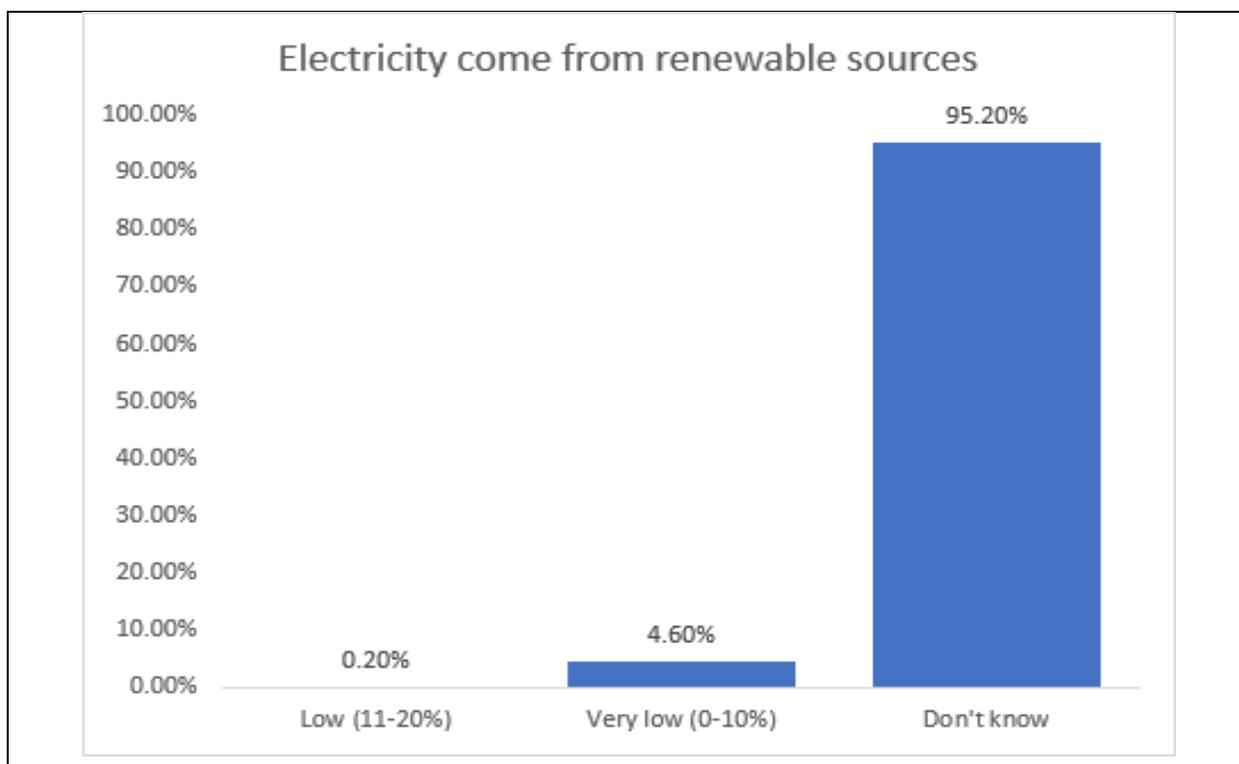


Figure 6.4 Knowledge about the sources of electricity of NC's people (Source: NC household survey /2022 by author)

The country-level preparation is deficient in promoting individual-level renewable energy uses. If the preparation is weak, no one cannot be so optimistic that the energy supply system will be a sustainable one. A possible solution for this would be introducing inspiration packages at individual levels (interviewee-I3, N2, A4). For example, if anyone produces twenty per cent of his energy from renewable sources, the government can give him/her a twenty per cent reduction of his/her monthly electricity bill. However, the affordability issue is a big challenge. As the technology of renewable energy production and its maintenance cost is remarkably high in Bangladesh, most people cannot bear this cost. Despite this, interviewee G1 argued that the people of Bangladesh are now more aware. In Bangladesh, there are about six

million solar home systems and ten to twelve, or a maximum of fifteen per cent of energy, comes from renewable sources. Some private buildings use renewable energy and reuse their water.

In contrast, the study of Md Abu and Imran (2021) revealed that the general people could not afford the cost due to the high price of Solar PV and inadequate financing options from the government. Due to this affordability issue, it would not be fair to blame the general people. Interviewee G2 suggested an easily installable net-metering system to resolve this problem.

It is also found that it is easier to introduce a net metering system at the bulk level rather than at the individual level. The current GoB net metering system policy only allows those with roof space and a 3-phase connection. Most of the city dwellers of Bangladesh live in a rented house. As a result, the net-metering policy has failed to achieve inclusiveness (Jager-Waldau et al. 2018). Moreover, Holdermann et al. (2014) studied 63 distribution networks in Brazil. Their study observed that small-scale grid-connected PV in residential and commercial sectors was not viable for residential and commercial consumers. While an SREDA report suggested that if modern energy-efficient alternatives replace traditional appliances in buildings, it could lead to a 36% reduction in total electricity demand (Muntasir 2020). This could be the most relevant solution for Bangladesh to ensure the power security of the Urban area. To do this, GoB can impose some liabilities on the most energy-consuming appliances producing companies. So, they can be more aware of the production of more energy-efficient devices.

Furthermore, as a country-level initiative, interviewee N2 suggested that the government capitalize on all sorts of opportunities. For example, Bangladesh has, on average, 4 to 11 hours of sunshine throughout the year except for the rainy season from June to August (Das et al. 2018). Despite this abundant sunlight, there are still plenty of bare rooftops in government and corporate offices. First, the government could install modern solar panels in its office buildings. Then the government could use that system as a model for RE and showcasing. As a result, other corporate bodies could come forward. The government can impose energy taxes on them if they do not come forward.

In addition, the present government policy is supportive of renewable energy. The 2012 Stability and Renewable Energy Development Authority Act gave birth to SREDA to ensure energy security (Das et al. 2018). The government also has the vision to produce thirty per cent renewable energy by 2030. For example, in Bangladesh, there are some bare lands and some agricultural land where the crops/plant needs shading. In these bare lands, solar panels could be set up on a massive scale (interviewee G1). The solar PV capacity of India jumped from 2.6 GW in 2014 to 20 GW in 2017. Bangladesh's government has an excellent opportunity to learn from India (Das et al. 2018).

In the present policy, there is also a provision for setting up roof-top solar panels in the newly constructed buildings; otherwise, they could not get the national grid connection. However, due to the weakness of policy implementation, the government is not benefiting from this policy. As interviewee A4 resonates that:

“Regarding renewable energy of urban area, in our policy, we need to produce a certain amount of energy by using solar panels. Solar panels are also installed otherwise no permission is given to build new buildings. But there is no monitoring regarding their activeness. After some years they become a waste. They cannot produce electricity as much as they were supposed to. Only panels are left. Sometimes we also use solar light. I also found it when I worked in a slum area. But they told me that we used them before but after a certain period, they are not functioning, and they were not able to replace them. We need to take care of these areas.”

Apart from the above short-term solution, an exciting and more effective long-term solution comes from interview data. The solution is educating a generation about the importance of renewable energy. The education institutions can arrange several dialogues with the students. A campaigning, distribution of leaflets, advertisement in print and electronic media, and billboards only create a temporary footprint in the mindset. After some days, people have forgotten all of those. To make a permanent footprint of the importance of renewable energy, this should be included in the educational curriculum. Then the students might say that taking energy from these sources will create this problem. If I could take this energy from sunlight, there would

be no problem. However, the first generation of this education system might not make their parents understand its importance, but after 10 or 20 years, this generation will be parents, and they can make a change (interviewee-V1).

Therefore, it can be concluded that energy consumption is a compulsory prerequisite for a country's urbanization; however, clean energy sources, for example, solar, hydropower, and wind, can make a city's energy supply more sustainable. To achieve this sustainable energy supply, household-level energy consumption database, construction of green buildings, energy efficiency appliances, the bulk-level net-metering system for solar power, the government-level model for solar power generation stations, and inclusion of the use of RE in the national curriculum are highly recommended. As Bangladesh has abundant sunlight and the technology of Solar PV is gradually improving, the government can strengthen the existing initiatives for producing solar power. For this, paying more attention to bulk solar power rather than individual level would be better. To do this, the government can first include its research organizations in urban areas, such as BCSIR, BAEC, BRRI and BARI. In the first stage, they can produce a certain amount of their energy from RE using their funds; then, the government can give some extra budget to support them. The government can also include different universities in this race.

There is also considerable bare land in different regional government offices, airports, and cantonment areas. These bare lands can also be used for solar power plants. Once these initiatives are completed, GoB can declare a highly performing research organization, university, or any other institution as a net zero energy institution and introduce a national award system. The private sector can then replicate this system.

Secondly, the government can declare a newly developed city area as a solar city. After completing this solar city project, the government can declare that no private developer company will get power from the national grid. They should generate their RE power, and the government will incentivise them through various tax cuts. Strengthening SREDA will oversee the RE activities on the government's behalf, and the Power Division will coordinate everything.

6.2.3 Environmental Dimension of Urban Sustainability

6.2.3.1 Food Waste Management

According to United Nations (UN), food waste is generated from negligence, poor stock management or economic behaviour, redirected to agricultural compost, animal feed or bioenergy (Joardder and Masud 2019). Every year urban areas of Bangladesh produce 0.603 million tons of food waste. To produce this amount of food, an estimated 17215.2 thousand acres (about twice the area of Belgium) of land and enormous amounts of natural resources are being used (Ananno et al. 2021).

Moreover, global food demand will increase by 70% to meet the predicted population to reach 9.8 billion by 2050 (Ananno et al. 2021). As a result, food waste is assigned as a global issue for all dimensions of sustainability (Hasan Masud et al. 2020). It is worth mentioning that, though the world produces enough food, one in nine people remains malnourished due to the waste of food, as 821 million people experience hunger daily (Mathew 2020). Therefore, limiting food waste is urgent and calls for a change in our present consumption behaviour (Hasan Masud et al. 2020).

The amount of food waste at various stages of food processing varies in developed and developing countries. For example, most food is wasted in developed countries in the consumer phase. On the contrary, in developing countries, a substantial amount of food is wasted in the production to retailer stage (Joardder and Masud 2019; Masud et al. 2020). For example, in Bangladesh total cultivated food was 52.78 million tons in 2016-17. The final amount of food on the consumer stage was 28.96 million tons. The remaining amount, i.e., 23.82 million tons (45.13%) of food, was wasted in the harvest, post-harvest, process, and distribution stages (BBS 2018, Joarder and Masud 2019). An interviewee- N3, also illustrated that:

“--- in our case, 40% food is wasted during harvest and post-harvest period, but it is very negligible during retailing or consumption. Compared to developed countries, it is completely opposite. It is very negligible during harvest period but extremely high when it is consumed. I think, in our consumption level or in retail phase system our food waste is very minimum.”

Further to this, rapid urbanization, industrialization, and the migration of citizens are considered the leading cause of enormous waste generation in the urban area of Bangladesh. Among these wastes, 68.11-81.1% is food waste (Shams et al. 2017). Whereas in Europe, 50% of the total Municipal solid waste is food waste, and 55% is in other developing and least-developed countries (Rich and Felfel 2015; Thi et al. 2015). The urban area of Bangladesh generates 10706.7 tons of solid waste per day. Only 40-50 is appropriately managed as there is no proprietary food waste collection system (Mourshed et al. 2017).

Apart from this, interviewees A1, A2, A3, A5, G1, G2, G3, I1, I3, N1, N2, N3, and P1 gave a detailed picture of the food waste generation and management system of the urban bodies of Bangladesh. Their comments revolve around the waste collection process, people's awareness, and infrastructure. They all agreed that there is no source separation system, lack of infrastructure, no comprehensive waste management program, workforce shortage in local authority, lack of citizen awareness/engagement, cultural problems, and mindset problems in the city food waste management system.

Some contradictory opinions are also found. For instance, interviewee- A2 recommends citizen engagement as one of the most effective ways of food waste management. Meanwhile, interviewee A1 opined that only citizen engagement would not do anything unless the provider (local governments) had a proper management provision. It indicates that an integrated waste management system is a necessity where both providers and users will play their roles.

Moreover, waste management systems do not get enough attention like other sectors, like water or electricity, in every developing country (Ahmed et al. 2023). However, if we consider urban sustainability, the waste management of urban areas should be considered more seriously. It is also noted that an extra burden should not be given to managing waste in developing countries (Kavanagh 2019). This view requires patronizing the existing novel initiative in some urban areas. For example, interviewee A2 informed that some housing societies in the city areas had taken the initiative to collect waste more systematically. If local authorities connect with all these individual initiatives, it will create a remarkable story that will make the entire urban area cleaner. According to his voice:

“If we look at the neighborhood housing society, giving different security services into the neighborhood, and sometimes they also play the responsibility of waste collection. So those sorts of small locus, we can work on it. So, different housing societies, different community groups, different small credit groups, small savings group. So, this sort of group we can accumulate, the good stories we can accumulate and then we can use those good stories to build a big story (Interviewee A2)”.

Awareness builds up, which might also be another no-extra-burden solution for food waste management in the urban area of Bangladesh. Interviewees N1, G2, A5, A2 agreed that citizen awareness could prompt results in managing urban waste. Awareness of the people’s representatives of local government is also essential. Because sometimes, it is found that the ward commissioners are taking the initiative to set up a dumping station near the park (interviewee-I3). Besides this, cultural problems are also an obstacle to urban waste management. For example, Bangladesh's city dwellers are accustomed to throwing waste on the roadside or the drain. Interviewee A2 also opined that-

“-----most of the people are not very much aware about those waste management things. MOST OF THE PEOPLE WANTED TO THROW THEIR WASTE INTO DUSTBIN OR JUST IN THE DRAIN. So, that culture, that practice has been developed for a long year. So, if you wanted to change this sort of culture, this sort of practice, you need lot of training program, citizen engagement program, campaign program, so that people can aware and then they will act on it.”

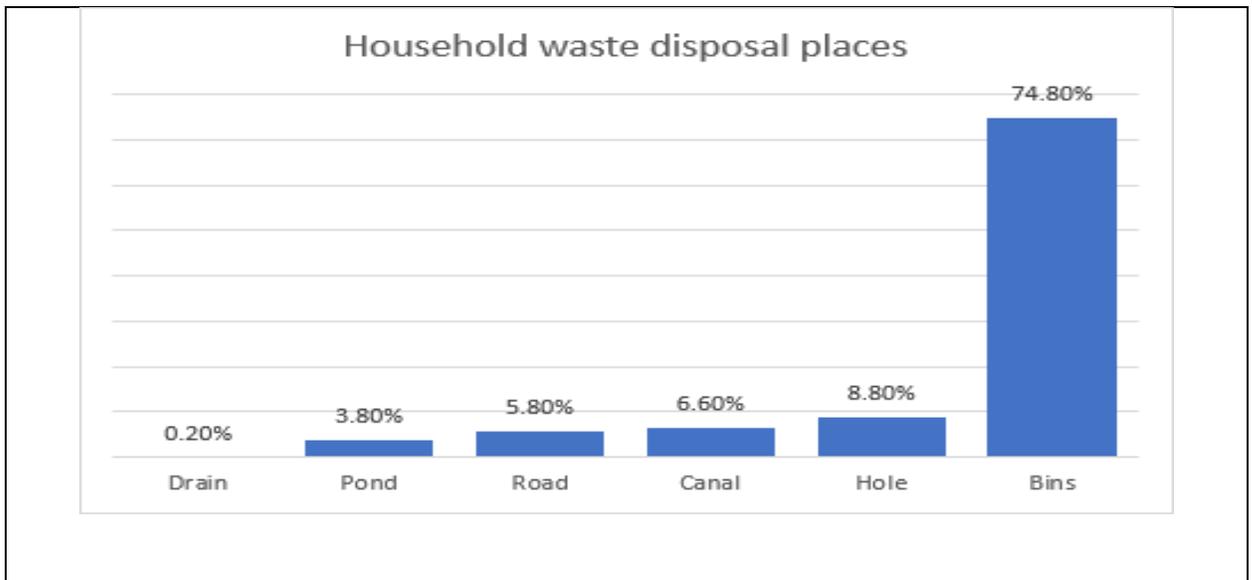


Figure 6.5 Household waste disposal places (Source: Author’s household survey of NC/2022)

The survey findings of NC (Figure 6.5) also show that more than twenty-five per cent of people still do not use the bin for household waste. They have thrown their waste in nearby holes, ponds, canals, drains, or roads.

Furthermore, food is wasted during ceremonies in the city areas, especially in the upper class. The people of this class consider food waste as a status symbol. As interviewee -A1 stated-

“----- in many events, I observe that, suppose, uh they take a lot of food, and they do not feed, they are not able to finish. And sometimes they think that, having half of the meal, and or keeping half of the meal on the plate, this is something, you know, status, or something you know and the wealthy people to show off something like that. Uaa, this is wrong (ironic tone). So, if you are having one banana and eating half of the banana and throwing remaining half or drinking half of the glass of the milk and keeping the remaining half, to showing that this is for something, you know to showing of the status, that is the wrong thing. So, to overcome this we need to make the people aware. With this, wasting food is nothing about the status or income or class of society.”

The government can take the “Clean Plate” campaign in this case. An online activist in China initiated this campaign, and it went viral. Then the government of China endorsed it and achieved dramatic success in the war against food waste (Huang and Qin 2020). Prasad et al. (2011) argued that developed countries allocated almost ninety per cent of their expenditure on waste management to grow awareness, establish treatment facilities or segregate activities. In contrast, developing countries spend almost eighty per cent on collections and landfills. As a result, developed countries waste management is far better than developing countries.

Furthermore, people in developing countries usually think the local government must only keep their area clean. However, due to a limited workforce, and resources, the local authority cannot manage the increasing amount of waste. Therefore, local government can get support from urban communities by making them more aware.

Sometimes, it is also revealed that only awareness built up cannot work correctly. Alongside awareness building, enforcement is also required. Interviewee N5 also opined that only awareness would not work, especially for the city area of Bangladesh. Enforcement of existing laws is also a big issue. Since 1972, GoB has enacted more than 200 laws, policies and national strategies related to environmental crimes and protection. Most prominent among these are the Environment policy 1992; the Bangladesh Environment Protection Act, 1995; the Environmental Conservation Rules, 1997; the Ozone-Depleting Substances (Control) Rules, 2004; the Bangladesh Environment Court Act (ECA), 2010 (formed in 2000); and the National Environmental Policy, 2018. These laws and policies have not been well enforced (Nahar et al. 2022).

Besides, in 2002 Bangladesh declared a ban on plastic bags thinner than 55 microns under the Environment Conservation Act 1995 as a part of her pollution control initiative. The 3R rule (reduce, recycle, reuse) was also implemented, and now it is upgraded to the 4R rules (reduce, recycle, reuse and recovery) (GoB 2021). The GoB also committed to meeting the UN’s SDGs Goal 12 (Ensure sustainable consumption and production patterns) and formulating Five Year Plans to achieve this goal. Ananno et al. (2021) claimed that while these are the significant achievements of the GoB, some of these regulations are outdated and do not address current food waste generation

levels. None of the acts and regulations generally deal with food waste and waste reduction.

However, it is a positive thing that several voluntary organizations, Viz Bidyandondo and BhatBank, donate food to hungry people, but there is no formal coordination between these VOs (Voluntary Organizations) (Ananno et al. 2021). Interviewee A5 also argued that a massive amount of food is wasted in the student dormitories of different universities. If there is coordination between the Dormitories authorities and these voluntary organizations or an app can be developed to inform that this amount of food is available in this area; the poor people of urban areas, especially rickshaw pullers, day labourers, will be informed by those voluntary organization and they will be able to collect the food from respective student dormitories. It will save a vast amount of food from waste. Similarly, Local government can incentivise restaurant and community centre owners through tax reduction, subject to the distribution of their remaining food to people experiencing poverty.

Additionally, a follow-up survey of the “Implementation of 3R initiative (pilot) project” informed that 35-55% of respondents were interested in source segregation, 45-65% in reducing, 60-75% in reusing and 70- 85% are interested in recycling (Alam and Qiao 2020). Therefore, we can say that our people greatly support clean waste initiatives.

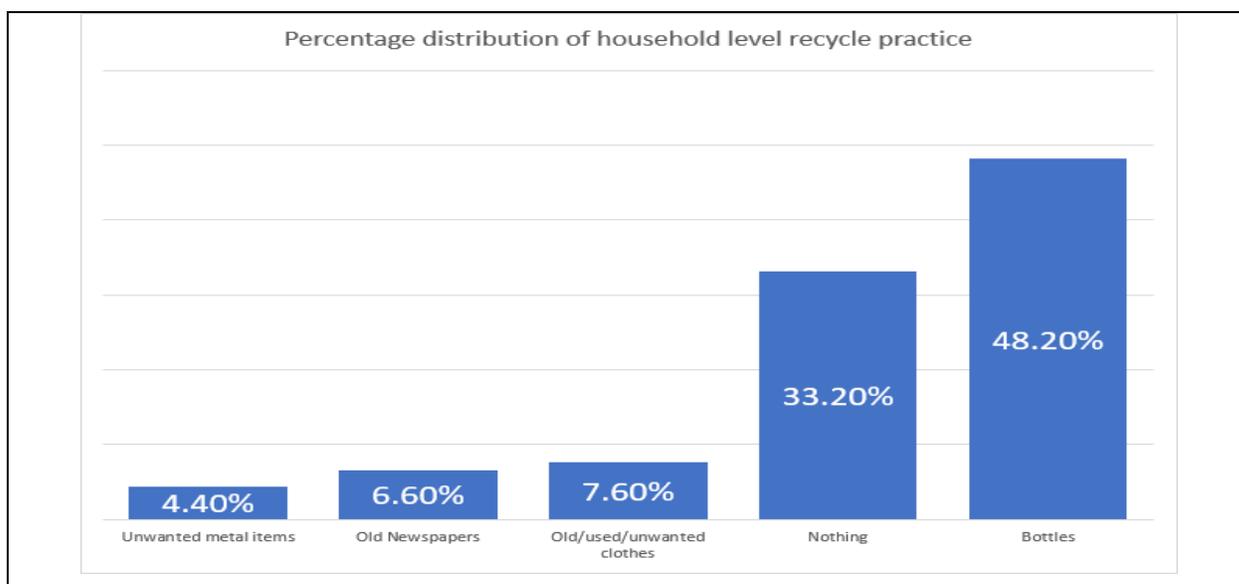


Figure 6.6 Household-level recycling practices in NC (Source: Household Survey of NC/2022 by Author).

It has also been found that a naturally grown recycling mechanism is already being developed in urban areas. The above figure-6.6 revealed that only 33.20 per cent of people in NC recycle nothing, whereas more than sixty-six per cent recycle several types of bottles, including plastic and glass, old newspapers, and unwanted metal items.

Figure 6.7 also presents that many poor urban people segregate recyclable waste from the dumping side, and some local vendors buy the recyclable waste directly from the household.

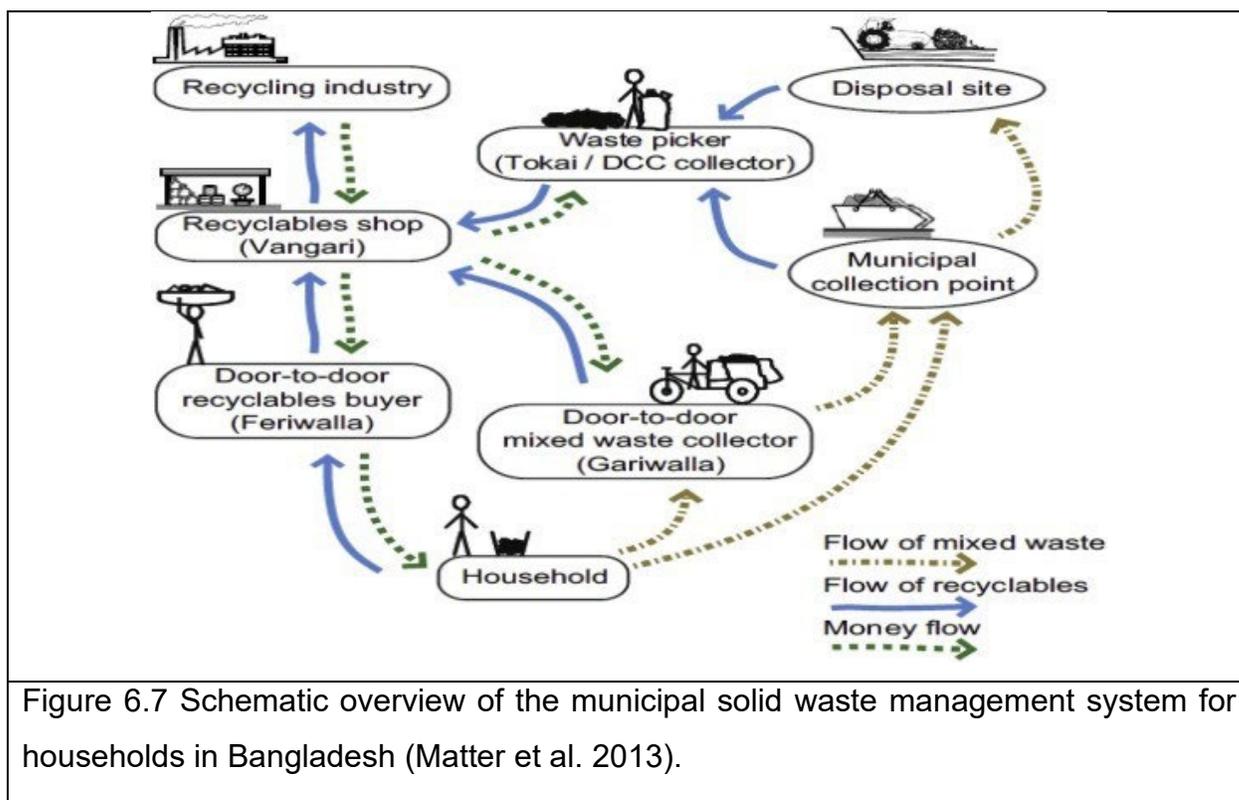


Figure 6.7 Schematic overview of the municipal solid waste management system for households in Bangladesh (Matter et al. 2013).

In addition, Interview V1 informed that many urban people are involved in this recycling process. A study by Swapan (2009) also reported that up to two per cent of the urban population depends on picking up recyclable waste from the dumping side. They work informally, and the local authorities do not recognize their work. Their formalization, i.e., integrating them into the formal waste management sector, can be another cost-free solution for city authorities to combat urban waste. It should be remembered that waste is considered a mirror of society (Alam and Qiao 2020). Therefore, the less waste, the more pretty the city's image will be.

Therefore, as a developing country, Bangladesh can take no extra burden approach to the citizen for food waste management. For instance, with existing activities, GoB can allocate more budget for people awareness. Local authorities can accumulate the existing novel practice of some urban areas and campaign for a “cleaning plate” program. Local authorities can also coordinate voluntary organization works. Student dormitories and restaurant owners can donate their extra food to people experiencing poverty, and the government can give them incentives in terms of tax reduction. Coordination in food donation can be done by developing an app using BUET or other relevant organizations. City authorities can also promote informal recycling practices of urban dwellers and formalize the informal workers of the household waste management system. Bangladesh's people support implementing clean waste initiatives and engaging them in the waste management system would be easier. However, there is still a lack of an integrated waste management system which is necessary. Only effective initiative from the provider side (local governments) is needed.

6.2.3.2 Land Use

Historically Bangladesh has been an agricultural country, and most of the land is now used for agriculture. The urban area is expanding spatially by transforming this agricultural land into built-up land. It is also found that Bangladesh is the largest delta in the world. As a result, there are many rivers, canals, and water bodies. Urban areas are also developing by encroaching on these water bodies. The interviewees gave more emphasis on nature-based solutions, keeping balance in blue and green space, green infrastructure, co-operatives in agriculture, and rented housing rather than ownership of a house to make the current urbanization process of Bangladesh more sustainable (Interviewee- I1, G2, G6, A4, G5, I3).

However, like all other developing countries, the current practices of land use patterns in Bangladesh produce many problems in achieving the goal of sustainable urban development (Rahman and Szabo 2022). Land use allocation is also critical in balancing the sustainability pillars. For example, building residents in low-lying areas may meet the housing demand, but it will create an urban drainage problem. Similarly, building construction may increase economic activity but deteriorate the environment

and urban health. Therefore, careful urban land-use optimization planning is vital in achieving urban sustainability (ibid).

Although, a different scenario is found in Rajshahi city of Bangladesh. Here the city authority implemented the master plan with the cooperation of the general people. There the city planner convinced the people to follow the master plan. Thus, they can maintain a balance between the green and blue spaces of the city, which make Rajshahi one of the best cities not only in Bangladesh but also in the world. According to World Health Organization (WHO) report, the city is recognized as the most prosperous city in the world in reducing harmful particles PM10 and PM2.5 in the air in 2014-16 (Graham-Harrison 2016). This proves that a good initiative from the city authority can make a city eco-friendlier, enhancing any government's sustainability endeavour. As an urban planner of the Rajshahi Development Authority interviewee, G6 illustrated:

“I found that in the last 15 years, 45 square kilometers have been developed where about 1.5 lakh structures are newly constructed. It means, they either developed on agricultural land or green space or any blue space. But our green space has decreased only about 1 percent. It was possible because we can convince people that they should follow the master plan. It means in every city, if our development controlling authority, concern that we should follow the master plan, we may not success 100 percent, but if we able to 40 to 50, that will help lot for sustaining the development of a city.”

Rahman et al. (2022) also reported that, except for Rajshahi and Sylhet, the urban area of Bangladesh is characterized by low tree plantation and highly fragmented vegetated areas. Most of the area is covered by built-up land. For example, 90 per cent of Dhaka city is covered by built-up land (interviewee I2). However, once upon a time, this city was blue and green. There were rivers and canals, but we destroyed them (interviewee G2). The built-up area has increased by 67% since 1990, replacing the water bodies, lowlands and vegetation areas (Imran et al. 2021).

Similarly, Chattogram city of Bangladesh also experienced an increase in built-up land at 3.55 Km²/year (Roy et al. 2020). Dhaka city's per capita green space availability is nearly zero (Arfanuzzaman and Dahiya 2019). The interviewee- I2 also reported that:

“As a result, in our every case, the ideal scenario, for sustainability we termed them, I can say it in an easy word that minimum 25 percent of a city area should be green, 10 to 15 percent should be waterbodies, and you can develop the rest 60 percent area in Bangladesh climatic condition. Within this 60 percent area, you need 20 percent for roads and 40 percent for buildings. It means green and water is a very urgent need. Because they create environmental balance. But to make Dhaka city into an environmentally balanced city, there was a need for 40 percent area for green and water, whereas 80 to 90 percent of the area of different ward are concrete area.”

However, interviewee G5 was very optimistic about the future of Dhaka city. He opined that now Dhaka is a mega city with 100 problems which are challenging to manage. Nevertheless, the central resource of the city is a massive amount of water bodies. By managing these water bodies, Dhaka would be an ecological island city. Then these problems will be segregated to these small island cities and can be easily handled.

The supporting voice was also found in the illustration of interviewee I1 but in a different way. He emphasized land ownership. He pointed out that the present individual land ownership is an obstacle to implementing the plan. In his opinion, it is found that nature-based solutions would be the best option for Bangladesh to ensure sustainable urban development. As he said:

“The focus of this country is agriculture. So, focus should remain on the agriculture sector during these changes. But as the approaches, it is good if the agricultural sector can go towards more mechanized agriculture. Also now, most of the agricultural land is owned by private owners. So, they decide themselves what to do with their land. It is good that during the process of urbanization, this private land can be transferred to co-operatives, to governments. --- Because right now it is difficult, and this part is especially important for sustainability. If the co-operatives and government can have more ---- for agricultural sector, which is particularly important for sustainability, that can again guarantee that implementation of sustainability principles in the field.”

In contemporary literature, it is also found that nature-based solutions (NBS) are the best solution to maintaining sustainability in urbanization. For instance, Laforteza et

al. (2018) reported that different countries and governments are now returning to nature to resolve environmental, social, and economic problems. Ferreira et al. (2020) termed it an umbrella approach with many ecosystem-based initiatives. European commission defined NBS as solutions inspired by, supported by or copied from nature that have vast potential for energy and resource efficiency (Tayefi Nasrabodi 2022). The European Commission proposed urban agriculture, green roofs, rainwater harvest, green (park), and blue space (water bodies) as NBS. NBS is an emerging issue that deals with using, conserving, and restoring nature to meet the social, economic, and ecological challenges that can contribute to urban sustainability (ibid). For instance, interviewee A4 stated:

“Another thing is the environment is such a place that once we destroy it, we never regain it. Particularly the natural resources. Probably we can build some artificial wetlands and others. But if we make plans by considering nature, then it will be more sustainable than the artificial one. You can build artificial canals and rivers, but it will not be a nature-based solution. Bangladesh is truly fortunate regarding the natural resources. Firstly, we are destroying nature then we are trying to amend it. Dhaka is already an example of what should not be done. Urbanization is happening in all over Bangladesh. It is not only confined to big cities. Other small cities are still developing. Therefore, in this small city still we can save our natural water bodies and agricultural land.”

Therefore, it is revealed that nature-based solutions would be the best solution for the sustainability of the urban area of Bangladesh. This solution was possible in one of the cities of Bangladesh called Rajshahi. It can be replicated in other cities. Additionally, land ownership can be transferred to a cooperative or government. Then it would be easy to implement any plan. Government or cooperative bodies can construct and rent/lease housing facilities to urban dwellers under a long-term contract. The existing water bodies, canals, and parks should also be nourished, especially Dhaka city planning could make this city an ecological island city. This will allow the existing complex problem to be distributed to many small cities that will be easy to manage.

6.2.4 Institutional Dimension of Urban Sustainability

6.2.4.1 Planning

Effective urban planning is considered a crucial factor not only for livable urban development but also for better progress towards sustainability. In a developing economy, urban planning usually focuses on the physical infrastructure construction of roads and drainage systems. These economies also tend to import the master plan of developed nations without considering their own social, economic, and political contexts (Baffoe and Roy 2023).

This tendency is due to the effect of the longtime colonialism of these countries. For example, Dhaka city of Bangladesh, has a 100-year history of urban planning, dating back to the first and second master plans in 1917 and 1959, respectively (Choudhury and Armstrong 2013). Till today, the city authority considered those plans as the foundation of new plans. Probably this is because of the dysfunctional structure of planning institutions, administrative discrepancies, and bureaucracy (Baffoe and Roy 2023).

Moreover, planning practices in Bangladesh suffer from technical shortcomings, financial constraints, lack of automation and unexpected political interferences. These challenges lead to a long delay in finalizing a simple planning task, ultimately hindering accommodating the urban area's changing socioeconomic needs. Partial implementation and failure of many plans are also worrying pictures of Bangladesh. A senior urban planner rightly pointed out that (Interviewee I3):

“--But still, we or country are not able to reach a stage to exercise such type of planning. Because whenever you say a good thing, the media of our country will give a negative message, as they belonging to different housing companies, planning means they are decreasing our square feet. We do not need planning, need to increase square feet. This is a big challenge in recent times. The real estate businessperson does not want to understand this, though this business is not only existed in Bangladesh, but also all around the world. The real estate businessperson is now also in government machinery, or a special type of

relationship is developed with the policy makers. As a result, challenge is manifold.”

The main limitation of development in Bangladesh is that development is happening without proper planning. Only need-based development is done (Interviewee-G6). Many projects are taken ad hoc, not based on sustainability. Another critical characteristic feature is that most urban development work is done for one or two big cities of Bangladesh, but the other urban centers are neglected. One of the government urban planners also illustrated that (interviewee G5):

“---We find that, we have invested a lot in Dhaka city, we have constructed more flyover, infrastructure, facilities, amenities in Dhaka, these will attract young people of Satkhira, Chattagram, Panchagor and they move to Dhaka. There is not a systematic network in our country. We have to decentralize all the facilities and in this regard, there is lagging in the government policy.”

However, one NGO representative (interviewee N1) opined a different view. He argued that recently, the government of Bangladesh has been taking several steps to create more employment opportunities outside of the major cities' areas. He called it a decentralization of development by setting up industries and creating employment opportunities. Interviewee-G5 also supported him and added that the government is now setting up EPZs (Export Processing Zone) outside major cities. One of Bangladesh's eminent urban planners also opined that the present policy of setting up 100 SEZ (Special Economic Zones) is a good initiative. According to his voice (Interviewee-I2):

“Urbanization in Bangladesh needs to be decentralized, with slowing down the growth of Dhaka and planning faster growth of regional large cities and intermediate cities. The present policy of developing 100 Special Economic Zones, all outside Dhaka is a good imitative.”

It was also found that the planning of Bangladesh is not inclusive. Bangladesh's planning practice does not consider the marginal, low-income people, though they are a significant part of economic activities (interviewee I3). Without an inclusive urban development policy and solid political commitment, it will be difficult for Bangladesh to

achieve SDG-11 (sustainable cities and communities). There are many national policies, but no policy will ensure sustainable urbanization. Ensuring sustainable urbanization, inclusive urban policy, proper planning, distribution of resources, necessary laws, rules and regulations, decentralization, and development of other small, medium, and big cities and towns are crucial.

However, adopting the SDGs results in a paradigm shift in the national development planning process. Before SDGs, the planning formulation of Bangladesh was only growth-oriented, not inclusive, and non-participatory. Nevertheless, after the SDGs, the present planning formulation process is more participatory and inclusive, emphasising decentralisation and governance at the local level (Okitasari and Katramiz 2022).

Despite this, the historical decentralization process in Bangladesh indicates that the government is very reluctant to transfer authority to local governance institutions. Evidence shows that the central government uses their financial power to influence the local governments (Devas 2001). Consequently, despite regular initiatives, an independent, empowered local government body is yet to emerge in Bangladesh (Asaduzzaman 2016). A representative of the Volunteer Organization of Bangladesh rightly argued that (Interviewee V1):

“I have to acknowledge that decentralization is a challenge for us. This actually comes first when you talk about Dhaka city. Because, I know my city has the capacity to take this portion, but I am giving him 10 times more. So that should be the first concern. Our government offices, factories, mills, sometimes educational institutions, should be very decentralized. Educational institutions should have outside campus, people should not come to Dhaka for just paperwork. They should easily get access from their own locality.”

Moreover, decentralization can make a scope to bring government and people closer to each other. Because it gives more information to the citizens, citizens can easily monitor the performance of government officials. In other words, at the local level, decentralization can make bureaucrats accountable, and citizens can easily communicate their problems and preferences to the local politicians (Campos et al. 2005). Local government authorities are also considered especially important to the city

dwellers as they try to protect urban people's rights to better services (Satterthwaite 2005).

Briefly, for sustainable urban development, Bangladesh needs inclusive planning with a decentralized approach that can strengthen the local government. The government is now setting up industrial zones in different areas, excluding the existing cities. This is a good initiative. Like previous planning, the government should not move back to implement this.

6.2.4.2 Implementation of plans

Devas (2001) argued that good urban development planning is a combination of policymaking, a planning system and the implementation of a plan. In Bangladesh's case, the plan's implementation picture is not satisfactory. Baffoe and Roy (2023) reported that out of 31 proposals of the Dhaka metropolitan development structure plan 1995-2015, only eight were fully implemented, 11 were partially implemented, and 12 remain unimplemented. A planner resonates with this implementation failure, noting (interviewee-G2):

“Umm, planners can produce plans, but implementation depends, lot of things depends on the policy maker, the political will, that is especially important. On the other hand, if the citizens are aware of their rule and they can also compel the government to do that. That can be helpful also from the bottom-up approach.”

Many governments in the world are now inviting general people to participate in implementing a plan, especially the poor and marginalized people. Local citizens' participation has also been patronized to scrutinize the programs and monitor the everyday activities of the public servants (Aiyar 2010). These will also help in implementing the plan in Bangladesh. A reputable urban planner remarked (Interviewee- A4):

“The general people will do their duties only when we include them in plan formulation and implementation. If we do not do that, there is a beautiful word of Jean Jawker, “every city can give something to every people, if they are included in the development work of a city.” Otherwise, it will not happen. For example,

the waste collection process. Now we are formulating some laws but if there is no people participation in policy formulation, they will not obey it. There are many stakeholders for development work. We have to hear the voice of all stakeholders, who is loser, who is more power full, who is gaining more? We have to compensate the loser. Otherwise, we cannot expect that he will obey everything. As a result, I think that when we plan, we have to include all the stakeholders. Then it would be possible to implement that plan.”

Besides the people’s participation, law enforcement is also essential for effectively implementing any plan. In Bangladesh, it is commonly observed that people are very reluctant to obey the rules. There are many good plans/rules, but the main challenge is convincing people to follow these rules (interviewee-I1). The absence of reward or punishment, incentives, and strict law enforcement undermines the existing situation of policy implementation. Some countries, for example, the Republic of Korea, have introduced radiofrequency identification (RFID) chips to monitor the general public's waste production and disposal process. Bangladesh can consider such monitoring tools at least to implement the waste management policy (Jerin et al. 2022). Because if we want a livable, clean, and particularly sustainable city, the desire of all people will never be fulfilled. Regarding this, an NGO representative expressed his frustration as follows (Interviewee N3):

“The expectation of people will never be fulfilled, if you want to make a plan city and if you want development, then people also need to sacrifice in many cases. Specially the musclemen, who are controlling the housing sectors or service sectors, they do not sacrifice at all. Rather they are influencing the government that those planed should not be implemented as planned. This is happening in case of DAP or CDA or KDA as well. Government should play a strong rule in this case, for law enforcement, for plan or zoning, as a result, the zone, which is made for a specific objective, that should be maintained (strong voice).”

Therefore, strong political will, specifying the functions of the different authorities, the adequate workforce in the local government, proper co-ordination among the implementing agencies, people’s participation in the policy formulation and strict law

implementation with a robust monitoring system would be enough to get the maximum benefit of the existing policy/plan of Bangladesh.

6.2.4.3 Governance

Rural-urban migration creates a massive influx of inhabitants in the urban area of Bangladesh, raising the question of urban governance (Ostarek 2021). Governance has the power to ensure proper management of resources for the country's economic and social development. As a result, effective governance is one of the crucial parts of any development strategy. Despite this importance, all the governance issues have been a long-standing challenge for sustainable development in Bangladesh (Barai 2020).

Corruption is a governance issue and the main obstacle to equitable and sustainable development. For the last five years (2016 to 2021), Bangladesh's rank in the Transparency International Corruption index lies between 143 to 149 out of 180 countries. However, the development puzzle is that this low ranking, poor governance, and corruption have not been able to stop the growth and development of Bangladesh. However, for the sake of sustainability, corruption and governance problems must be controlled (Barai 2020). Most of the interviewees of this study also identified urban governance problems as one of the significant challenges for the sustainable urban development of Bangladesh. As one of the participants opined (Interviewee V1):

“Personally, I think people can adjust to all the things. The people of Bangladesh are not bother about separate lane for rickshaw, bike, traffic congestion, some people like horn. But the people of this city want citizens' rights, rule of law, good governance, no corruption, implementation of our promise of basic needs, empathy. This could be the priority. If these things happen other things will automatically happen.”

Another eminent urban planner of Bangladesh with more than 58 years of experience (Interviewee-I2) also supports his statement. He expressed his opinion as follows:

“Major challenge of urbanization in Bangladesh are many, but particularly, i) too rapid growth of population, ii) lack of policy and planning at the national level, iii) **poor governance at city level, iv) poor management of environmental**

problems----- If we want to tell a city is sustainable in three words, that would be a city with Good Urban Governance, Reduced physical mobility (possible by virtual communication) and citizen awareness.”

Rahman and Hossain (2021) argued that the major obstacle to good governance at the city level in Bangladesh is the lack of coordination among the different city authorities. For instance, 22 ministries and 51 agencies are now involved in the planning and development of Dhaka city. Due to a lack of coordination, these agencies frequently overlap with their work, which creates more problems than solutions. The interviewee-A2 also provided his final comment as:

“Last thing is we need to ensure good governance in the city. One major thing is we do not have enough coordination. Sometimes the organization which is working in the city has overlapping responsibilities they have. And they are doing the same thing working in the city. So good governance is lacking. ----- The local body, the city corporation, does not have enough financial and administrative power to deal with all the challenges and implement different projects to reduce the challenges, so that is why good governance. So---- good governance issues we need to consider if we develop our city sustainably.”

Baffoe and Roy (2021) and Jerin et al. (2022) also argued that lack of legitimate policy guidelines, overlapping the functions of the different authorities, workforce shortage, and poor or lack of coordination among the authorities obstructs the effective implementation of policies. The main reason for poor coordination is that the organizations in the city area work under separate ministries in Bangladesh (Rahman 2015).

Therefore, if we want to ensure sustainable urban development, Bangladesh needs to establish a high-powered coordinating body which will only deal with the development activities in the urban area. This body could be under the direct control of the Hon’ble Prime Minister of BD. At the same time, GoB could set up a separate division for urban development in the planning commission. Presently the planning commission has six divisions. The Physical Infrastructure division oversees all infrastructural development projects' appraisal and approval systems among these six divisions. Another division,

like the Sustainable Urban Development Division, can be established, which will be dedicated only to the development activities in the Urban area.

6.3 Sustainable Urban Development Framework (SUDF)

The interviewee of this study has produced a series of recommendations. By analyzing their comments, my working experience, and considering the other relevant studies, this study offers a framework for the urban sustainability of Bangladesh (Figure 6.8). The overall goal of this framework is to promote urban sustainability by using the existing facilities according to the principles of “no extra burden to the citizen”. If an initiative imposes additional costs on the citizen, this initiative would not be acceptable. The framework is developed by considering the four dimensions of sustainability. Each dimension was segregated into different sectors. The tools are then allocated to these sectors to sustain the respected sector.

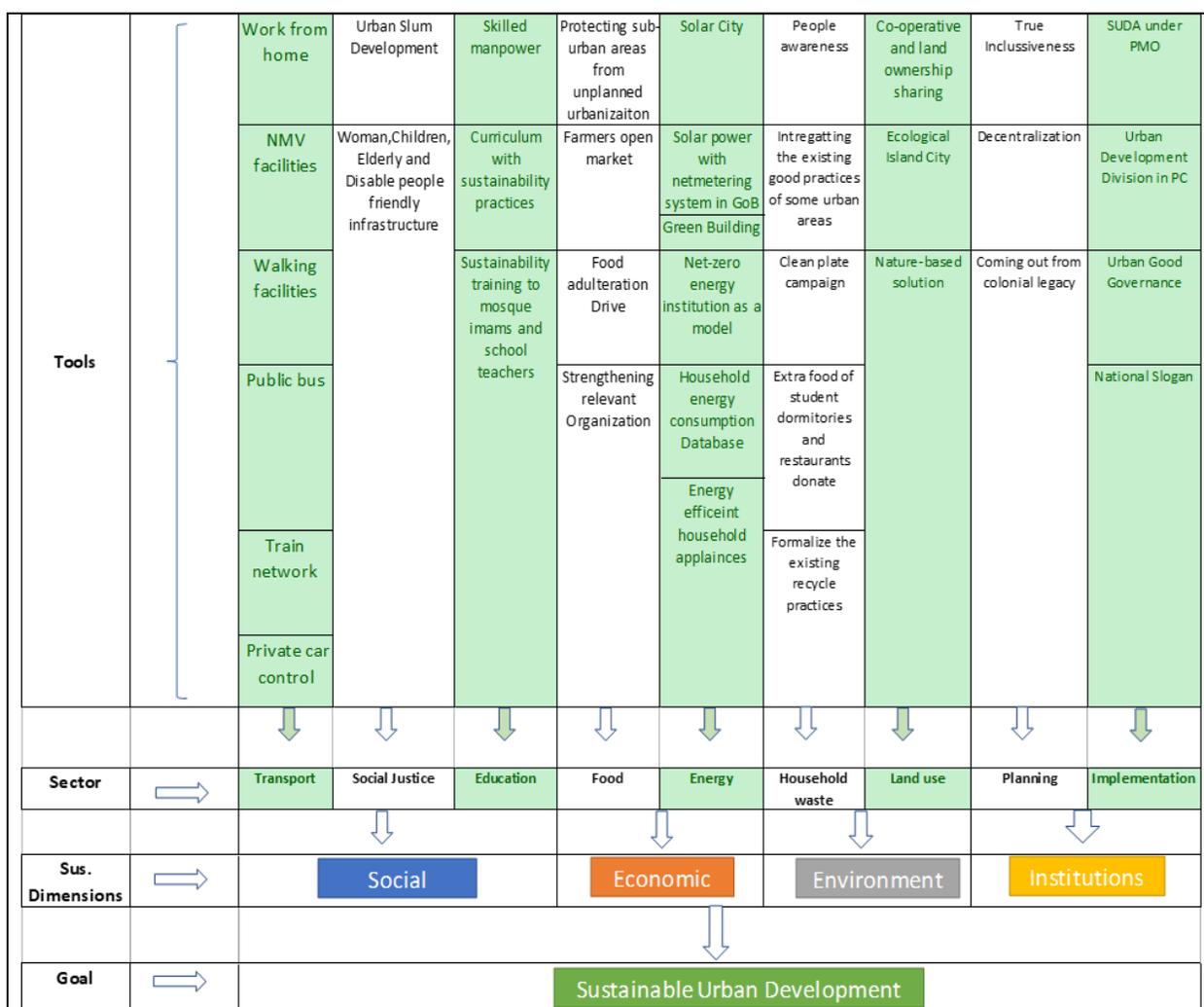


Figure 6.8 Sustainable urban development framework (SUDF) for Bangladesh (Author's creation)

The SUDF suggested that as a developing country, BD should now emphasize social dimensions of urban sustainability, then economic, environmental and institutional dimensions of sustainability. In social dimensions, transport, social justice and the education sector deserve more attention. To achieve the sustainability of these subsectors, different tools are also identified. For example, work-from-home, NMV facilities, walking facilities, public bus, train network and private car control mechanisms should be taken for the sustainability of the transport sector. The following section elaborates the tools in detail as the recommendations of this study for ensuring the urban sustainability of Bangladesh.

6.4 Recommendations from SUDF

6.4.1 Social Dimension of Urban Sustainability

6.4.1.1 Transport

i) Work from home:

It is learning from the COVID-19 pandemic. In this pandemic, most inter- and intra-ministerial meetings were held online. In addition, in the first few months, all officials worked from home, and then the rotation system was implemented. It reduces government officials' movement, reducing traffic congestion in the urban area. This practice is easy to continue and reduces traffic congestion in the city.

If we consider only government offices, for example, each month, at least thirty meetings are held in each ministry. In some meetings, all agency heads and project directors with supporting officers attend far away from the ministries. All agencies also hold coordination meetings at their headquarters before attending monthly coordination and annual development project monitoring meetings in the respective ministries. Consequently, some officials must stay for two or three days around the ministries/headquarters. There are thirty-nine ministries and twenty-six divisions (excluding his excellency president and honorable prime minister's office) (GoB 2022a). As a result, a considerable movement of officials used their vehicles. Thus, if COVID-19 pandemic practices continue, it will reduce traffic congestion in the capital, other divisions, and district cities. Similarly, if other non-governmental organizations follow government offices, this will reduce urban traffic.

ii. NMV (Non-Motorized-Vehicles) Facilities:

Rickshaws (three-wheeler pedal drive) should be considered public transport for Bangladesh's city area, especially for Dhaka city. Because most people love rickshaws for short-distance movement, it also creates employment opportunities for many low-income people with zero emissions. It is also a heritage of Dhaka. Now there is no plan to bring discipline to the rickshaw; instead, imposing restrictions on it. However, regarding environmental or emissions prospects, it would be better to train the rickshaw puller about the traffic rules.

The road infrastructure of the city is also not suitable for bicycles. However, separate bike lanes cannot be created in the old part of the city but would be possible in the new part / newly built urban areas. In the old part of the city, some roads can only be declared NMV roads, where motor vehicles are only allowed in emergencies. Additionally, globally it is found that the popularization of active transportation, for example, bicycles, is taking a long time for cultural and socioeconomic problems. To make it more popular, GoB can involve civil society, political leaders, celebrities, high-level government officials and business people, and even honourable MPs and Ministers. Similarly, employers can encourage employees who use bicycles or walk in the form of tax cuts and additional bonuses.

iii. Walking Facilities

The present Integrated Multimodal Transport Policy of GoB favours promoting walking, where pedestrians are given the highest priority. However, the present condition of the footpath is not walking friendly. Footpaths are usually occupied by small business groups locally known as “Hawkers.” Though there are some dedicated places for hawkers, they are very reluctant to go there. In these dedicated places, there is also space limitation. Some places are situated in such a position that the customers of these shops do not feel comfort. As a result, the design of the hawkers' market can be redesigned.

Moreover, some parts of footpaths can be declared as business areas for a specific time, for instance, from 5 pm to 8 pm, every day or two or three days a week. In addition, there is an advantage that most urban dwellers are used to walking, and their

perception of walking is also conducive to walking. It is also revealed that some parts of the urban area are declared as pedestrian zones during the major festival times. This kind of pedestrian zone can be kept all year round.

Furthermore, no dedicated pelican, toucan, or puffin crossing is on the cities' major roads. GoB can introduce this kind of crossing. However, there are some foot-over bridges, but they are not suitable for the elderly and disabled people.

iv. Public Bus

By considering the road as a space for the people, not for the vehicles, the GoB can emphasize improving Public Bus Network. In the present policy, GoB has the vision to introduce Bus Rapid Transit (BRT), Intelligent Transportation System (ITS), Bus route rationalization and a company-based bus operations system. However, all these will take time. In the meantime, the government can introduce more double décor buses, chain buses, school buses and office bus services on a cluster basis, more frequent buses in pick hours, short distance bus stoppage, elderly, children, women, and disabled people-friendly buses. It is also observed that there is a big gap between the footpath and the door of most public buses. As a result, women, children, especially people with disabilities and older people, are not quickly getting on and off the buses and from the footpath. Therefore, the GoB can decrease the footpath height in the first stage and instruct all bus owners to fix their door height with the footpath level in the second stage.

v. Private Car Control:

It is found that private cars carry eight per cent of total commuters but occupy more than sixty per cent of road space. Though GoB is imposing a high tax on private cars imports, the number of private cars is gradually increasing. It would also be against human rights to stop using private cars. However, GoB can take some additional measures that could discourage people from using their private cars. For instance, imposing more parking fees, congestion fees, high insurance, road tax, parking restrictions, declaring a weekly car-free day, and odd/even number car playing rules with a robust monitoring system.

vi. Train Network:

The government is implementing the rapid mass transit (MRT) project, a highly appreciated initiative. However, to get hundreds of per cent benefit from this MRT, the other paratransit system should be aligned with this. For instance, people of BD are very fond of short distances travelled. If the MRT stations are within a one-kilometer radius, more people will use them. Therefore, MRT stations should be based on population density. Also, the MRT stations should have bicycle parking, correctly linked with footpaths. In a nutshell, there should be a smooth exit and entry system with MRT stations and should be well-linked with multimodal transport systems. After the successful implementation of MRT, GoB can think about circular train networks like trams for the big cities of BD.

6.4.1.2 Social Justice

i. Urban Slum Development

Urban poverty is also increasing as urbanization increases. A significant portion of the people of BD moved to urban areas with the dream of a better life. However, in many cases, their dreams remain dreams, and they are forced to live in urban slum areas. Although slum dwellers contribute significantly to the informal economy, they are neglected in the formal urban planning process. They are also politically abused. However, if we think about urban sustainability, we should consider and move with them. GoB should provide them basic support, such as safe water, shelter, education, and treatment. However, this support can attract more people to urban areas. To mitigate this, in addition to the current social safety net program, GoB should create jobs outside the city area. The current initiative to set up 100 economic zones in various parts of the country could help. Besides this, GoB can take the initiatives to use the unutilized plots of BSCIC (Bangladesh Small and Cottage Industries Corporation) throughout the countries by giving more incentives to the investors.

ii. Women, children, elderly and disable friendly environment:

Presently more than half of the urban population of Bangladesh are women and children. Presently urban development planning is done by considering only able, wealthy, and male people. This mindset should be changed. The transport network,

footpaths, existing open spaces, and parks should be women and children friendly. It is also revealed that there are no facilities for disabled people. The footpath, the foot over bridges, and the shopping malls are not elderly and disabled people friendly. If we think about inclusive urbanization, we must restructure the existing infrastructure.

6.4.1.3 Education

i. Skilled Manpower:

Presently, Bangladesh has the highest amount of working-age people. To benefit from this demographic dividend, more emphasis should be given to vocational education to produce a more skilled workforce.

ii. Curriculum with sustainability practices:

Urban areas of Bangladesh are now experiencing many development activities. However, the general public is not aware of them. To make these development activities more sustainable, sustainability-oriented teaching materials, content, and innovative curricula are essential. These types of content will make a generation aware, and the country will get advantages from generation to generation.

iii. Sustainability training for school teachers and mosque imams:

The schoolteachers and mosque imams have a massive impact on urban society. General people usually obey their requests, and there are many scopes for them to reach the general people. There are 250,000 mosques (Prapti 2017) and 20960 schools in Bangladesh (GoB 2021b). If we somehow train the school teachers and mosque imams about sustainability, they can talk about sustainability in their weekly lecture, especially on Friday (before Jumma prayer time), when many people congregate to perform the salah. This will quickly leave a scar in their mind, which ultimately helps to implement the urban sustainability initiatives of GoB.

6.4.2 Economic Dimension of Urban Sustainability

6.4.2.1 Food

i. Protecting sub-urban areas from unplanned urbanization:

Suburban areas, which once served as food factories for urban areas, are now becoming unplanned urban areas. As a result, the ecological footprint of food is

gradually increasing. Therefore, the GoB should focus more on planned urbanization in suburban areas by protecting farmland.

ii. Farmers Open Market

GoB can set up some farmers' open markets, where farmers of nearby areas can sell their products directly. This will help urban dwellers to get more fresh food, and farmers will also get the correct prices.

iii. Food adulteration drive

An opportunity for the city area of Bangladesh is that most people still take unprocessed traditional food for their daily meals. However, the main concern is food adulteration by mixing toxic chemicals. As a result, GoB should conduct a more frequent drive against food adulteration.

iv. Strengthening relevant organization:

To conduct more frequent drives against food adulteration, GoB should strengthen the relevant organizations, such as BSTI and Bangladesh Food Safety Authority, and be strict in enforcing the existing law.

6.4.2.2 Energy

i) Solar City

GoB can take a project to develop a new urban area where only solar power will be used and declare it as a solar city. Once the project is completed, the government may not allow other private developer companies to build model cities with the power of the national grid. To promote this, GoB can incentivize them through various tax cuts.

ii. Solar power with net metering system in government organizations

It is revealed that the individual net metering system in Bangladesh is not feasible. Moreover, the roof of many GoB organizations is still empty. The GoB can use these empty rooftops for solar power production.

iii. Net-zero energy institutions as a model

There are many research institutes in the city area of Bangladesh. GoB can make one of these research organizations as a model of net-zero energy institutions. The other

organizations, including private organizations, can follow it. To promote this, GoB can introduce a national award system for net zero energy institutions.

iv. Household energy consumption database

At present, there are no energy labelling options for the household. As a result, the government cannot regulate household-level energy use. Therefore, a household-level energy use database is necessary for sustainable energy use and distribution.

v. Green Building

Bangladesh has an abundance of sunlight. However, the residential buildings, shopping malls, and other public and private office buildings in urban areas are not constructed considering the utilization of this sunlight. It also found that a building consumes twenty per cent of the energy at the construction stage and eighty per cent at the operating stage. As a result, GoB can now emphasize the construction of green buildings rather than traditional ones.

vi. Energy Efficient appliances

An SREDA study found that energy-efficient household appliances can save thirty-six per cent of domestic energy consumption. As a result, GoB can impose some responsibility on companies that produce more energy-consuming appliances to ensure energy sustainability in urban areas.

6.7.3 Environmental Dimension of Urban Sustainability

6.4.3.1 Household waste

i) Public awareness:

It is well established that the citizens of developed countries are more educated and lead a modern lifestyle than those of the developing world. Nevertheless, developed countries spent more on people's waste management awareness, while developing countries spent nearly eighty per cent of their budget on waste collection and landfill. As a result, waste management in developed countries is much better than in developing countries. In the case of Bangladesh, there are enough policies and laws for waste management; however, a little reflection of these policies and laws is found in cities' waste management systems, especially in food waste management. Because

people of Bangladesh always think that keeping their area clean is the work of city corporations, but due to some limitations, city corporations cannot do that. As a result, people's awareness and participation in the food waste management system could produce satisfactory results in the urban food waste management system. To do this, city authorities can form a voluntary committee for each local area (usually known as panchayet), where honorable people from respective areas will be included. This committee can conduct a weekly cleaning drive in their areas. The ward commissioners of these areas might co-ordinate these committees. To promote this sort of activities, city authority can declare them as “social heroes” and give them a special kind of ID card with renewal options, by which they would be able to enjoy some special kind of facilities such as “VIP facilities” from different offices of the respective city areas.

ii) Integrating the existing good practices of some urban areas

It is found that there are some excellent practices in the waste management system in some parts of the city. For instance, some housing societies employ people to collect waste from their homes and keep their areas clean. City authorities can link these initiatives and set up a local committee to replicate them in other areas.

iii) Clean plate campaign

As urban people's incomes gradually increase, the food consumption pattern is also changing, especially in the upper and higher-middle-class income groups. Most of the time, they ate only half the plate, especially at social events. They think it is a status symbol. Consequently, much food is wasted. Thus, if the city authority conducts a “clean plate” campaign regularly, this will save a substantial amount of food from waste.

iv. Extra food of student dormitories and restaurant donation

Additional food is usually thrown into the drain from student dormitories and restaurants. However, volunteer organizations now donating food to people experiencing poverty can coordinate with the dormitory authorities and restaurant owners to collect this extra food. In turn, city authorities can give restaurant owners some incentives in terms of tax cuts. Moreover, with the help of technical institutions, city authorities can develop an app from which the volunteer organization can get information and distribute food to people experiencing poverty.

v. Formalizing existing recycling practices:

It has been found that most urban dwellers are happy to recycle plastic bottles, unwanted metal items, and old newspapers. This recycling work also involves a considerable number of poor urban people. City authorities can formalize these recycling practices by treating them as their regular staff or outsourcing them to encourage city dwellers to be more sensitive to recycling practices.

6.4.3.2 Land use

i. Co-operative and land ownership sharing:

City authorities can promote existing initiatives of groups of people who build multistoried buildings for personal use and renting by creating more cooperative societies in underdeveloped urban areas. Additionally, city authorities can take over the small pieces of bare land and construct the appropriate buildings (residential or shopping malls or other business centers). City authorities can then share the benefits of these complexes with landowners at a mutually agreed ratio which is now partially carried out by the private developer's company. Because private developers' companies always try to benefit more and choose only forward prominent places. The conflict between the landowner and the developer company is also observed. As a result, people with small plots of land and backward places cannot use their land properly.

ii. Ecological Island City:

Naturally, Bangladesh is a riverine country, and most cities, including the capital Dhaka, are crisscrossed by canals. For instance, Dhaka was crisscrossed by 45 canals with 142 km (about 88.23 mi) in length. However, now many of these canals and floodplain areas are filled up. The same thing applies to other urban areas of the country. On the contrary, if we keep these natural canals, and water bodies, every city would be an ecological island city. The canals can be used as a transport system as well. Then the current complex problems of the city traffic and drainage could be segregated into different regions. It would then be easier to deal with the problems. The government can revive the canals of different cities and should follow the “no tolerance” principle while enforcing the existing laws.

iii. Nature-based solutions

Nature-based solutions are the best solutions to maintain sustainability in urbanization. In Bangladesh, Rajshahi City is a thriving city where nature is prioritized. Other cities can follow this city.

6.4.4 Institutional Dimension of Urban Sustainability

6.4.4.1 Planning

i) True inclusiveness

Though GoB now claims that the present planning documents are more inclusive than before, these plans are yet to bring a meaningful change in urbanization. Because GoB had to come back from implementing some plans, for instance, the detailed area plan of Dhaka city several times. It indicates a lack of true inclusiveness in the planning process. Therefore, the city authorities should make their plan with the active participation of all stakeholders.

ii) Decentralization

Evidence has been found that the central government uses their financial power to regulate the local government authorities. However, delegating more freedom to the local authorities can make scope to bring the government and people close to each other. It can also make the bureaucrats more accountable. As a result, GoB can take more initiative to decentralize central power to the city authorities.

iii. Coming out from Colonial Legacy:

Bangladesh should come out from the colonial legacy by making existing planning institutions more functional and removing administrative discrepancies and bureaucracy.

6.4.4.2 Implementation

i) SUDA (Sustainable Urban Development Authority)

Urban areas are extraordinarily complex, and there are hundreds of actors. The existing city governing institutions should be under the umbrella of one organization named Sustainable Urban Development Authority (SUDA) under the Prime Minister's Office.

Because, in Bangladeshi culture, it will be easier to implement any plan if it is under Prime Minister's Office.

ii) Urban Development Division in Planning Commission

At present, the planning commission has six divisions. Among these six divisions, the physical infrastructure division deals with all the infrastructure development activities of the countries, including the urban area. To ensure proper coordination, GoB can establish a separate division in the planning commission that will only deal with the development activities of the urban area.

iii. Good Urban Governance

Lack of coordination among the various agencies and those working for urban development is the main obstacle to good urban governance. To mitigate this, GoB might set up SUDA branches in Bangladesh's major cities to coordinate all the activities.

iv. Urban sustainability with the people, for the people and by the people

As a developing country, Bangladesh still has enormous potential to afford more urbanization. Bangladesh has enough good policies, laws and acts to make this urbanization process sustainable. Bangladesh also has a good reputation regarding achieving MDGs and in track to achieving the SDGs. To expedite this, GoB can declare a national slogan as “urban sustainability with the people, for the people and by the people.” This slogan will inspire marginal urban people to get involved in urban planning, which will ultimately help GoB to the smooth implementation of urban planning.

6.5 Conclusion

The well-established sustainability concept has four dimensions: social, economic, environment and institutions. Following the theoretical thematic analysis principle, this chapter analyzed the primary data collected by the in-depth semi-structured interview. The four dimensions of sustainability were selected as the theme, and the interview findings were then fitted with this theme under different relevant sectors, i.e., sub-theme. For instance, the social dimension of sustainability is one of the themes, and

under this theme, transport, social justice, and education arose as the sub-theme that I considered as a sector in my analysis.

The previous studies on Bangladesh dealt with only one specific sector of the urban area, whereas this chapter focuses on the different essential sectors of the urban area. Because urban areas are complex areas, and a comprehensive approach with all sectors is a prerequisite for their sustainability. In addition to the extensive amount of literature and previous explorations of urban sustainability and city-specific research that covers both developing and developed countries, this study adds to the knowledge in this field by exploring the views of academia, NGO, GoB, VO, and the information of the grass-root level of the people of Narayanganj city. This study proposed an urban sustainability framework (Figure 6.7) emphasizing sustainability's social dimensions with transport, social justice, and education. The tools of this framework were also elaborated as recommendations for the government.

Similar to the previous chapter, this chapter is not free from limitations. Firstly, it would be excellent to include the views of current city corporation mayors, environmental journalists and workers. Despite repeated initiatives, I was not able to convince/reach them. Probably because I was not in the field because of the Covid-19 travel restriction, I could take their views if I were there. Some were not also used to using online platforms. Secondly, focused group discussions with local communities and public representatives might provide more intensive information. Future research can consider these tools.

Chapter Seven

Conclusion

7.1 Introduction

Bangladesh has experienced long British colonization. Even after colonization, Bangladesh faced massive deprivation as a province of the then Pakistan. After winning the liberation war in 1971, the country was called “an international basket case”. Nevertheless, fifty years after its independence, the country is known worldwide as a development miracle. Bangladesh has transformed itself from an agrarian society to an industrial revolutionary society. Consequently, urban areas of this country have experienced rapid growth, and this tendency cannot be stopped. As a result, this research aims to study the sustainability of urbanization of Bangladesh from an ecological footprint viewpoint with a focus on one of her cities, Narayanganj.

The big picture issue from this research is highly relevant to achieve the SDG-11 (sustainable cities and communities) in Bangladesh. The official mission of SDG-11 is to make cities inclusive, safe, resilience and sustainable. This research findings suggest that Bangladesh’s rapid urbanization does not significantly affect her EF. As EF is vital index measuring whether an area is developing in sustainable or unsustainable manner, this finding indicates that Bangladesh, as a country, can afford more urbanization that might not create any extra pressure on her environment. However, an in-depth study of Narayanganj revealed that the EF of this city is much higher than the biocapacity of Bangladesh. As a result, though the per capita EF of Bangladesh is still low (in terms of global perspective 0.9gh/person, GFN 2018), Bangladesh government can take a pilot project to measure the EF of some of her prominent city for instance, Dhaka, Chattagram, Rajshahi, to get actual picture of EF of this cities. This might help the government to take the decision about how to use the existing capacity of Bangladesh to afford more urbanization.

In addition to this, this research also identifies the major driving forces of higher EF of NC. Finally, this study has also proposed a SUDF for Bangladesh with a series of policy recommendations.

“EF significantly determines the sustainability of an urban area” is the main argument of this study. It is, therefore, worth exploring the driving forces of the high EF of urban areas and taking steps to address these driving forces. Bangladesh's urban area is a hub of economic activities, and more than sixty per cent of GDP comes from urban areas (GoB 2020a). On the other hand, the support of citizens is crucial to implementing sustainability initiatives. If initiatives impose additional costs on citizens, they usually refuse to accept them. As a result, it is essential to find out existing facilities that do not impose any extra burden on the citizen and play an important role in the sustainability of urbanization of Bangladesh.

From this perspective, this research starts with a literature review to obtain an accurate image of sustainable development and EF issues. The examination of the effect of urbanization on EF followed this. Then the research question was built based on gaps found in the literature. Both primary and secondary data were used to answer the research question. World Bank and GFN were the sources of secondary data. Primary data was collected by a survey of five hundred households in NC and twenty in-depth semi-structured interviews with relevant academics, political leaders, senior policymakers and specialists from government, NGOs and independent urban research organizations. Interviewees were conducted using an online platform. The interviewees were asked to express their opinion regarding the urbanization trends of Bangladesh, the consumption habits of urban dwellers, and their attitude to sustainability practices related to the four dimensions of sustainable development. The collected data were analyzed using statistical packages E-views, Microfit 5.5, SPSS (version 28), and theoretical thematic analysis.

7.2 The Research Question and Objectives Revisited

This research attempts to deal with urbanization and its sustainability from EF's viewpoint of Bangladesh with an in-depth study of one of her cities, NC. As the literature review explains, urban sustainability can be assessed by multidimensional, indicator-based or life cycle assessment techniques. Most of the studies have taken indicator-based assessment methods. There are hundreds of sustainability indicators. Among these indicators, EF is more acceptable in measuring the urban sustainability of developing countries, particularly for Bangladesh. Because, in spite of some criticism,

many scholars argued that EF methodology can be used for sustainability assessment. EF can be measured from a single product to the entire world and offers responsibilities for environmental intervention from producers to final consumers. Some scholars termed it as an accounting tool to quantify the consumption of natural capital by human beings (Wackernagel and Yount 2000), to measure the appropriated carrying capacity of the world (Rees 1992). It can also be used to plan for sustainable urban development (Wackernagel et al. 2006) and represents the strong sustainability view (Huang et al. 2015).

As a result, this study has chosen EF to answer the research question, “To what extent can we extend the ecological footprint analysis to draw inferences about the sustainability of urban development in Bangladesh? What are the policy implications of this?”

To answer the research question, this study sets three objectives: i) To empirically examine the effect of urbanization on EF of Bangladesh; ii) To explore the sustainability of an urban area in Bangladesh using EF as methodology; and iii) Based on this, to develop a Sustainable Urban Development Framework (SUDF) to encourage more sustainable practices for sustainable urban development in Bangladesh.

Objective 1: To empirically examine the relationship between EF and urbanization of Bangladesh.

Following the extensive literature review, a conceptual framework for this study was developed where EF is selected as an indicator for urban sustainability. As the environment is one of the main pillars and crucial for strong sustainability, environmental degradation can be considered a vital issue for measuring urban sustainability. In this regard, a review of empirical studies on environmental degradation disclosed that EF could also be used as a proxy for environmental degradation. As a result, before using EF for sustainability assessment, it was necessary to examine the exact relationship between EF and urbanization of Bangladesh. Consequently, this study sets this objective.

In chapter four, I have found that EF has no significant effect on urbanization of Bangladesh both in the long run and short run. The Toda-Yamamoto Granger causality

test also reveals that urbanization does not cause EF. Since there does not appear to be a causal relation between EF and urbanization, Bangladesh might be able to afford more urbanization.

There may be several reasons. Firstly, the government is now adopting more environmentally friendly policies and the private sector, especially the industry sector, also supports following the policies. Secondly, it might assume that people are now more aware of cleaner urban development, voices of environmental activities are working. Overall, my results are consistent with Bangladesh's current policies that promote urbanization as an effective tool for increasing economic growth.

Moreover, a bidirectional causal relationship to and from GDP and EF is also found. It indicates that the recent economic growth of Bangladesh is happening at the expense of the environment. If the environment deteriorates, that will affect human health, which might reduce productivity in the long run, ultimately decreasing the GDP. Therefore, Bangladesh should emphasise using green technology in her production process.

I have also found a unidirectional causal relationship between trade openness to EF. This finding suggests that due to more openness, more outdated technology is now entering Bangladesh, creating more pressure on her environment. This indicates a need for policy measures to stop the import of dirty technology. It is also necessary to increase the capacity of present industries to accept new technologies. However, caution must be taken for this sort of policy. Because as a developing country, Bangladesh needs both rapid economic growth and more trade. Sacrificing one of them would not be a good policy. Nonetheless, cleaner technology, new technology absorption capacity of local industries, and environmentally friendly government policy will intensify the recent growth of Bangladesh in a sustainable way.

Objective 2: To explore the sustainability of an urban area in Bangladesh using EF as methodology.

The findings of chapter four raise the question of if Bangladesh can afford more urbanization, then what is the EF of one of her cities? Is the EF of a city higher than the country's biocapacity? What would be the consequences be if a city's EF exceeded the country's biocapacity? Answering these questions helps to achieve objective 2 of

this study. In this paradox, the EF of NC was measured. The comparison of EF among the different regions of NC and with Bangladesh's EF and Biocapacity was also explored. In addition to this, the main driving forces of EF were also identified.

This research reveals that the EF of NC is **6.54gha/person**, which is sixteen times higher than the Biocapacity of Bangladesh (0.41gha/person). It indicates that NC is consuming more resources than the production capacity of Bangladesh. The gap between EF and Biocapacity is also increasing. The carbon footprint is a significant part of total EF, probably because of high resource consumption in the shelter and household energy. In a nutshell, it can be said that NC is moving away from sustainability.

A comparison of the EF of the three different regions of NC reveals that Region-1 has the highest EF of 6.82gha/person. It was also found that the major driving forces of EF of NC are housing type, household waste generation, household income, household size, energy use, mode of transportation and recycling practices. As a result, NC authorities should pay more attention to these driving forces.

Objective 3: To develop a Sustainable Urban Development Framework (SUDF) to encourage more sustainable practices for sustainable urban development in Bangladesh.

The findings of chapter four indicate that Bangladesh can afford more urbanization. However, the findings of chapter five signal that the EF of the urban area is much higher than the EF and biocapacity of Bangladesh, i.e., urban areas are now moving away from sustainability. As a result, to utilize the present affordability of more urbanization, this study feels a need to develop a SUDF for Bangladesh. Chapter six takes the initiative to develop such a type of SUDF, which is objective 3 of this research.

To develop the SUDF, primary data collected by the in-depth semi-structured interview were used. The data was analyzed by following the principle of theoretical thematic analysis. The well-established four dimensions of sustainability viz social, economic, environment and institutions were selected as the theme, and the interview findings were then fitted with this theme under different relevant sub-themes. For instance, the social dimension of sustainability is one of the themes, and under this theme, transport,

social justice, and education arose as sub-themes that I considered as sectors in my SUDF. In some cases, survey data is also used for data triangulation.

The SUDF is one of the original contributions of this study. The main difference with the previous studies on Bangladesh is that the previous studies dealt with only one specific sector of the urban area, whereas this study gives a comprehensive focus on the different essential sectors of the urban area. Because urban areas are complex areas, and a comprehensive approach with all sectors is a prerequisite for their sustainability. In addition to exploring the sustainability of urban areas covering both developing and developed countries, this study added value to the existing knowledge by adding the views of academia, NGO, GoB, VO, and the information of the grass-root level of the people of NC. The proposed SUDF emphasizes the social dimensions of sustainability in the transport, social justice, and education sector. The tools of this framework were also elaborated as recommendations for the government to achieve sustainability in the respective sectors.

7.3 Policy Implications of EF Analysis of this Research

To achieve SDG-11 Bangladesh government has set the priority to adopt a holistic multistakeholder approach to address urban resilience and provide support to the local governments, and other city/regional/national stakeholders in building multi-level governance and institutional capacities (GoB 2022c). This priority indicates that to achieve the goal of SDG-11 local needs and demands should be identified and addressed accordingly. Furthermore, the realization of our EF and its main drivers that lead to a non-sustainable way of living, may ignite a personal endeavor towards the modification of our daily activities for the minimization of our impact on the environment.

It is very normal that the needs and demands of every city should not be same. The EF methodology might be helpful to identify these local needs and demands that will help to achieve relevant SDGs. For instance, EF analysis of NC identified the following driving forces those could be linked with respective SDGs to make NC a more sustainable city (Figure 7.1).

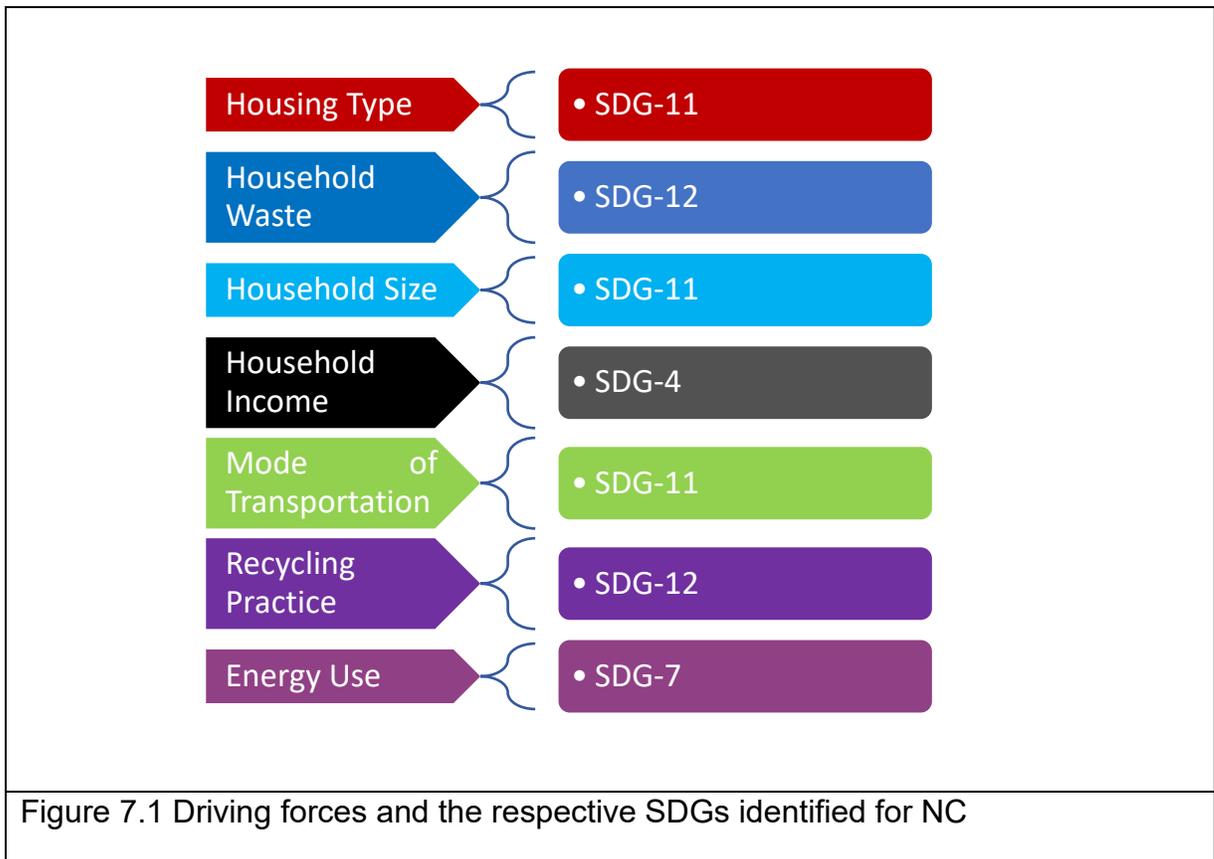


Figure 7.1 shows that housing type, household size and mode of transformation are linked with SDG-11. Household waste, household income and energy use are linked with SDG-12, SDG-4 and SDG-7 respectively. The following points are highlighted for the policy implications of EF methodology:

Housing Type:

This research findings revealed the people who live in luxury houses have significantly higher EF than the people who live in multistory apartments. Given the economic development and living standards of the people it is normal that a tendency might grow to live a more luxurious life. However, their luxurious life, especially a luxury house will increase the use of land which is disadvantageous for sustainable development. Holden (2004) also suggested that ecological footprint per household member is almost 20% higher than for people living in more concentrated types of housing, i.e. semi-detached or terraced houses and multi-family residential buildings (blocks of flats).

The survey finding of NC reveals that only 13.60 per cent of people in NC live in luxury houses and the remaining 86.40 per cent of people live in other types of housing. Therefore, it could be suggested that NC have a considerable scope to convert these houses into multistory apartments, which ultimately decreases the EF of NC. This study also found that shelter is the biggest part of EF by consumption type of NC (38.38%) (Table 5.7).

With this finding, this study suggests, NCC should take policy to build collective housing or cohousing or multistory apartments building to reduce the loss of land area. This study also found that still there are lot of open spaces in NC where the city authorities can take initiative to build multistoried apartment with the partnership of private landowner. NCC already have the experience to implement such a type of project in some of their own land. Such initiatives will save land that could be used for other purposes as well as ensuring the housing facilities to marginal people especially the industrial workers who migrated to urban area. There is a hope that GoB will also set housing as the priority areas for SDG-11. The only thing is needing a specific land use policy for urban areas where collective housing or cohousing or multistoried apartments could be built. It will ultimately help to achieve the **SDG-11** (Make cities and human settlements inclusive, safe, resilient and sustainable).

Household waste generation:

This research findings revealed that the people who generate more trash have higher EF than the people who produce less trash. Household waste is normally generated from the food item consumed by households' members. This indirectly indicates that the household who has generated more waste, consume/waste more food and consequently have high ecological footprint. People of Bangladesh always think that keeping their area clean is the work of city corporations, but due to some limitations, city corporations cannot do that. As a result, people's awareness and participation in the waste management system could produce satisfactory results in the urban food waste management system. To do this, city authorities can form a voluntary committee for each local area (usually known as panchayet), where honorable people from respective areas will be included. This committee can conduct a weekly cleaning drive in their areas. The ward commissioners of these areas might co-ordinate these

committees. To promote this sort of activities, city authority can declare them as “social heroes” and give them a special kind of ID card with renewal options, by which they would be able to enjoy some special kind of facilities such as “VIP facilities” from different offices of the respective city areas. This will ultimately help to achieve **SDG-12**(Ensure sustainable consumption and production patterns).

Household income:

This research identified household income as one of the driving forces of EF. With the increase of household income, the ecological footprint is also increasing. The fascinating thing is that the result of this research provides a deep insight that the theory on the hierarchy of human needs, also known as **Maslow’s Pyramid**, is not fully working in NC. This theory assumes that human beings are motivated by unsatisfied needs. Certain basic needs (physiological, survival, safety, love and esteem) must be fulfilled before a person can act unselfishly (Maslow, 1968, 1999). This foundation for unselfish behavior could be seen as one of the most critical factors for sustainable development (Moldan et al. 2012). However, these findings of this research suggest that people who can meet their all-basic needs have self-esteem, consume more resources, and create more pressure on the environment, resulting in higher EF. However, it would not be practical to impose something against the human right to lead a luxurious lifestyle if they can do so. Instead, environmental education can enhance public awareness and the willingness to protect the environment to avoid risks and achieve sustainability which is linked to achieve the **SDG-4** (Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all).

Household Size (members of a household):

Generally, household size should have a negative sign in relation to the EF because more people living in a house share common facilities like electricity, water, cooking fuel, and floor area. It means the higher number of people living in a house should have less EF than the smaller number of people living in a house. This expected relationship is found in this study. MLR output in Table 5.19 shows that the houses where only one person lives have 3.130 units more EF than the 10+ people living in a house. However, city authorities cannot compel people to live in a joint family. Moreover, people migrated to city area for their employment, and they cannot always be able to bring their family.

Alternatively, city authorities can build some multistory buildings those will act as the hostel of working people. This will ensure safe shelter and ultimately help to achieve **SDG-11** (Make cities and human settlements inclusive, safe, resilient and sustainable).

Mode of Transportation.

This research finds that the people who use rickshaw and walk have less EF than the people who use private cars/rented cars. It is also found that 37.80% of people in NC always prefer to walk and 77% of people think that walking to at least one of their destinations makes them healthier. NC can use this opportunity by declaring some areas of NC only for pedestrians, i.e. pedestrian zone and making the footpath more pedestrian friendly. In some parts of city areas, some roads can be declared as one-way roads, especially in residential areas, where roads are very narrow. Moreover, the city authority can introduce a circular bus system on the major roads with a minimum fare and with specific stoppage, drastically reducing traffic gridlocks, especially during pick hours. All these things will reduce the existing private car, rented private cars, and auto rickshaws use tendency of the people, which will reduce the traffic congestions, CO₂ emissions, ultimately decreasing the EF. This will also help to achieve **SDG-11** (Make cities and human settlements inclusive, safe, resilient, and sustainable). However, intensive community consultation, engagement and piloting of projects will be required before implementing this proposal.

Recycling practices:

The findings of this research confirm that the people who recycle old newspapers and unwanted metal items have significantly 0.944 and 0.836 units less EF, respectively, than those who do not recycle. In general, this sort of recycling practice is very informal in Bangladesh. The local vendors are buying this sort of recyclable material from door to door and sell it to recyclable shops (Vangari). These shops then sell it to recycling industries. The survey data of NC shows that 33.20 per cent of people recycle nothing, whereas 48.20 per cent recycle different types of bottles, including plastic and glass (Figure 5.20). Therefore, city authority can formalize this informal recyclable material collection and reward the people presently recycling the materials. To encourage the people who are not practicing recycling, city authority can provide separate bags to all households to store the recyclable items. For collecting these items, the city authority

can employ some casual workers who can collect them once every two weeks/ month. This will help to achieve **SDG-12**(Ensure sustainable consumption and production patterns).

Energy Use

This research also finds that household energy use (Electricity) has a significant role in increasing the EF of NC. It is also normal that with the increase of living standards, household energy use will also increase. However, to control this more energy use tendency the city authority of NC can take the initiative to introduce a star rating of the energy demand of the houses. If a house has a high star rating, that house owner could get some incentives in the form of a tax cut or declaration as a celebrity of NC and be provided with some extra facilities from the NCC authority. However, a strong and dedicated monitoring team is needed to implement this plan. To do this, NC can easily outsource a highly technical team. This will help to achieve **SDG-7** (Ensure access to affordable, reliable, sustainable, and modern energy for all).

In summary, this research strongly recommend that Bangladesh government can take pilot projects to measure the EF of some of her prominent city for instance, Dhaka, Chattagram, Rajshahi, to get an actual picture of EF of these cities. The direct effect of this would be, EF methodology will help government to identify the sectors that need very urgent action. This methodology will also help people to become more aware about the effect of their day-to-day activities on the city environment, which ultimately helps government to implement any urban sustainability initiative. For instance, this research finds that if people live in multistoried apartment buildings, that will ensure more accommodation and will also give less pressure on the environment. This finding will help the local authority to build more multistory buildings on the existing underutilized land. On the other hand, the citizens of other cities, where EF methodology is not applied, would not be able to understand their impact on city environment, thereby, they might be less supportive to implement any sustainability initiative.

7.4 Agenda for Further Research

Like other research, this research is not free of limitations. In every chapter, I have mentioned the specific limitation. Here, I will briefly re-memorize them.

In the empirical study of EF and urbanization, I might include other variables (e.g., foreign direct investment, human capital, industrialization, air pollution, and mode of transportation). Their inclusion might come up with a different outcome. Moreover, using city-level data to find the exact relationship between EF and urbanization would be more acceptable for city-specific policy. However, city-level time series data of EF in Bangladesh is not available. The present study also uses the aggregate data of GDP and Trade. This also opens a window for future study of each component of GDP and Trade.

Measuring the EF of a single city is another limitation of this research. However, considering the time and resources, this is the best thing to do. Surveying five hundred households was a tough job. The covid-19 pandemic made it more difficult. Measuring the EF of three cities and then comparing them would be better. I think this is the scope for further research to include other cities in a similar vein. However, this study tried to minimize this gap by measuring the EF of three regions of NC and then comparing them. This study also uses stepwise MLR method to identify the driving forces of NC. However, the other method, for instance, enter method might identify different driving forces. This is another area for exploration.

Another significant limitation of this study is the use of an online calculator of GFN to measure the EF. Due to pinpointing errors in calculator, the same data provides a slightly different output. Moreover, the Biocapacity of NC was not possible to measure with this calculator. Therefore, it was not possible to find out the exact ecological overshoot of NC. This limitation demands intensive data for the production capacity of NC, which might need a mixture of secondary and primary data that can be done in a future study.

Due to the COVID-19 pandemic, respondents were reluctant to talk to the data enumerators and tried to provide information without taking enough time. The survey was conducted mostly in day times. As a result, working people might exclude from this

survey, whereas housewives, older people, and retirees were more likely to interview. The other limitation of the survey is recalling food items taken in the previous week or month. It is crucial to memorize the types of food taken in the preceding week or month. However, some respondents were unsure about their food items or could not clearly remember the required consumption data.

The final limitation is this study only uses in-depth semi-structured interviews to develop SUDF for Bangladesh. However, other data collection methods, viz focus group discussion with public representatives, local environmental workers, and journalists, might provide more intensive information for the policy formulation specifically for a single city. I think there is some scope for future research by engaging only local people, journalists, public representatives and environmental workers. However, this research has a greater potential to provide a deeper incitement from human consumption behavioral perspective, which will facilitate the community movement for the sustainability of the urban area of Bangladesh.

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Appendix-1-Survey Questionnaire

By: Muhammad Nuzmul Hoque, PhD Candidate, University of Bradford, UK. UoB ID: 13022717

Hello and Thank you for answering this questionnaire, which is supported by the Bangabandhu Science & Technology Fellowship Trust of Ministry of Science and Technology and University of Bradford, UK. It was primarily designed to calculate the ecological footprint associated with the activities of the residents of Narayanganj City Corporation. This questionnaire is for research purposes only. Your personal data will not be disclosed. So please fill it out with complete peace of mind. Ethics Approval No. EC26848.

PhD Supervisor: Prof PB Anand PhD, PHEA, FICRS
Professor of Public Policy and Sustainable Development, University of Bradford, UK.

Please consent to participate

- I have received information regarding this research and had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this research and I voluntarily consent to take part.

A. GENERAL INFORMATION						
1.	Gender	Female <input type="checkbox"/>	Male <input type="checkbox"/>			
2.	Age (between)	<input type="checkbox"/> 0--17	<input type="checkbox"/> 18-35	<input type="checkbox"/> 36-45	<input type="checkbox"/> 46-60	<input type="checkbox"/> 61+
3.	Household Size	<input style="width: 50px;" type="text"/> Members				
4.	Household Income*	<input type="checkbox"/> Below Average		<input type="checkbox"/> Average	<input type="checkbox"/> Above Average	
5.	Household type	<input type="checkbox"/> Owned		<input type="checkbox"/> Rented		
6.	Occupation					
7.	Religion					
8.	Education					
	Head of household	<input type="checkbox"/> Illiterate	<input type="checkbox"/> High School	<input type="checkbox"/> College	<input type="checkbox"/> Graduate	<input type="checkbox"/> Post Graduate
*According to Power and Participation Research Centre (PPRC) Governance and Economic Survery, 2015 Household average income-BDT- 24031/-.						

B. Food

F 1. How often do you eat meat?

- a) Never
- b) Infrequently
- c) Occasionally
- d) Often
- e) Very often

F 2. How often do you eat fish?

- a) Never
- b) Infrequently
- c) Occasionally
- d) Often
- e) Very often

F 3. How often do you eat eggs/milk/dairy?

- a) Never
- b) Infrequently
- c) Occasionally
- d) Often
- e) Very often

F 4. How much of your diet is based on fresh, unpacked foods?

- a) 100%
- b) 99 to 80%
- c) 79 to 60%
- d) 59 to 40%
- e) Any other percentage (please specify)

F 5. How much of the food that you eat is locally grown or produced?

- a) 100%
- b) 99 to 80%
- c) 79 to 60%
- d) 59 to 40%
- e) Any other percentage (please specify)

F 6. How often do you eat animal based products (eg. Beef, chickens, fish, eggs, dairy products)?

- a) Never
- b) Infrequently
- c) Occasionally
- d) Often
- e) Very often

F 7. How much of the food that you eat is unprocessed, unpacked or locally grown? (less than 30 km away)

- a) None
- b) 1-25%
- c) 26-50%
- d) 51- 75%
- e) 76-100%

C. Housing

H 1. Which housing type best describes your home?

- a) Free standing no running water
- b) Free standing running water
- c) Multistory apartment
- d) Duplex row house or building with 2-4
- e) Luxury Condominium

H 2. What material is your house constructed with?

- a) Straw/bamboo
 - b) Brick/Concrete
 - c) Steel/Other
 - d) Wood
 - e) Others
-

H 3. How many people live in your house?

- a) Just you
- b) 2-3
- c) 4-6
- d) 7-9
- e) 10+

H 4 . What is the size of your house (sqf/sqm)?

Please write down the number-----

H 5. Do you have electricity at your home?

- Yes No

H 6 . How much is your monthly average electricity bill? (please write

down the amount in BDT)

Summer_____ --

Winter_____

H 7. What type of fuel do you use for cooking?

- a) Natural Gas
- b) Barrel Gas
- c) Electricity
- d) Kerosene
- e) Fuel Wood
- f) Any Others -----

H 8. What is your monthly average cost related to cooking (other than electricity)? (Please write down your cost in BDT)

H 9 . How energy efficient is your house?*

- a) Very inefficient (few led lamp, cooling system used often)
- b) Below average (inefficient lighting, standard appliances)
- c) Average (modern appliances, climate controls)
- d) Above average (efficient lighting and appliances, careful use)

- e) Efficiency centered design (passive cooling, advanced temperature control and ventilation, low electricity use)

*How often do you run your air conditioner? Do you use energy-efficient appliances and lighting? If you live in an energy-efficient house designed for passive colling or live in a mild climate when cooling are unnecessary, adjust your answer towards very efficient.

H 10. What percentage of your home's electricity comes from renewable sources?

- a) Don't Know
- b) Very Low (0 - 10%)
- c) Low (11-20%)
- d) Any figure from 21 to 99% _____
- e) 100%

H 11. Compared to neighbors how much trash do you generate?

- a) Much less
- b) Less
- c) Same
- d) More
- e) Much more

H 12. How frequently do you dispose of wastes from your house?

- a) Once in two or three days
- b) Once daily
- c) As soon as there is some waste
- d) When we see the waste collector
- e) Others -----

H 13 . Do you sell?

- a) Newspapers
- b) Bottles
- c) Old/used/unwanted clothes
- d) Unwanted metal items
- e) Others -----

H 14. Who disposes of wastes from your household? (Please Specify)

 H 15 . Where do you usually dispose of? (Please Specify)

H 16. Where is the bin located? (Please Specify) -----

 H 17 . How often do you think the municipal waste collection vehicles clear the wastes?

- a) Everyday
- b) Alternate day
- c) Twice a week

- d) Once a week
- e) Others -----

D. Transportation

T 1. How often you use walking as a mode of mobility, from one place to another?

- a) Rarely
- b) Seldom
- c) Not at all
- d) Often
- e) Always

T 2. What is your most frequently used medium of transport?

- a) Personal car
- b) Rented private car
- c) Auto Rickshaw (CNG)
- d) Rickshaw
- e) Other

T 3. How far do you travel by car or motorcycle each day?*

- a) Car -----
- b) Motor cycle -----

*If you only walk or bicycle or rickshaw choose zero

T 4. What is the average fuel economy of the vehicles you use most ?

- a) Car (Km/liter) -----
- b) Motor Cycle (Km/liter) -----
- c) Electric car -----
- d) Hybrid car -----
- e) Electric motorcycle -----

T 5. When you travel by car, how often do you carpool?

- a) Never
- b) Infrequent
- c) Occasionally
- d) Often
- e) Always

T 6. How far do you travel on public transportation each day? (Please write down in km)

T 7. How many hours do you fly each year? (Please write down in number)

- a) Never
- b) Hours -----

T 8. How willing you will be to use mass transport in future if efficient and quality mass transport is introduced?

- a) Yes I will, as I have responsibility towards environment
- b) No, I need to keep up with my social position
- c) Yes, based on my needs

- d) Yes, if it is convenient for me
- e) Not sure

T 9. Commuting at least one of your routine destinations by walking will make you healthier?

- a) Strongly Agree
- b) Agree
- c) Not sure
- d) Disagree
- e) Strongly Disagree

T 10. To join a wedding or social event that reflect your social position you prefer your private vehicle or renting a transport to other cheaper alternatives or public transport?

- a) Rarely
- b) Seldom
- c) Not at all
- d) Often
- e) Always

Appendix-1

জরিপের প্রশ্নমালা

পিএইচডি প্রার্থী: মোহাম্মদ নাজমুল হক, ব্রাডফোর্ড বিশ্ববিদ্যালয়, যুক্তরাজ্য, UoB ID: 130022717

এই পিএইচডি গবেষণাটি বিজ্ঞান ও প্রযুক্তি মন্ত্রণালয়ের অধীন বঙ্গবন্ধু বিজ্ঞান ও প্রযুক্তি ফেলোশিপ ট্রাস্ট এবং ব্রাডফোর্ড বিশ্ববিদ্যালয়, ইউকে কর্তৃক পৃষ্ঠপোষকতা করা হচ্ছে। এটির প্রস্তাবিত শিরোনাম “Sustainable urbanization and ecological footprint: empirical evidence from Bangladesh”। এর মাধ্যমে অন্যান্য বিষয়ের পাশাপাশি নারায়ণগঞ্জ সিটি কর্পোরেশনের পরিবেশগত পদচিহ্ন (Ecological Footprint) পরিমাপ করা হবে। আমি নিশ্চয়তা দিচ্ছি যে, এ জরিপের মাধ্যমে সংগ্রহকৃত তথ্য অন্য কারো নিকট প্রকাশ করা হবে না এবং শুধুমাত্র গবেষণা কাজে ব্যবহার করা হবে। তাই নির্দিষ্টভাবে এটি পূরণ করুন। এ গবেষণার ফলাফল নারায়ণগঞ্জ সিটি কর্পোরেশনকে আরো সুন্দর, পরিবেশবান্ধবভাবে গড়ে তোলার পাশাপাশি এর টেকসই উন্নয়নে সহায়তা করবে বলে আশা করা যায়। এ সংক্রান্ত প্রস্তাবনা ব্রাডফোর্ড বিশ্ববিদ্যালয়ের নির্ধারিত প্যানেল এবং নৈতিকতা (Ethics) কমিটি কর্তৃক অনুমোদিত হয়েছে (নৈতিকতা অনুমোদন নং EC 268468)।

পিএইচডি সুপারভাইজার: অধ্যাপক পি বি আনন্দ, পিএইচডি, এফএইচইএ, এফআইসিআরএস
ইউনিভার্সিটি অব ব্রাডফোর্ড, রিচমন্ড রোড, ব্রাডফোর্ড, BD7 1DP, টেলিফোন:+88 ১২৭৪২৩৩৯৫৭।

অংশগ্রহণ করতে সম্মতি দিন

আমি এই গবেষণা বিষয়ে অবগত হয়েছি এবং প্রশ্ন জিজ্ঞাসা করার সুযোগ পেয়েছি। আমি এই গবেষণা আমার সম্পৃক্ততার উদ্দেশ্যে, ব্যাপ্তি এবং সম্ভাব্য ঝুঁকি বুঝতে পেরেছি এবং স্বেচ্ছায় অংশ নিচ্ছি।

ক. সাধারণ তথ্যাবলী						
১.	জেন্ডার	মহিলা <input type="checkbox"/>	পুরুষ <input type="checkbox"/>			
২.	বয়স	<input type="checkbox"/> ০-১৭	<input type="checkbox"/> ১৮-৩৫	<input type="checkbox"/> ৩৬-৪৫	<input type="checkbox"/> ৪৬-৬০	<input type="checkbox"/> ৬১+
৩.	খানার আকার	সদস্য সংখ্যা <input type="text"/>				
৪.	খানার আয় *	<input type="checkbox"/> গড় আয়ের নীচে		<input type="checkbox"/> গড় আয়ের সমান	<input type="checkbox"/> গড় আয়ের উপরে	
৫.	বাসার মালিকানা	<input type="checkbox"/> নিজের	<input type="checkbox"/> ভাড়া			
৬.	পেশা	<input type="text"/>				
৭.	ধর্ম	<input type="text"/>				
৮.	শিক্ষাগত যোগ্যতা	<input type="text"/>				
	গৃহকর্তা/কর্ত্রী	<input type="checkbox"/> অশিক্ষিত	<input type="checkbox"/> হাই স্কুল	<input type="checkbox"/> কলেজ	<input type="checkbox"/> অনার্স/ডিগ্রী	<input type="checkbox"/> মাস্টার্স
* পাওয়ার অ্যান্ড পাটিসিপেশন রিসার্চ সেন্টার (পিপিআরসি) এর গভর্নেন্স অ্যান্ড ইকোনমিক সার্ভে ২০১৫ অনুযায়ী, পরিবারের মাসিক গড় আয় ২৪০৩১/- টাকা।						

জরিপের প্রশ্নমালা

খ. খাদ্য

- খ ১. আপনি কত ঘন ঘন মাংস (গরু/খাসি/ভেড়া) খান?
- a) কখনই না
- b) মাঝে মাঝে
- c) কখনো কখনো
- d) প্রায়ই
- e) খুবই ঘন ঘন
- খ ২. আপনি কত ঘন ঘন মাছ খান?
- a) কখনই না
- b) মাঝে মাঝে
- c) কখনো কখনো
- d) প্রায়ই
- e) খুবই ঘন ঘন
- খ ৩. আপনি কত ঘন ঘন ডিম/দুধ/দুগ্ধজাত পণ্য খান?
- a) কখনই না
- b) মাঝে মাঝে
- c) কখনো কখনো
- d) প্রায়ই
- e) খুবই ঘন ঘন
- খ ৪. আপনি কত ঘন ঘন পোল্ট্রি খান?
- a) কখনই না
- b) মাঝে মাঝে
- c) কখনো কখনো
- d) প্রায়ই
- e) খুবই ঘন ঘন
- খ ৫. আপনার খাদ্যের কত অংশ তাজা, অপ্যাকেটজাত খাবার?
- a) ১০০%
- b) ৮০ থেকে ৯৯%
- c) ৬০ থেকে ৭৯%
- d) ৪০ থেকে ৫৯%
- e) অন্য কোন % (অনুগ্রহপূর্বক সুনির্দিষ্ট করে লিখুন) -----
- খ ৬. আপনি কত ঘন ঘন শূকরের মাংস খান? (শুধুমাত্র অমুসলিম ও যাদের ধর্মীয় বাধা নেই তাদের জন্য প্রযোজ্য)
- a) কখনই না
- b) মাঝে মাঝে
- c) কখনো কখনো
- d) প্রায়ই
- e) খুবই ঘন ঘন
- খ ৭. আপনার খাদ্যের কত অংশ স্থানীয়ভাবে জন্মানো বা উৎপাদিত হয় (৩২০ কিলোমিটারের কম দূরত্বে)?
- a) ১০০%
- b) ৮০ থেকে ৯৯%
- c) ৬০ থেকে ৭৯%
- d) ৪০ থেকে ৫৯%
- e) অন্য কোন % (অনুগ্রহপূর্বক সুনির্দিষ্ট করে লিখুন) -----

জরিপের প্রশ্নমালা

গ. আবাসন

আ ১ . আপনার বাড়ির ধরন কি?

- a) পাইপ লাইনের মাধ্যমে পানি সরবরাহের সংযোগছাড়া একক বাড়ি
- b) পাইপ লাইনের মাধ্যমে পানি সরবরাহের সংযোগসহ একক বাড়ি
- c) বহুতল অ্যাপার্টমেন্ট (ভাড়া) (Multistory Apartment)
- d) ২-৪ টি আলাদা আলাদা ইউনিটযুক্ত দু-তলা বাড়ি
- e) বিলাসবহুল অ্যাপার্টমেন্ট (মালিক) (Luxury Condominium)

আ ২. আপনার বাড়ি কি দিয়ে তৈরি?

- a) খড়/বীশ
- b) ইট/কনক্রিট
- c) স্টিল/অন্যকিছু
- d) কাঠ
- e) অন্যান্য _____

আ ৩. আপনার বাসায় কতজন থাকেন?

- a) একা
- b) ২-৩
- c) ৪-৬
- d) ৭-৯
- e) ১০+

আ ৪ . আপনার বাড়ির আকার কত বর্গফুট?

আ ৫. আপনার বাসায় কি বিদ্যুৎ সংযোগ আছে?

হ্যাঁ না

আ ৬. আপনার বাসার মাসিক বিদ্যুৎ বিল কত?

গ্রীষ্মকাল _____ শীতকাল _____

আ ৭. আপনি রান্না করার জন্য কি জ্বালানি ব্যবহার করেন?

- a) প্রাকৃতিক গ্যাস
- b) সিলিন্ডার গ্যাস
- c) বিদ্যুৎ
- d) কেরোসিন
- e) জ্বালানি কাঠ
- f) অন্য কিছু _____

আ ৮. আপনার রান্নার কাজে ব্যবহৃত জ্বালানির মাসিক খরচ কত (বিদ্যুৎ ছাড়া)?

আ ৯ . আপনার বাড়ি কতটা শক্তি সাশ্রয়ী (energy efficient)?*

- a) খুবই অসাশ্রয়ী (কোন এলইডি লাইট নেই, A/C খুব বেশি ব্যবহৃত হয়)
- b) গড়পড়তার নীচে (সাধারণ লাইট ও অন্যান্য যন্ত্রপাতি)
- c) গড় (আধুনিক যন্ত্রপাতিসমৃদ্ধ)
- d) গড়পড়তার উপরে (এলইডি লাইটযুক্ত এবং যন্ত্রপাতি প্রয়োজনমত ব্যবহার করা হয়)
- e) কেন্দ্রীয়ভাবে তাপমাত্রা নিয়ন্ত্রিত, প্যাসিভ কুলিং, বায়ুচলাচল করতে পারে এবং কম বিদ্যুৎ ব্যবহার করা হয়।

জরিপের প্রশ্নমালা

* আপনি কত ঘন ঘন আপনার A/C চালান? আপনি কি শক্তি-দক্ষ (energy efficient) যন্ত্রপাতি এবং লাইট ব্যবহার করেন? আপনি যদি প্যাসিভ কুলিংয়ের জন্য ডিজাইন করা বা ডিতে থাকেন বা ঠাণ্ডার প্রয়োজন হলে আপনার বাসায় প্রাকৃতিক বায়ু ব্যবহারের সুযোগ আছে, এসব কিছু বিবেচনায় নিয়ে আপনার উত্তর দিন।

আ ১০. আপনার বাসার মোট বিদ্যুতের কত অংশ নবায়নযোগ্য (renewable) উৎস যেমন সূর্যের আলো/বাতাস/নিউক্লিয়ার পাওয়ার থেকে আসে?

- | | | |
|----|------------------------------------|--------------------------|
| a) | জানিনা | <input type="checkbox"/> |
| b) | খুবই কম (০-১০%) | <input type="checkbox"/> |
| c) | কম (১১-২০%) | <input type="checkbox"/> |
| d) | ২১-৯৯% এর মধ্যে যেকোন সংখ্যা _____ | |
| e) | ১০০% | <input type="checkbox"/> |

আ ১১. আপনার বাসায় আপনার প্রতিবেশির তুলনায় কতটুকু ময়লা-আবর্জনা তৈরি হয়?

- | | | |
|----|-----------|--------------------------|
| a) | অনেক কম | <input type="checkbox"/> |
| b) | কম | <input type="checkbox"/> |
| c) | সমপরিমাণ | <input type="checkbox"/> |
| d) | বেশি | <input type="checkbox"/> |
| e) | অনেক বেশি | <input type="checkbox"/> |

আ ১২. আপনার বাসার আবর্জনা কত ঘন ঘন পরিষ্কার করেন?

- | | | |
|----|--------------------------------|--------------------------|
| a) | দুই অথবা তিন দিনে একবার | <input type="checkbox"/> |
| b) | দিনে একবার | <input type="checkbox"/> |
| c) | যখনই আবর্জনা তৈরি হয় তখনই | <input type="checkbox"/> |
| d) | যখন আবর্জনা সংগ্রহকারীকে দেখেন | <input type="checkbox"/> |
| e) | অন্যান্য | ----- |

আ ১৩. আপনি কি নিম্নলিখিত বিষয়সমূহ বিক্রি করেন?

- | | | |
|----|-----------------------------------|--------------------------|
| a) | পুরানো সংবাদপত্র | <input type="checkbox"/> |
| b) | কাঁচ/প্লাস্টিক বোতল/কনটেইনার | <input type="checkbox"/> |
| c) | পুরানো/ব্যবহৃত/অপ্রয়োজনীয় কাপড় | <input type="checkbox"/> |
| d) | অপ্রয়োজনীয় মেটালের জিনিসপত্র | <input type="checkbox"/> |
| e) | অন্যান্য | ----- |

আ ১৪. আপনি সাধারণত কোথায় আপনার বাসার ময়লা- আবর্জনা ফেলেন?

আ ১৫. আপনি কি বিন ব্যবহার করেন? করলে বিনের আকার কত লিটার?

আ ১৬. আপনার বিন কোথায় রাখেন?

আ ১৭. কত দিন পর পর সিটি কর্পোরেশনের গাড়ি ময়লা-আবর্জনা সংগ্রহ করে বলে আপনি মনে করেন?

- | | | |
|----|-----------------|--------------------------|
| a) | প্রতিদিন | <input type="checkbox"/> |
| b) | একদিন পর পর | <input type="checkbox"/> |
| c) | সপ্তাহে একদিন | <input type="checkbox"/> |
| d) | সপ্তাহে দুই দিন | <input type="checkbox"/> |
| e) | অন্যান্য | ----- |

জরিপের প্রশ্নমালা

ঘ. যানবাহন

য ১. আপনি এক জায়গা থেকে আরেক জায়গায় আসা-যাওয়া করার জন্য হাটেন:

- a) খুবই কম
- b) কদাচিৎ
- c) মোটেই না
- d) প্রায়ই
- e) সব সময়

য ২. আপনি প্রায়ই কোন ধরনের যানবাহন ব্যবহার করেন?

- a) ব্যক্তিগত গাড়ি
- b) ভাড়ায় চালিত গাড়ি
- c) অটো রিকসা (সিএনজি)
- d) রিকসা
- e) অন্যান্য

য ৩. আপনি প্রতিদিন গাড়ি অথবা মোটরসাইকেলে কত কিলোমিটার ভ্রমণ করেন? (যদি হাটেন, সাইকেল অথবা রিকসা ব্যবহার করেন তাহলে “০” দিন এবং প্রশ্ন ৫ এ যান)

- a) গাড়ি -----
- b) মোটর সাইকেল -----

য ৪. আপনি যে যানবাহন ব্যবহার করেন তা কতটুকু জ্বালানী সাশ্রয়ী?

- a) গাড়ি (কিমি/লিটার) -----
- b) মোটর সাইকেল (কিমি/লিটার) -----
- c) ইলেকট্রিক কার (১বার চার্জে কত কিমি যাওয়া যায়) -----
- d) হাইব্রিড কার (কিমি/লিটার) -----
- e) ইলেকট্রিক মোটরসাইকেল (১বার চার্জে কত কিমি যাওয়া যায়) -----

য ৫. আপনি যখন কারে (গাড়িতে) ভ্রমণ করেন তখন আপনি কি কারপোলিং (নিয়মিতভাবে কয়েকজন মিলে একটি গাড়ি ব্যবহার করা) করেন?

- a) কখনই না
- b) মাঝে মাঝে
- c) কখনো কখনো
- d) প্রায়ই
- e) সব সময়

য ৬. আপনি প্রতিদিন কত কিলোমিটার গণপরিবহনে (বাস/সিএনজি/অন্যান্য) ভ্রমণ করেন?

য ৭. আপনি প্রতিবছর কত ঘন্টা বিমানে ভ্রমণ করেন?

- a) কখনই না
- b) ঘন্টা -----

জরিপের প্রশ্নমালা

য ৮. ভবিষ্যতে মান সম্পন্ন এবং দক্ষ গণপরিবহন চালু হলে তা ব্যবহার করতে আপনি কতটা ইচ্ছুক ?

- a) হ্যাঁ আমি করব, কারণ পরিবেশের প্রতি আমার দায়বদ্ধতা আছে
- b) না করবা না কারণ সমাজে আমার অবস্থান ধরে রাখতে হবে
- c) হ্যাঁ, আমার প্রয়োজনমত করব
- d) হ্যাঁ, যদি এটা আমার জন্য সুবিধাজনক হয়
- e) নিশ্চিত নই

য ৯. আপনার নিয়মিত গন্তব্যের অন্তত: একটি গন্তব্যে হেটে আসা-যাওয়া আপনাকে সুস্বাস্থ্যের অধিকারি করবে:

- a) খুবই একমত
- b) একমত
- c) নিশ্চিত নই
- d) অসম্মত
- e) খুবই অসম্মত

য ১০. আপনার সামাজিক অবস্থানকে প্রতিফলিত করে এমন একটি বিবাহ বা সামাজিক অনুষ্ঠানে যোগ দিতে আপনি আপনার ব্যক্তিগত গাড়ি পছন্দ করেন (ব্যক্তিগত গাড়ি না থাকলে প্রশ্ন ১১ তে যান)।

- a) খুবই কম
- b) কদাচিৎ
- c) মোটেই না
- d) প্রায়ই
- e) সব সময়

য ১১. আপনার সামাজিক অবস্থানকে প্রতিফলিত করে এমন একটি বিবাহ বা সামাজিক অনুষ্ঠানে যোগ দিতে আপনি ভাড়া গাড়ি পছন্দ করেন। (ভাড়া গাড়ি ব্যবহার না করলে প্রশ্ন ১২ তে যান)।

- a) খুবই কম
- b) কদাচিৎ
- c) মোটেই না
- d) প্রায়ই
- e) সব সময়

য ১২. আপনার সামাজিক অবস্থানকে প্রতিফলিত করে এমন একটি বিবাহ বা সামাজিক অনুষ্ঠানে যোগ দিতে আপনি গণপরিবহন পছন্দ করেন?

- a) খুবই কম
- b) কদাচিৎ
- c) মোটেই না
- d) প্রায়ই
- e) সব সময়

বিশেষ কোন মতামত (যদি থাকে):

শৈর্ষ্য সহকারে এ প্রশ্নমালার উত্তর দেয়ার জন্য আপনার প্রতি অশেষ কৃতজ্ঞতা। আপনার সময় ও বস্তনিষ্ট মতামত এ গবেষণা সবসময়ই শ্রদ্ধার সহিত স্মরণ করবে। সর্বদা আপনার সুস্বাস্থ্য ও দীর্ঘায়ু কামনা করি।

খন্যবাদান্তে



(মোহাম্মদ নাজমুল হক)

পিএইচডি প্রার্থী

ব্রাডফোর্ড বিশ্ববিদ্যালয়, যুক্তরাজ্য।

Appendix-2- Permissoin to Conduct Survey in NC



গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
স্থানীয় সরকার, পল্লী উন্নয়ন ও সমবায় মন্ত্রণালয়
নারায়ণগঞ্জ সিটি কর্পোরেশন
পূর্ত ও ডিজাইন শাখা
নগর ভবন, ১০, বঙ্গবন্ধু রোড, নারায়ণগঞ্জ।
www.ncc.gov.bd



স্মারক নম্বর: ৪৬.১৬.০০০০.০১২.৯৯.০০২.১৯.১৩

তারিখ: ১০ ফাল্গুন ১৪২৮

২৩ ফেব্রুয়ারি ২০২২

বিষয়: পিএইচডি গবেষণার জন্য খানা জরিপ (Household Servey) পরিচালনার অনুমতি প্রদান প্রসঙ্গে।

সূত্র: গত ০৩/০২/২০২২ইং তারিখের আবেদন পত্র।

উপর্যুক্ত বিষয় ও সূত্রস্থ স্মারকের প্রেক্ষিতে জানানো যাচ্ছে যে, জনাব মোহাম্মদ নাজমুল হক, যুক্তরাজ্যের ব্রাডফোর্ড বিশ^বিদ্যালয়ের একজন পিএইচডি গবেষক। তিনি মূলত: গণপ্রজাতন্ত্রী বাংলাদেশ সরকারের একজন কর্মকর্তা (২৭ তম বিসিএস, উপসচিব পদে পদোন্নতি প্রাপ্ত) তাঁর পিএইচডি'র প্রস্তাবিত শিরোনাম “Sustainable Urbanization and ecological footprint: empirical evidence from Bangladedsh” এর মাধ্যমে অন্যান্য বিষয়ের পাশাপাশি নারায়ণগঞ্জ সিটি কর্পোরেশন এলাকার Ecological Footprint পরিমাপ করা হবে মর্মে জানা যায়।

০২) এমতাবস্থায়, শুধুমাত্র গবেষণার উদ্দেশ্যে, নারায়ণগঞ্জ সিটি কর্পোরেশন আওতাধীন এলাকায় জনাব মোহাম্মদ নাজমুল হক এবং তাঁর টিম-কে গবেষণার জন্য খানা জরিপ (Household Servey) পরিচালনার অনুমতি প্রদান হলো।

১-৩-২০২২

মোঃ আবুল আমিন

প্রধান নির্বাহী কর্মকর্তা

ফোন: +৮৮০২৭৬৩৩৪২৩

ইমেইল: ceo@ncc.gov.bd

জনাব মোহাম্মদ নাজমুল হক, পিএইচডি গবেষক,
ব্রাডফোর্ড বিশ্ববিদ্যালয়, যুক্তরাজ্য।

স্মারক নম্বর: ৪৬.১৬.০০০০.০১২.৯৯.০০২.১৯.১৩/১

তারিখ: ১০ ফাল্গুন ১৪২৮

২৩ ফেব্রুয়ারি ২০২২

সদয় অবগতি ও কার্যার্থে প্রেরণ করা হল:

১) পি এ টু মেয়র, (মেয়র মহোদয়ের সদয় অবগতির জন্য), নারায়ণগঞ্জ সিটি কর্পোরেশন।

২) অফিস কপি।

৩) গার্ড ফাইল।

১-৩-২০২২

মোঃ আবুল আমিন

Appendix-3- Application for the Permission to Condcut Survey in NC

বরাবর

মাননীয় মেয়র
নারায়ণগঞ্জ সিটি কর্পোরেশন
নারায়ণগঞ্জ।

বিষয়: পিএইচডি গবেষণার জন্য খানা জরিপ (Household survey) পরিচালনা প্রসংগে।

মহোদয়,

যথাযথ সম্মান প্রদর্শন পূর্বক আপনার সদয় অবগতির জন্য জানাচ্ছি যে, আমি মোহাম্মদ নাজমুল হক, যুক্তরাজ্যের ব্রাডফোর্ড বিশ্ববিদ্যালয়ের একজন পিএইচডি গবেষক। আমি মূলত: গণপ্রজাতন্ত্রী বাংলাদেশ সরকারের একজন কর্মকর্তা (২৭তম বিসিএস, উপসচিব পদে পদোন্নতিপ্রাপ্ত)। আমার পিএইচডি'র প্রস্তাবিত শিরোনাম “Sustainable urbanization and ecological footprint: empirical evidence from Bangladesh”। আপনি জেনে আনন্দিত হবেন যে, এর মাধ্যমে আমি অন্যান্য বিষয়ের পাশাপাশি নারায়ণগঞ্জ সিটি কর্পোরেশন এলাকার Ecological Footprint পরিমাপ করব। এ সংক্রান্ত প্রস্তাবনা ব্রাডফোর্ড বিশ্ববিদ্যালয়ের নির্ধারিত প্যানেল এবং নৈতিকতা (Ethics) কমিটি কর্তৃক অনুমোদিত হয়েছে (সংযুক্তি-০১)। এছাড়াও আমার পিএইচডি সংক্রান্ত সরকারি আদেশ এতদসংগে সংযুক্ত করা হলো (সংযুক্তি -০২)। Ecological Footprint পরিমাপ করার জন্য নারায়ণগঞ্জ সিটি কর্পোরেশনে বসবাসরত মানুষের খাদ্যাভাস (Food Habit) , আবাসন ব্যবস্থা (Housing) এবং পরিবহন (Transportation) সংক্রান্ত তথ্য প্রয়োজন, যা একটি খানা জরিপের (Household survey) মাধ্যমে সংগ্রহ করা দরকার। জরিপের মাধ্যমে সংগ্রহকৃত তথ্য শুধুমাত্র গবেষণা কাজে ব্যবহার করা হবে এবং জরিপে অংশগ্রহণকারী সম্মানিত সুধীজনের গোপনীয়তা নিশ্চিত করা হবে। এ গবেষণার ফলাফল নারায়ণগঞ্জ সিটি কর্পোরেশনের টেকসই উন্নয়নে আপনার প্রচেষ্টায় সহায়তা করবে বলে আশা করা যায়। বিশ্ববিদ্যালয়ের নৈতিকতা নীতিমালা (Ethics Principles) অনযায়ী এজন্য আপনার সদয় অনুমতি প্রয়োজন।

বর্ণিতাবস্থায়, শুধুমাত্র গবেষণার উদ্দেশ্যে, নারায়ণগঞ্জ সিটি কর্পোরেশন এলাকায় একটি খানা জরিপ (Household survey) পরিচালনার অনুমতি এবং এ সংক্রান্ত কাজে সহযোগিতা করার জন্য সকল সম্মানিত ওয়ার্ড কমিশনার মহোদয়গণকে একটি নির্দেশনা প্রদানের সবিনয় অনুরোধ করছি।

বিনীত নিবেদক

তারিখ:

(মোহাম্মদ নাজমুল হক)

বিশেষ ভারপ্রাপ্ত কর্মকর্তা(উপসচিব পদে পদোন্নতিপ্রাপ্ত)

জনপ্রশাসন মন্ত্রণালয়

বর্তমানে পিএইচডি গবেষক

ব্রাডফোর্ড বিশ্ববিদ্যালয়, যুক্তরাজ্য

Email: nuzbcseco@gmail.com

Appendix-4 Questionnaire for in-depth Semi-structured Interview

By: Muhammad Nuzmul Hoque, PhD Candidate, University of Bradford, UK. UoB ID: 13022717

Hello and Thank you for participating this research, which is supported by the Bangabandhu Science & Technology Fellowship Trust of Ministry of Science and Technology and University of Bradford, UK. The research is principally designed to calculate the ecological footprint of Narayanganj City Corporation associated with the consumption habits of its residents. This semi-structured interview is for research purposes only to develop policy recommendation for sustainable urban development for overall Bangladesh.

PhD Supervisor: Prof PB Anand PhD, PHEA, FICRS
Professor of Public Policy and Sustainable Development, University of Bradford, UK.
Richmond Road, Bradford, BD71DP, Tel: +441274 233957.

Please consent to participate

- I have received information regarding this research and had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this research and I voluntarily consent to take part.

GENERAL INFORMATION

1. Organization Type
Government
Local Government Please Specify.....
NGO
Academic
2. Professional Experience _____ years
3. Gender Female Male
4. Age (between) 0--17 18-35 36-45 46-60 61+

General

5. In what way do you think that the urban area is changing? Is it good or bad? If you move, where would you like to move?
6. Please comment on the general trend of urbanization in Bangladesh. Do you feel that the present urban development of Bangladesh is sustainable?
7. Urbanization has brought remarkable development in Bangladesh, even though it has been a great challenge environmentally, socially and economically. In your view what are the major challenges that need to be considered at this moment?

Food

8. Food consumption has major implications for the environment, individual and public health, social cohesion, and the economy. As a result, food consumption plays an important role in sustainable urban development. What do you think about the present food consumption habits of urban populations of Bangladesh?
9. Do you think the present city dwellers are now moving to a more processed food rather than unprocessed, unpacked foods? What could be done to promote healthy, affordable and responsible food consumption at individuals and household level?
10. Food waste management in the city area of Bangladesh is a major problem. In your view what are the limitations of the present food waste management in the city area. Do you think citizen engagement in food waste management is helpful for sustainable urban development?

Household energy use

11. What do you think about the current household level energy use pattern in urban areas and what are the limitations of present policies and regulations regarding the household energy consumption?
12. Renewable energy sources are considered more environment friendly than other energy sources. Do you think that urban dwellers are much aware of this and in your view, what would be possible solutions for efficient energy use at household level?

Transport

13. Mass transport and carpooling is better than using personal car. City dwellers will use mass transport more frequently in future if efficient and quality mass transport is introduced. In this regard, what is your opinion and what do you feel about?
14. Environmental concern in the transportation sector is influencing the transportation planning process now a day in all around the world. Notably, traffic generated pollutant for instance, carbon dioxide, nitrogen oxide has been increasing in the air of the cities. In your view, what would be the efficient transport system with low emissions?

Conclusion

15. And from your general observation, what three words come to mind when you think about sustainable cities?
16. What is the most important thing we can do, to make cities more loveable and sustainable?

Appendix-5- Ethics Apporval Letter from UoB

From: Ethics <ethics@bradford.ac.uk>
Sent: Thursday, December 2, 2021 1:37:29 PM
To: Prathivadi Anand <P.B.Anand@bradford.ac.uk>
Subject: APPROVAL: Ethics Checklist EC26848

Dear Anand,

Ethics Checklist: EC26848
Title: Sustainable Urbanization and Ecological Footprint: Empirical Evidence from Bangladesh

Your ethics submission and documents have now been reviewed by the Chair of the Research Ethics Panel.

I am pleased to inform you that the Chair has confirmed approval of this study, with no further ethical scrutiny required.

NOTE that this approval is for this study only.
Should there be any changes to this study, you must inform ethics@bradford.ac.uk.
Once your changes have been reviewed and you have approval to proceed, only then can you recommence the study.
Failure to do so will render your original approval invalid and withdrawn.

Please add a sentence onto any material you share with participants confirming that ethics approval has been granted by the Chair of the Humanities, Social and Health Sciences Research Ethics Panel at the University of Bradford on 02/12/21.

Best wishes
Nazreen Akhtar
Research & Innovation Administrator

Research & Innovation Services (RAIS)
Directorate of Research, Innovation and Engagement
F.24 Richmond Building
T: 01274 236554
E: N.Akhtar67@bradford.ac.uk

Appendix-6- Consent form to Participate in Survey



সার্ভেতে অংশগ্রহণের সম্মতিপত্র

একমত হলে অনুস্বাক্ষর
প্রদান করুন

আমি নিশ্চয়তা প্রদান করছি যে, আমি এ গবেষণা সংক্রান্ত বিষয়ে অবগত হয়েছি এবং এর উদ্দেশ্য বুঝতে পেরেছি।	
আমি বুঝতে পেরেছি যে, এই সার্ভেতে অংশগ্রহণ একান্তই আমার ব্যক্তিগত ইচ্ছা/অনিচ্ছার বিষয় এবং আমি স্বেচ্ছায় এতে অংশগ্রহণ করছি। আমি যে কোন সময় কোন কারন ছাড়াই আমার এই অংশগ্রহণ প্রত্যাহার করে নিতে পারব। আমি যদি আমার অংশগ্রহণ প্রত্যাহার করি তাহলে আমার নিকট হতে সংগ্রহকৃত তথ্যসমূহ ধ্বংস করে ফেলা হবে। আমি যদি কোন নির্দিষ্ট প্রশ্নের উত্তর দিতে না চাই তাহলে আমি সেটার উত্তর না দেয়ার অধিকারও রাখি।	
আমি সম্মতি প্রদান করছি যে, সার্ভে টিমের সদস্যবৃন্দ আমার প্রদত্ত তথ্যে প্রবেশের অধিকার রাখে এবং তাঁরা ছাড়া অন্য কেউ আমার তথ্য জানতে পারবে না। আমি নিশ্চিত হয়েছি যে, আমার তথ্যসমূহের গোপনীয়তা রক্ষা করা হবে।	
আমি নিশ্চিত হয়েছি যে, আমার প্রদত্ত তথ্যসমূহ যুক্তরাজ্যের ব্রাডফোর্ড বিশ্ববিদ্যালয়ের নিজস্ব সার্ভারে সংরক্ষণ করে রাখা হবে এবং এটি নাম প্রকাশ না করার শর্তে অন্য যে কেউ ব্যবহার করতে পারবে।	
আমি বুঝতে পেরেছি যে, অন্যান্য গবেষকগণ কঠোর গোপনীয়তা রক্ষার শর্তে আমার প্রদত্ত তথ্যসমূহ তাঁদের প্রকাশনা, রিপোর্ট, ওয়েব পেইজ এবং অন্যান্য গবেষণা সংক্রান্ত কাজে ব্যবহার করতে পারবে।	
অংশগ্রহণকারীর নাম	
অংশগ্রহণকারীর স্বাক্ষর	
অংশগ্রহণকারীর যোগাযোগ নম্বর	
ঠিকানা (ওয়ার্ড নম্বরসহ)	
তারিখ	
লিড গবেষকের নাম	মোহাম্মদ নাজমুল হক
তথ্য সংগ্রহকারীর নাম	
তথ্য সংগ্রহকারীর যোগাযোগ নম্বর	
স্বাক্ষর	
তারিখ	

Appendix-7- Interview Data Coding

Interview G3	Interview G2 Autonomous body
24 19-22 Facilities extension	09 17 Primacy of Dhaka
2430-31 Migration	09 34 Economic contribution of Dhaka
24 31-34 Primacy of Dhaka city	09 38 Environmental degradation
24 34-37 Imbalance Urbanization	09 49- prefer to live in rural areas or small urban areas
Interlinked small city	09 67- Land fill
24 48-54 Migration	09 72- Pollution from industries
24 61-68 Migration for education and job	09 93-less process food
24 76-79 Waste management	09 103-reuse of plastic
24 90-94 Planned Development	09 123-Segregation
24 94-99 Lack of Co-ordination	09 135- Heat Island
24 99-104 Happiness of Planner	09 140- Electrical appliances uses increased
24 109-110 Drainage	09 150- lack of inclusive policy
24 110-111 Salinity	09 152- illegal electricity connection
24111-112 underground water shortage	09 156- electricity supply imbalance
24 116-117 Migration	09 177- Multi-metering system for energy pricing
24 123-128 Fastfood culture	09 189-Solar power
24 129-131 Processed food	09 196-Water reuse
24 131-133 Rice and bread	09 210-Bus-transport, MRT
24 134-136 Green fertilizer	09 215- Rail
24 136-recycle	09 226-MRT supportive transportation
24 138-140 No segregation	09 236-Private car control system
24 140-148 unsystematic waste management	09 247- Inclusive policy
24 154-155 Fund shortage	09 259-Advocating Traditional water transport
24 155-157 Lack of manpower	09 272- Blue and green development
24 161-165 Behavioral change	09 298-Law enforcement
24 193-196 Solar Pannel	09 304-Political support
24 201-202 Unplanned development	
24 202-203 need-based development	
24 207-209 Improper investment	
24 212-213 Decentralization	
24 215-222 City readiness and development	
24 241-244 imbalance in budgetary allocation	
24 244-246 Centralized approach	
24 246-249 Satellite township	
24 266-272 Food adulteration	
24 272-275 Basic needs and environment	
24 285-291 Solar power	
24 292-294 Wind power	
24 294-295 Hydropower	
24 304-307 Unsupportive Building structure	
	Interview I3
	13 22-Least livable
	13 24-Unplanned
	13 25-Planned (20 to 30%)
	13 27-Unplanned
	13 31-Urbanization rate decrease in Khulna
	13 35-Controlled urbanization in Rajshahi
	13 38- Unemployment
	13 40-Migration
	13 42-Counterproductive situation
	13 46-Air pollution
	13 46-Noise pollution
	13 46-Env. Degradation

<p>24 307-313 carelessness of using electricity 24 313-317 Aware for marketing 24 337-339 Chain Bus service 24 343-346 Corporate body for bus services 24 351- Metro rail 24 352-353 Expressway 24 353-354 Double railway 24 376-378 Foot path 24 379-381 Plantation in road 24 383-384 City ventilation 24 384-392 Green and blue space balance 24 392-398 masterplan implementation 24 405-406 Safe city 24 407 Women and children friendly city 24 410-412 Ecofriendly development 24 412-413 Proper distribution of benefit 24 419-421 Personal benefit rather than sustainability</p>	<p>13 46-Population Density 13 50-Unplanned 13 51-Negative impact on env and biodiversity 13 52-Engine of growth 13 61-income generating 13 62-least livable 13 63-unsustainable urbanization 13 68-bangladesh can be a case study 13 85-No national physical plan 13 91-Zoning/Zone guideline 13 98-No national guideline 13 103-Industries in village 13 104-Rural urban transformation 13 107-Linear fashioned growth of industries 13 111-Zoning 13 121-Haphazard Urbanization 13 128-Public Health 13 137-Environmental pollution 13 157- bad governance 13 160-governance 13 176-Governance failure 13 190-water body filling 13 191-Urbanization in flood prone zone 13 196-Governance failure 13 206-Right people not in right place 13 233- Changed food consumption habit 13 236-urban poverty 13 241-Migration 13 243-Multidimensional poverty level 13 249-Migration 13 259-food poverty 13 279-Less processed food 13 281-Affordability crisis 13 284-bad quality of food 13 290-health hazard 13 291-traditional food taking 13 296-weak food quality control 13 302-quality control of processed food 13 310-waste segregation 13 316- Door to door collection 13 318-Mixed collection 13 319-secondary transfer center 13 323-ward basis secondary transfer center 13 328-No segregation 13 327-waste as resource</p>
Interview I2	
<p>08 11- Mixed impact of urbanization 08 13-Personally adjusted with city live 08 20-Primacy of Dhaka 08 25- Unsustainable from environmental perspective 08 35-rapid population growth 08 36- lack of national level 08 37-poor city governance 08 37-poor env. Management 08 39-resource constraint 08 40 Inequality 08 41- Low citizen awareness 08 42- Needs Decentralization 08 42-Intermediate city 08 53- Rice-based food consumption 08 65- Favoring unprocessed food 08 74-Food waste in hotels 0875-Food waste in ceremonies 08 76-citizen awareness 08 83-low per capita energy use 08 84-wastage of energy 08 86 –Need awareness 08 88-increased use of electric appliances 08 89-Climate friendly architecture 0896-Solar energy 08 106-MRT 08 106-BRT 08 106-Franchise Bus</p>	

08 107-Corporate and state (public office) level carpooling	13 331-Air pollution from dumping station
08 113- NMV	13 336-unscientific waste management
08 124- NMV in small towns	13 338-ward basis secondary transfer center
08 124-NMV in local neighborhoods in large towns	13 341-park side secondary transfer center
08 126-electric mass transport	13 343- Lack of Priority
08 128-less intra-urban mobility	13 350-Citizen engagement
08 130-work from home	13 356-People awareness
08 135-good urban governance	13 357-Penalty
08 135-reduced physical mobility	13 361- Absence of rule of law
08 136-citizen awareness	13 365-Penalty
08 141-Education	13 380-heat island
08 141-Commitment to the environment	13 381-temperature increased
	13 388-Artificial light
	13 393-increased energy consumption
	13 397- absence of sustainability in building construction rules
	13 406-energy intensive building structure
	13 409-Poor law implementation
	13 417- High density of Building
	13 420-Artificial lighting
	13 427-Poor building construction law implementation
	13 428-Governance failure
	13 435-Tendency to increase profit margin
	13 437-Mindset to manage the law enforcement agency
	13 444-Green and water
	13 447-concrete area
	13 452-increased use of A/C
	13 457- No green space
	13 458- No water bodies
	13 465-Public health crisis
	13 469-Solar light
	13 476-Problem in planning exercise
	13 484-Policy implementation problem
	13 494-Low preparation for RE
	13 498-Incentive
	13 500-Affordability
	13 504-Country initiative
	13 509-Shreda Law
	13 514-Contry initiative
	13 520-New urban area
	13 522-Country commitment for RE
	13 525-Affordability
	13 528-incentives
	13 535- Wish to live in urban area with rural flavor
	13 553-Private car
Interview A3	
07 8-Environmental imbalance	
07 10-Migration	
07 12-Centralized approach	
07 15-Primacy	
07 18-Inequality	
07 22- Both, good and bad	
07 27- Accustomed to urban live	
07 31-Migration of poor people	
07 35-No planned development	
07 35-Poor implementation of planning	
07 42-Urban poverty	
07 43-Climate change impact	
07 43-No secondary cities	
07 44-Poor implementation of master plan	
07 44-inequal distribution of resources	
07 45-Poor democracy in local and central government	
07 52-Food safety	
07 55-Mindset of the people of food supply chain	
07 56-Governance failure	
07 69-Awareness of the people of food supply chain	
07 76-Resource constraint	
07 77-Awarenes of urban community	
07 79-Segregation of waste	
07 85-Integrated waste management	
07 103-Lack of awareness about RE	
07 104-Affordability	
07 106-integrated master plan	
07 114- Carpooling infeasible for BD	
07 131-Unsupportive due to poverty and safety	

<p>01 153-Dichotomy 01 167- Good Feeder services 01 172-Positioining of MRT stations 01 175-walking facilities around the MRT Stations 01 176-Short distance public transport stoppage 01 179-para transit for MRT 01 184- Restrictions for Private cars 01 185-High parking charge 01 187-Quality public transport 01 199-Prioritisation of transport system for sustainable urbanization 01 223- Walking friendly, open space, NMV, quality public transport</p>	<p>05 127- No segregation 05 129- No recycle or reuse plant 05 134- need to build awareness in different level 05 141-cultural shift for waste management 05 171- RE plant financing 05 178-Promoting LPG 05 199-Incentive for RE 05 208- GoB to Private offices transfer 05 219- Electrifying the city, I.e. everything run by electricity 05 247- Ensuring private car alternatives 05 253- Parking restriction for private cars 05 279- BRT 05 281- MRT 05 287- Walking facilities 05 288- Bicycling facilities 05 295- Polycentricity 05 302-Land use and transportation interaction 05 314- Equity 05 316-Waste as resource 05 320-Policy implementation 05 322- Good governance 05 322- Co-ordination 05 326- Good governance 05 327-Citizen engagement in policy formulation 05 329-Good governance 05 346-Community cohesion 05 348- Accumulating the good initiatives/ small locus of welfare societies</p>
Interview A4	
<p>23 15-Urbanization as obligation 23 18-Both positive and negative 23 29-Organic growth of urbanization 23 32- Migration 23 33- Urbanization due to definition change 23 36-Migration 23 40- Service challenge 23 41-Environmental challenge 23 42- Distribution of urbanization challenge 23 52- Migration 23 54-Environmental challenge 23 57- Climate change challenge 23 59- Waste management challenge 23 62- 3R 23 72-Food adulteration 23 77- Food footprint 23 83- Wet land encroaching 23 84- Food transportation 23 86- Food storage 23 89- Less process food 23 91- Increasing trend of process food 23 101- Nurturing natural sources (Nature based solution could be a theme) 23 106- Urban agriculture (roof top agriculture) 23 112- Street food 23 114- health hygiene 23 115- Street food 23 131- 3R 23 134- Waste collection chain 23 138- Weakness of policy</p>	<p style="background-color: #002060; color: white; text-align: center;">Interview A5</p> <p>25 17- Engine of development 25 19- increase urban poverty 25 20-Increase disparity 25 21-Increased ecological and environmental consequences 25 24- Urbanization as mix experience 25 29- Rapid urban growth 25 35- Primacy of major cities 25 40-Scute picture 25 48-Unfulfilment of good dream 25 54- Urban poverty 25 57- Limited facilities in both old and new cities 25 64- Planning body in big cities</p>

23 141- Business of waste management	25 68- No body in small cities
23 142- Waste recycle	25 70-lack of human resource
23 144- Integration of initiatives	25 73- Awareness for setback effect in big cities
23 146- National determinate contribution	25 79-Irreversible land use changing in new cities
23 150- Community engagement	25 84- Urban poverty
23 156-Waste as fertilizer	25 84- Urban disparity
23 158-Mismanagement of polythene	25 87- Dual governing body in big cities
23 180-increased energy consumption level	25 100- increase of population
23 184-A/C, artificial ventilation	25 100- increase urban poverty
23 187- Tree plantation	25 100-increase disparity
23 192- Solar panels	25 101- Challenge of planning and development control
23 204- Limited awareness about RE	25 102- Urban governance issue
23 205- Limitation of solar panel	25 114- Food adulteration
23 208- Un supporting building structure to use natural resources(sunlight, air)	25 121-use of toxic chemicals
23 214- Mindset problem	25 123-Poor food supply chain
23 216- Un supporting building structure	25 124-lack of storage facilities
23 223- Private cars as obstacle for sustainable transportation	25 126- Supply chain management
23 226- Need policy for discouraging Private car	25 128-Food diversity
23 230- Alternatives of private cars	25 133- Food quality
23 236- ensuring safety in Public transport	25 141- more unprocessed food as more poor people
23 243- Bike lane in new cities	25 144- Affordability
23 249- Public transport and land use pattern	25 151- Locally produced food
23 254- Prioritize the mode of transportation	25 154- EF of food increased
23 264- Waterways	25 156- Increased of build environment
23 264- Walking	25 160 EF of Food
23 269- Safety and comfort	25 176-Lack of awareness in food waste
23 276- Bike lane in some places	25 197-Income and food waste
23 277- Declare some places as pedestrian zone with flyover	25 181- Food donation
23 287- very early to declare as air pollution free zone	25 187-Unused food storage
23 299- Great challenge is balancing the aspects of sustainable development	25 194-no initiative to storage
23 303- Inclusive planning	25 198- No initiative to donate
23 311- Proper distribution of benefit	25 201- incentive for hotel owners
23 317-Gender sensitive planning	25 212- food dumping in drain
23 322- Nature-based planning	25 218- road side dumping
23 336- Rental housing rather ownership	25 222- food waste during transportation
23 345- Planning with informal sector worker	25 233- Waste segregation project failure
23 350- Climate change and SDGs	25 239-No separate waste collection system
23 357- Citizen engagement in urban planning	25 244- Limited collection from slum
23 363- Stakeholder consultation in development work	25 247- Road side dumping
	25 251- Two step collection system
	25 257- Uncleaned/infected large bins
	25 260- odor/bad smell from bins
	25 264-Open truck transportation system
	25 269- Limited No. dumping stations
	25 271-No 3R policy

Interview N3	
18 20-Urbanization's good perspective	25 273-Litching of waste
18 28-Urbanization's bad perspective	25 274-Unplanned declaration of urban area
18 41-City wise trends	25 277-Position of dumping site
18 52- Unpredictable trend of Dhaka	25 295- Reuse of food
18 54- Area out of planning	25 297-Awareness for poor people
18 59-haphazard industrialization	300-reuse of food waste (eg for dairy farms etc)
18 64- Authority differences	25 306- reuse of food
18 67-Unplanned	25 317- Food waste in student dormitory
18 72- increased population density	25 326- student sensitization
18 75- Disobey the law	25 331- rule of university/hall
18 77-Haphazard growth	administration
18 88-Governance failure	25 333- unused food distribution
18 94-Haphazard growth	25 335- ICT or App based solution
18 104-Enforcement and awareness	25 359- No power shortage
18 105-sacrifice for plan development	25 366- no filtering/marking for energy
18 134- enforcement	consumption in electrical appliances
18 140- plan with people	25 373- lack of sensitization
18 161- Unhealthy food consumption	25 376- Unsustainable energy use
18 176-More unprocessed food	25 379- Unplanned urbanization
18 207- Lack of waste management	25 388- more A/C use
infrastructure	25 396-Advocating Rickshaws/NMV
18 212- No segregation	25 399 –Unsupportive policy for NMV
18 218- food waste in different level ie.	25 401- increased Private cars
Harvest, post harvest and consumption	25 404-Public transport as good option
18 233-citizen engagement in waste	25 407-MRT
collection	25 407-BRT
18 265- increased electricity consumption	25 411-Non-shifting tendency of private
18 297-Awareness in electricity	cars users
consumption	25 425-Quality public transport passengers
18 314- People awareness for RE is not	25 430-Public transport expansion project
necessary	25 448-Rickshaw as public transport
18 321- Useless Solar Pannels	25 483- Training of rickshaw pullers
18 327-Large plant for solar power	25 471- Bicycle lane
18 344- Low number of private car owner	25 476-Rickshaw priority
18 349-crowded public transport	25 483- Mindset change of people
18 351-MRT	25 485-acknowledge the benefit of
18 353- High demand of public transport	rickshaw
18 369- Advocating battery run three-	25 488-Trips distribution in terms of vehicle
wheeler	use
18 375-Policy requirement for Electric	25 494- Trips distribution in terms of
vehicles	distance
18 393- RE target of GoB	25 498-Prioritization of the mode of
18 401- Uncontrolled Public transport	transportation
system	25 500-Mindset
18 405- RE policy and it's implementation	25 504- Infrastructure changed
18 419-bangladesh position in NMV	25 514-Non-awareness for renewable
18 422- Bike lane and car driver's	energy
awareness	

<p>18 427- Need of Mindset change for NMV 18 437- Advocating Bike 18 451- No space for separate bike lanes 18 462- preferer to live in rural area with urban facilities 18 480- City should be- Green, Environment friendly, employment opportunities 18 497- Obey the rule 18 503- Policy abundance 18 506- Awareness of individual responsibilities.</p>	<p>25 516- Basic needs priority 25 518- Affordability of RE 25 523- Incentive and penalty 25 527- Incentive for NMV and public transport users 25 530-Incentive through employer 25 534- rearrange the tax structure /Public transport friendly tax structure 25 538- Solar energy policy. 25 575-Encroaching water bodies 25 575- Encroaching hills 25 587-Dis-organized consumer 25 592- Civil society rule 25 597-Urbanizatin as Neutral/nonpolitical agenda 25 602-dis-organized mass people 25 604- Role of civil society 25 615-Sub-urban area preference to live</p>
Interview N1	
<p>12 22- Change maximization 12 24-Both positive and negative 12 28-Administrative centralization and urbanization 12 32- Migration 12 43-Decentralization of industries and other opportunities and urbanization 12 47- Connectivity and urbanization 12 52- Distribution of development 12 54- Presently good, previously bad 12 63- Improvement in food supply chain 12 67- Diversification of food 12 75- Affordability and food intake 12 76-Misuse and food crisis 12 88- Food bank setting up 12 103- Food problem as opportunity 12 119- Cultural shift in food intake 12 122- Food diversification 12 124-Busy schedule and food intake 12 126- Street food or ready food 12 128- Unhealthy food 12 134-Busy Schedule 12 139-Promoting traditional healthy food 12 147-Urban sustainability by traditional food taking 12 160-Awareness of food waste 12 162- Food reuse 12 166- Mindset change for food waste 12 167- Affordability 12 172- Food bank or road side food bank 12 176- Attracting the young generation 12 182- Incentive for roof top gardening eg tax reduction 12 191- Active citizenship 12 193- Food bank</p>	<p>Interview N2</p> <p>15 21-climate change migration 15 28-Migration due to facilities 15 30-good in terms of facilities 15 35-imbalance development 15 41- Challenge in terms of Water, health, services, mobility and security 15 52- accustomed to urban life 15 86- centralized approach 15 91- Disparity 15 98- traffic congestion 15 99-water quality 15 110- challenge of supporting the marginalized people 15 126- pressure for centralization 15 130-sexual harassment 15 134- Rule of law 15 157- restaurant food 15 163- Rice as staple food 15 168- Food waste 15 172- Ground water 15 179-imbalance in food intake 15 191-food waste in restaurant and occasion 15 200- food distribution problem not scarcity 15 218- less process food 15 243- private vehicles 15 256- food supply chain 15 261- Accountability for food wasting 15 268- food waste monitoring</p>

<p>12 190-Citizen engagement in food waste management</p> <p>12 203-Affordability balancing</p> <p>12 216-Supportive policy for RE</p> <p>12 223- High-price technology for RE</p> <p>12 225-Security for Investment in RE</p> <p>12 227-Policy implementation support</p> <p>12 240- Lot of aware people for RE</p> <p>12 241- Solar Pannel</p> <p>12 245- Lack of academic information for RE</p> <p>12 248- More RE in informal settlement</p> <p>12 258- Safe shelter for RE</p> <p>12 264- Integrated policy</p> <p>12 288- Mass transport for everyone</p> <p>12 292- Commitment for env. And humanity</p> <p>12 294- mass transport is more relevant for Dhaka</p> <p>12 299- MRT</p> <p>12 300 –rapid transit</p> <p>12 301-elevated express</p> <p>12 306- Mass transit according to local context/Prioritize the local context</p> <p>12 317-Electric car</p> <p>12 324- Hydropower</p> <p>12 332- Opposing the rickshaw</p> <p>12 333-advocating the bike</p> <p>12 359- Dhaka is unsustainable</p> <p>12 361- Dhaka can't be declared as abandon city</p> <p>12 365- 100 economic zone</p> <p>12 373- Huge population</p> <p>12 378-Pool back initiative</p> <p>12 383- No shortcut way</p> <p>12 389-Global responsibility</p> <p>12 393- Displacement due to climate change</p> <p>12 398- Relating covid-19 and global responsibility</p> <p>12 414- Need to cherish our own tradition</p>	<p>15 288- developing the habit of waste segregation</p> <p>15 295- difficulties in developing the urban habit</p> <p>15 303-awareness</p> <p>15 304- Accountability</p> <p>15 332- Knowledge raising</p> <p>15 336- door to door waste collection</p> <p>15 340- Waste segregation</p> <p>15 357- Net-metering</p> <p>15 366-energy hungry city</p> <p>15 378-Net-metering</p> <p>15 382- Govt. Offices roof top for solar panels</p> <p>15 405-low-cost solar panels</p> <p>15 421- Unaware about RE</p> <p>15 432- country initiative to mitigate climate change effect</p> <p>15 245-no incentive for solar energy</p> <p>15 448-wind power is not feasible</p> <p>15 461-model development for RE</p> <p>15 467-Showcasing</p> <p>15 469- model for less power consuming equipment</p> <p>15 497- Technology and sustainability</p> <p>15 503- Responsibilities of companies</p> <p>15 524- MRT and BRT</p> <p>15 528- Safety in public transport</p> <p>15 533-Gender responsive public transport</p> <p>15 537-Safety in public transport</p> <p>15 556-electrification of transport system</p> <p>15 566- RE for charging</p> <p>15 577- Solar plant</p> <p>15 590-Piloting for windmill</p> <p>15 592- diverse power generation system</p> <p>15 605- Disadvantage of Bike</p> <p>15 621- disadvantage of bike</p> <p>15 651- City should be green, clean and resilience</p> <p>15 662- Urban behavior</p> <p>15 669- Changing the basic habit</p> <p>15 676- Rainwater use</p>
Interview N4	
<p>26 4- Both good and bad</p> <p>26 15- Migration</p> <p>26 17- Traffic congestion</p> <p>26 18- Environmental degradation</p> <p>26 19- Unplanned urbanization</p> <p>26 20- Poor implementation of master plan</p>	<p>Interview I1</p> <p>06 20- Space for urbanization</p> <p>06 28-Good for BD</p> <p>06 38-Small urban network</p>

<p>26 22- agricultural land decrease 26 24- home for home less people 26 33- population growth 26 34- Poor policy implementation 26 46- Rising process food 26 70- Food waste amount 26 73- Food supply chain 26 83- Governance failure in gas connection 26 92- Why urban dwellers are not aware about RE 26 94- incentive or subsidy for RE 26 107- PPP for transport 26 119- PPP for transport 26 128- Environment, employability and safe food 26 134- Citizen awareness and sensitivity grown up</p>	<p>06 43-Primacy problem 06 54-Opportunity based approach 06 54-Mechanized agriculture 06 58-Land ownership co-operative 06 68-Sweet water export 06 94-Planning implementation challenge 06 118- Limited amount of process food 06 148- Rule of media for healthy food 06 152-Local market supply chain control 06 155- Street food quality control 06 159-Need for a comprehensive waste management program 06 165- Need to invest in waste management infrastructure 06 179- More income more energy use 06 183- Solar power 06 189- Power price mechanism to promote less and diverse energy use 06 213-Building weighting mechanism 06 217-Energy labelling options 06 238- Mass transport system- MRT, BRT, Busses 06 253- Rickshaw, CNG, Autorickshaw is suitable in the short run 06 256- For long run sustainability- Railway 06 260- Water boat-based transportation 06 269- Opportunity based approach 06 290- Green building 06 298- solar power at least for hot water 06 299- Resilience 06 316- Sustainability practice in personal life 06 320- Educating the youth 06 327- Training for School teacher 06 337- Training for Mosque's Imam</p>
Interview G3	
<p>14 15-Both good and bad impact of urbanization 14 28- Prefer to live in rural area with urban facilities 14 41-Garment industry-based urbanization 14 46-Migration 14 51- Economic activities-based urbanization 14 62-Primacy of Dhaka 14 78-Untreated sewage 14 79-Inadequate dumping station 14 81- Brick fields in semi-urban area 14 88- Rice as main meal 14 97- 90% no process food 14 107- Process food as a hobby 14 120-Food waste in production level 14 140-informal waste segregation 14 142- energy from waste 14 153- citizen engagement in waste management 14 168- People awareness for clean energy 14 178- Solar power 14 198- why use personal car? 14 204- School bus services 14 208- Office bus 14 214- Electric vehicle 14 220-MRT 14 228- Indirect emission from Rickshaw 14 234- Drivers awareness for bike lane</p>	<p>Interview G5 22 54- Primacy of Dhaka 22 56- Garments and urbanization 22 62- Migration 22 64- Urban planning history 22 71- Linear urbanization or informal urbanization 22 82- EPZ and urbanization 22 85-Govt. Initiatives and private urbanization 22 98- Environmental imbalance 22 103- Garments industries pollution 22 109- Disobey the law 22 121- Migration</p>

14 242- No waste - Clean - No traffic - Available transport - Education - Treatment	22 143- Skill manpower for urbanization boom 22 148- Political stability 22 162- Processed food habits in young generation 22 176- Policy implementation problem for food waste management 22 182- Human resource for development control 22 188- Disobey the law 22 197- Law enforcement problem 22 209- Garbage collection outsourcing 22 220- informal segregation 22 235- increased energy use 22 243- increased connectivity 22 257- power price mechanism 22 262- Solar power/green energy 22 281- BRT 22 285- Demo train 22 287- MRT and urban transportation 22 302- Electric transport system 22 311- Primacy of Dhaka 22 322- why decentralization? 22 330- Lack of holistic urban planning 22 347- Green and blue network approach 22 374- Road with canal 22 384- Oneway or two way road 22 388- Walking habit development 22 398- Ecological Island city 22 408- Satellite city 22 419- Urbanism 22 433- Decentralization of power 22 455- Formalization of informal economy
14 252- People awareness	
Interview G1	
04 19- Development and urbanization 04 21- Rapid urban growth 04 25- Industrialization and urbanization 04 27- Communication and urbanization 04 28- Market place and urbanization 04 30- Economic activity 04 31- Migration 04 35- Urbanization in growth centers 04 38- Expansion of urbanization concepts 04 39- Unstoppable urbanization 04 42- Industrialization and urbanization 04 49- Increase of service sectors 04 50- Increased connectivity 04 54- Urbanization is good for us 04 71- No major change in food intake habit. ie less process food 04 75- Process food habit in working people, young generation and high income people 04 80- Food diversification 04 93- Export-import basket expansion 04 106- Increase of total population 04 109- Food waste management problem 04 112- Rural industry waste unprocessed 04 120- CETP and ETP 04 129- Private and government sector engagement 04 131- Increased energy production capacity 04 137- Policy support for govt. Officials in power sector 04 141- Subsidy 04 143- PPP 04 146- Nuclear power 04 155- Green energy production plan 04 159- Solar home system 04 161- Law for solar panels 04 165- Agriculture and solar plant 04 184- Mass transport plan 04 185- MRT 04 190- Metro Rail	
Interview G4	
	20 21- Should be planned but not 20 25- Migration 20 28- Unplanned 20 30- Decentralization through creating employment in other cities 20 40- Challenge for shelter 20 44- Safety challenge 20 49- Unplanned urbanization 20 60- Mostly unprocessed food 20 63- Rice as staple food 20 66- bead and others 20 80- Fresh food preference 20 95- E-waste management rules 20 103- Old fashioned waste collection 20 107- Waste segregation initiatives

<p>04 192- Reforming the present policy for introducing public transport</p> <p>04 194- Private companies of Public transport</p> <p>04 196- High number and more frequent bus</p> <p>04 202- Passenger harassment</p> <p>04 203-Extortion</p> <p>04 205- Corruption</p> <p>04 207-Rail development</p> <p>04 216- Diversion road to remove traffic congestions</p> <p>04 225- Diversion roads and new urban area</p> <p>04 240- Climate change adaptation</p> <p>04 244- resource demand</p> <p>04 245- Compensation from developed countries</p> <p>04 251- Industrial waste from RMG and dying industries</p> <p>04 259- Advocating separate lane for NMV</p> <p>04 262- Footpath</p> <p>04 269- Law enforcement strictly</p> <p>04 276- Unstoppable urbanization except government intervention</p> <p>04 281- Public health concern</p> <p>04 283- Environment hazard</p> <p>04 285- People's unwillingness to move</p> <p>04 287- Township within 50 km range</p> <p>04 292- Residential area in this township</p> <p>04 293- Good connectivity between townships and city center</p> <p>04 297- Educational institute, offices should be moved to these townships</p>	<p>20 115- EPR (Extended producer responsibilities)</p> <p>20 121- Awareness with alternatives</p> <p>20 129-EPR</p> <p>20 179- Ad-hoc thinking</p> <p>20 202- People awareness for electricity use</p> <p>20 213- Cost-effective RE equipment's</p> <p>20 224- Motivation for private car</p> <p>20 230- Governance failure in transport sector</p> <p>20 233- Political will/Good governance</p> <p>20 244- Electric vehicles</p> <p>20 256- Environmental protection and development</p> <p>20 262- Balancing between NMV and employment</p> <p>20 275- Sustainable city image</p> <ul style="list-style-type: none"> -Clean - Housing -Safe food -Women safety <p>20 291- Obey the law</p> <p>20 291- Growing personal responsibilities</p>
<p>Interview 19 V1</p> <p>19 20- Lack of open space</p> <p>19 23- High population density</p> <p>19 36- No decentralization</p> <p>19 49- Knowledge development through curriculum</p> <p>19 59- Training for general people/authorities (Shrot film, drama, showing in every city area specially in open space of Dhaka city)</p> <p>19 68- Education for using the traffic/road infrastructure</p> <p>19 73- Training with long term planning</p> <p>19 88- mindset change</p> <p>19 90- Curriculum change/inclusion</p>	<p>Interview P</p> <p>17 18- Rapid expansion rather change</p> <p>17 21- Urbanization as agglomeration</p> <p>17 25- Small bazar to municipalities</p> <p>17 28- GDP vs urbanization</p> <p>17 36-habazard communication networks</p> <p>17 37-unplanned housing</p> <p>17 38-Lack of far-sighted planning</p> <p>17 39-Positioning of different area/unplanned urbanization</p> <p>17 47-Planned but not well timed</p> <p>17 49-Lack of far-sighted planning</p> <p>17 52-Resource limitation</p> <p>17 53-Case-based initiative</p> <p>17 55-Population and vehicle increase but not infrastructure</p> <p>17 58- Far-sighted/long-term plan</p> <p>17 60-Paradigm shift</p> <p>17 64-Five year plan</p> <p>17 65-Demands of time</p> <p>17 66-Urbanization in planning umbrella</p> <p>17 68-Far-sighted planning</p> <p>17 71-Planned development in new urban area</p>

19 100-long-term circulating before starting the development work	17 73-Lack of resources
19 103- enlightens knowledge sharing first then development	17 74-Inexperience of planning
19 113- Decentralization	17 76-Activity-based urban development
19 122- Pollution	17 78-Lack of long-term planning
19 125- Underground water	17 79-Haphazard development
19 128- Ground water	17 89-Waste collection
19 131-Underground water	17 91-Power from waste
19 134- Water waste at household level	17 92- Waste classification
19 138- Water recycle	17 94-Unscientific or unplanned waste management
19 141- Air pollution	17 97,107- Connectivity
19 145- Maintaining the rule	17 98-People movement
19 146- Tree plantation	17 102-Consumption pattern
19 147- Vehicle movement regulation odd or even number excluding the emergency vehicles	17 104- Food diversification
19 152- Safety on public transport	17 110-Consumption pattern
19 153- systematic bus network	17 119- RE awareness
19 164- More double décor bus, safety and security	17 120-Solar energy
19 168- Number of buses and pressure on people	17 123- Obstacle for solar plant
19 172- Different office time	17 125-Uses of solar power
19 175- City zoning	17 136- Mass transport
19 180- Number of buses vs office time	17 137-Private car
19 185- Community volunteering	17 139-Mass transport
19 197-Distributing personal responsibility	17 143-Metro rail/sky rail/MRT-6
19 199- Community volunteering	17 148-Dedicated Road
19 205- individual involvement benefit	17 150-Resource
19 214- Community volunteering	17 151- Sky train
19 222- Corruption in City authority	17 159-Underground train
19 227- Good governance	17 169- Green growth
19 243- Farmers market in city	17 171-Electric car
19 251- way of reducing chemical and ensuring proper price (Food supply chain could be a theme)	17 175- Tree plantation
19 262- Farmers market in city	17 180- Electric vehicle
19 281- Processed food in the young generation	17 187- NMV
19 289- Reason of process food taking	17 188- Walking
19 310- Waste picker training	17 189- Separate Lane for NMV
19 319- Waste picker and household support	17 192- Hawkers
19 325- Formalizing the waste picker	17 199- Hawkers and foot path
19 329-Penalty or fine	17 202- Hawkers and health hazard
19 335- Solution from surface, not the root problem	17 206- Street food
19 366- Energy use data base	17 215- Wish to live in planned urban area
19 388- increase awareness for energy use	17 219- Villages for holidays
	17 229- Green
	17 230-Safe drinking water
	17 232-Solid and kitchen waste management
	17 235- three conditions to become a sustainable city
	17 240- Good citizen
	17 241- Awareness
	17 243- Good conduct

19 400- Awareness for RE 19 403- RE in curriculum 19 421- safety and security and cleanliness in public transport 19 424-specific stoppage 19 427-MRT 19 428- Policy implementation 19 436- Public heroes 19 446- separate lane for NMV in new cities 19 454- Adjustment capacity of the people 19 462- Rule of law 19 463- Good governance 19 464- Empathy 19 473- Smiling face for all the time 19 479- Respect individual duty 19 481- Empathy	17 244- Participatory and accountable urban government
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Appendix-8-Empirical Research Table on Environmental Degradation

The empirical research on environmental degradation (Author's creation).

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
Econometrics analysis with Panel Data for group of countries					
1.	Bhattacharya and Ghoshal (2010)	Per capita CO ₂ Emission, Per capita income, Aggregate consumption, aggregate CO ₂ emissions	OLS, Johansen procedure for co-integration, Granger causality test	Union of top 25 countries in terms of CO ₂ emissions, population and per capita GNP (1950 to 2000)	Stable long run relationship between emissions and economic developments in al 10 of top 10 per capita income countries, Causality from consumption to CO ₂ emission are mostly in high income countries.
2.	Acaravci and Ozturk (2010)	Per capita energy Consumption, Per capita CO ₂ emissions and Per capita real GDP	Autoregressive distributed lag (ARDL) bounds testing approach of co-integration, Granger Causality	19 European Countries (1970-2005 for Germany, 1965-2005 for Hungary and 1960-2005 for other countries)	Long-run relationship found in Denmark, Germany, Greece, Iceland, Italy Portugal and Switzerland, no long-run relationship for other countries, EKC hypothesis in not valid for most of the countries
3.	Gurluk (2009)	Biochemical oxygen demand and per capita gross domestic product (GDP), Modified HDI.	Different models- Quadratic, logarithmic, inverse logarithmic.	15 Mediterranean Countries (1970-2006)	Follow EKC Except France
4.	Farhani and BenRejeb (2012)	CO ₂ Emissions measured in metric tons per capita, Energy consumption measured in kg	Panel unit root tests, panel co-integration methods and panel causality test. To deal	15 MENA countries (1973 to 2008)	No causal link between GDP and energy consumption and between CO ₂ emissions and energy consumptions in the

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		of oil equivalent per capita, Economic growth considered at GDP per capita in constant 2000 US\$.	with heterogeneity in the countries FMOLS and to deal with endogeneity bias in regressors DOLS approach		short run. However, in the long run there is unidirectional causality running from GDP to CO ₂ emissions.
5.	Ozcan (2013)	Per capita CO ₂ emissions (metric tons per capita), Energy consumption (kt of oil equivalent per capita); Real GDP per capita (constant 2000 international dollars)	Lagrange multiplier test developed by Breusch and Pagan (1980); Bootstrap unit root tests of Smith et al. (2004); Swamy's (1970) slope homogeneity test, Pedroni's (2000) heterogeneous FMOLS estimator; Panel-based error correction model following the two steps of Engle and Granger (1987)	12 countries of Middle East (1990 to 2008)	Evidence favorable to the U-shaped EKC for 5 Middle east countries whereas an inverted U-shaped curve were found only for 3 Middle east countries. Unidirectional causality from economic growth to energy consumption in the short-run, in the long-run, however, the unidirectional causality chain runs from energy consumption and economic growth to CO ₂ emissions.
6.	Omri (2013)	Real GDP per capita (constant 2000US\$), energy consumption (kg of oil equivalent per capita), CO ₂ Emissions (metric tons per capita), trade	Cobb-Doughlas Production function, Generalized Method of Moments (GMM), Durbin-Wu-Hausman test used to use endogeneity	14 MENA Countries (1990-2011)	Results suggest that energy consumption enhances economic growth. Bi-directional causal relationship between the two series. Results also significantly reject the neo-classical assumption that energy is neutral for growth. Uni-directional causal relationship from energy

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		openness (% of exports and imports of GDP), financial development (total credit to private sector as a ratio of GDP), urbanization (% urban population of the total population), total population (in thousands), capital stock (constant 2000us\$) and total labour force (%of total population)			consumption to carbon dioxide emissions without feedback is found. This implies that due to the expansion of production, the countries are consuming more energy which puts pressure on the environment leading to more emissions. Bi-directional causality between economic growth and CO ₂ emissions is found. It implies that degradation of the environment has a causal impact on economic growth and a persistent decline in environmental quality may exert a negative externality to the economy through affecting human health, and thereby it may reduce productivity in the long run.
7.	Giovanis (2013)	Air pollution and income (Social and micro level data)	Fixed effects model, dynamic panel data and Arellano-Bond GMM, Binary logit model with fixed effects	Great Britain (1991-2009)	Fixed effects result show no evidence favoring EKC hypothesis, but Arellano-Bond GMM and logit Model's with fixed effects and all the types of household income favor EKC hypothesis. Furthermore, personal income using Arellano-Bond GMM does not

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
					hold EKC hypothesis. This indicates that air pollution and income might be based on communitarian arrangements instead of on individualistic actions
8.	Narayan and Narayan (2010)	Real GDP, CO ₂ Emissions	Panel unit root tests of Breitung (2001) and Im et al. (2003), Co-integration relationship by Pedroni (1999);	43 developing countries (12 Middle Eastern, 4 South Asian, 9 Latin American, 6 East Asian, 12 African countries) (1980-2004)	Long-term elasticity of income with respect to carbon dioxide is lower than the short-run elasticity of 35 percent of the sample countries. It means as these countries' economies have grown their emissions have fallen over the long run i.e. they follows EKC hypothesis.
9.	Arouri et al (2012)	Per capita CO ₂ Emission (in metric tons) , Per capita energy consumption(K t of oil equivalent), Per capita real GDP	Panel Unit root test, Panel co-integration, (1981-2005)	12 MENA Countries (Middle Eastern and North African)	In the long run energy consumption has a significant and positive effect on contaminating emissions and GNP has a Quadratic relationship with CO ₂
10.	Al-mulali (2011)	Gross Domestic Product (GDP), Oil consumption measured in thousands of barrels per day, Total CO ₂	Panel unit root test, panel con-integration test, Panel Granger causality	Middle East and North African (MENA) Countries except Iraq, Libya, Palestinian and Djibouti	CO ₂ emission and oil consumption has Long run relationship with economic growth, Bidirectional causality among the three variables both in short and long run

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		emissions from the consumption of Energy (Million Metric Tons)		due to data unavailability (1980-2009)	
11.	Chang and Soruco Carballo (2011)	Energy consumption is measured in kilotons of oil equivalent, the gross domestic product (GDP) in millions of U. S. dollars at constant 2000 prices and the carbon dioxide emissions in kilotons of carbon	Phillips and Perron (PP) tests, Co-integration model with vector error correction modeling (VECM) and Vector autoregression (VAR) with Granger Causality	20 Countries from Latin America and Caribbean Region (1971 to 2005)	Argentina, Dominican Republic, Mexico, Panama can conserve environment without affecting economic growth, In case of Bolivia, El Salvador Guatemala and Trinidad and Tobago, relationship among the variables was not possible to discuss due to non-stationary in the first difference of the unit root test, while others 12 countries should focus on their economic growth before designing any energy conservation policies.
Econometrics analysis of time series data of a single country					
12.	Mondol (2019)	Total GHG emissions (kt of CO ₂ equivalent), Total GDP (current US\$), Population Size	Pearson correlation analysis	Bangladesh (1972-2012)	Statistically significant positive co-relation between all variables meaning that all variables tend to increase together.
13.	Nathaniel et al. (2019)	Per capita Ecological footprints, income level, energy use,	Augmented Dickey Fuller(1979) and Phillips and Perron (PP) and	South Africa (1965-2014)	Unidirectional causality flowing from economic growth to ecological footprint, and from energy use to economic

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		urban population and financial development	ZA test for Stationary test, Bayer and Hanck (2013) co-integration test, ARDL Bounds Tests of Pesaran et al. (2001), Granger Causality test,		growth and that though energy use increases environment degradation in the short run, urbanization appears to have the greatest impact on Ecological Footprints in the short run while GDP and in financial development also exact a detrimental effect on the environment both in the short and long run.
14.	Hassan et al. (2019)	Per capita Ecological Foot Prints (measured in hectares), Per capita real natural resources (measured as composite index of gas rents, oil rents, coal rents, mineral rents and forestry rents) Per capita real GDP (in constant 2010 USD), Urbanization (annual percentage of urban population growth),	Ng and Perron's (2001) unit root test, ARDL Bound Testing Approach, The VECM Granger Causality Approach,	Pakistan (1970-2014)	Confirming EKC hypothesis, i.e economic growth initially increases ecological footprints but later economic growth improves environment quality. Natural resource has positive and significant effect on the ecological footprint; human capital and bio-capacity do not enhance ecological footprint and bidirectional causality between the ecological footprint and bio-capacity.

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		human capital(measured as skills, education, capabilities and attributes of the workforce, from Penn world Table version 9.0), Per capita Biocapacity.			
15.	Ahmed and Wang (2019)	Per capita Ecological footprints (global hectares), Per capita GDP (in constant (2010 USD), Quadratic term of GDP i. e. GDP^2 , Per capita energy consumption (kg of oil equivalent), Human capital index based on years of education and rate of return for primary, secondary and tertiary education, Trade openness [sum of exports	ADF and Kwiatkowski-Phillips-Schmidtshin (KPSS) unit root test, Recently developed combined co-integration method of Bayer and Hanck (2013) and ARDL bound tests, DOLS, CCR and PMOL techniques to validate the long-run findings of ARDL, Vector error correction model for causality.	India (1971-2014)	Variables are co-integrated, long-run negative relationship between human capital and ecological footprints which implies that human capital improves the environment. The relationship between economic growth and EFP support EKC hypothesis. Energy consumption increases EFP and urbanization reduces it. The DOLS, CCR and FMOL techniques are employed to validate the long-run findings of ARDL bound test. Unidirectional causality from human capital to the ecological footprints both in long-run and short-run.

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		and imports (goods and services) as percentage of GDP], Urban population (percentage of growth rate).			
16.	Ahmed et al (2019)	Per capita ecological footprints (global hectares), Per capita GDP (constant 2010 USD), Per capita energy consumptions (kg of oil equivalent), Population density (people per square km of land area), globalization (overall KOF index), Financial development (domestic credit to private sectors percentage of GDP), Ecological carbon footprint in terms of forest land required	ADF, KPSS, Dickey-fuller generalized least squares (DG-GLS), Zivot and Andrew structural break unit root test, Bayer-Hanck co-integration approach and ARDL bound testing approach, VECM for causality test.	Malaysia (1971 to 2014)	Variables are co-integrated, globalization has no significant effect on ecological footprint, however it increases the ecological carbon footprint. Energy consumption and economic growth are the major drivers of ecological footprint and carbon footprint. Population density reduces ecological footprint and carbon footprint. In addition financial development mitigates the ecological footprint. Bi-directional causality between energy consumption and economic growth, Economic growth and ecological footprint, energy consumption and ecological footprint, financial development and ecological footprint.

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		to absorb CO ₂ emissions.			
17.	Alam et al (2012)	Per capita real GDP, Per capita energy consumption (measured as kg of oil equivalent), Per capita electricity consumption (measured as Kilowatt hours) and per capita CO ₂ Emissions (measured in metric tons)	Augmented Dickey Fuller (1979) and Phillips and Perron (PP) tests for Stationary test, Johansen con-integration test, Autoregressive distributed lag (ARDL) bound test, Granger causality in the error correction modeling (ECM) framework	Bangladesh (1972 to 2006)	Unidirectional causality from energy consumption to economic growth both in long and short run, Bidirectional long run causality between electricity consumption and economic growth but no causality in the short run, Unidirectional causality from energy consumption to CO ₂ emissions in the short run but feedback causality in the long run, Unidirectional causality from CO ₂ to economic growth both in long and short run.
18.	Alvarado and Toledo (2017)	Vegetal cover (in Sq. kilometers of forest area, Total real GDP (constant 2005 US\$) and Urbanization (percentage of total population)	Augmented Dickey and Fuller (1979) and Phillips and Perron (1988) test for unit root, Johansen co-integration test (1988) and Granger causality test (1969) based on error correction models (Engle and Granger 1987)	Ecuador (1971-2010)	Johansen co-integration test indicate long-term equilibrium between the variables, Error correction model give short-term equilibrium and no Granger causality found.

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
19.	Ang (2008)	Per capita real GDP, Per capita commercial energy use, Per capita CO ₂ emissions	Augmented Dickey-Fuller (ADF) Test, Phillips-perron (pp) test and Kwiatkowski-Phillips-Schmidt-Shin (KPPS) test for unit root tests, Johansen approach, Short run Granger non-causality test, weak exogeneity and strong exogeneity test	Malaysia (1971-1999)	Long-term positive relationship between variables, Bi-directional causality between energy consumption and economic growth in the long Weak causality running from CO ₂ emissions to economic growth.
20.	Shaari et al (2013);	Real Total GDP, Total electricity consumption, total crude oil consumption, total gas consumption and total coal consumption.	Unit root test by Augmented Dickey-Fuller (ADF) Test, Johansen co-integration test; Granger causality test	Malaysia (1980 to 2010)	Long-run relationship between energy consumption and GDP. Oil and coal consumptions do not Granger cause economic growth and vice-versa. Causality runs from economic growth to electricity consumption. A unidirectional relationship exists between gas and economic growth, with causality running from electricity use to economic growth.
21.	Ozturk and Acaravci (2010)	Real per capita GDP (constant 2000 US\$); Per	Autoregressive distributed lag (ARDL) Co-	Turkey (1968-2005)	Long-run relationship between the variables.

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		capita carbon emissions (metric kg); per capita energy use (kg of oil equivalent), total labor force.	integration analysis of Pesaran and Shin(1999) Pesaran et al (2001) approach for testing the existence of long or short run relationship between the variables; two steps procedure of Engle and Granger (1987) model for causality test.		Neither carbon emissions nor energy consumption cause real GDP in the short run. Therefore conservative energy and carbon emission policy can be adopted without impeding economic growth in the long run. No causal relationship between real GDP and carbon emissions, this indicates no evidence of EKC hypothesis. Although main source of CO ₂ is energy consumption but no evidence of causal relationship between them. No causal relationship between carbon emissions and employment.
22.	Pao and Tsai (2011)	Total CO ₂ Emissions in metric tons, Total Energy consumption in BTU (British Thermal Unit), Real GDP is measured in US\$ at 2000 prices.	Three different Unit root test ADF (1981), PP (1988) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS)(1992) to verify the order of integration, Johansen maximum Likelihood method (1990) for co-	Brazil (1980-2007)	Long-run relationship between variables was found. Evidence of Inverted U-shaped curve i. e. EKC hypothesis is found. Bi-directional strong causality running between income, energy consumption and emissions.

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
			integration relationship, Granger causality test		
23.	Hwang and Yoo (2014)	CO ₂ Emissions per year in kiloton, Energy consumption was the total amount of primary energy used in a year in ton oil equivalent(TOE), Real GDP in constant 2005 US\$ as proxy for Economic growth	Unit root by Phillips-perron (1988), Johansn Co-integration test by Johansen and Juselius (1990), Granger-causality, ECM,	Indonesia (1965-2006)	Uni-directional causality runs from economic growth to energy consumption means economic development does not completely dependent on energy consumption; Uni-directional causality runs from economic growth to CO ₂ emissions and finally bi-directional causal relationship was detected between energy consumption and CO ₂ emissions.
24.	Hossain (2012);	CO ₂ Emissions (metric tons per capita), Energy consumption (kg of oil equivalent) Per capita real GDP (constant 2000 US\$ proxy for economic growth) trade openness (% of exports and imports of GDP as the proxy of Foreign Trade),	ADF and PP for Unit roots, ARDL of Pesaran Shin and Smith for co-integration; Granger Causality Test; Cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests for stability of long-run relationship	Japan (1960-2009)	Variables are co-integrated, Statistically insignificant long-run positive impact of economic growth and urbanization and negative impact of trade openness on CO ₂ emissions were found which indicates in respect of economic growth, trade openness and urbanization the environment quality of Japan is found to be normal good in the long-run. Unidirectional short-run

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		Urbanization (% of urban population of total)			causal relationship from energy consumption and trade openness to CO ₂ emissions, from trade openness to energy consumptions, from CO ₂ emissions to economic growth and economic growth to trade openness were found.
25.	Zhang and Cheng (2009)	Total real GDP and gross fixed capital formation (both in constant price), total CO ₂ Emissions (kt), Total Energy consumption (kt of standard coal equivalent), Total urban population	ADF, PP and Kwiatkowski-Phillips-Schmidt-Shin for unit root, TY procedure, Vector autoregression (VAR) and error correction model (ECM) used to examine Granger causality	China (1960-2007)	Unidirectional causality from real GDP to energy consumption in the long run. Unidirectional causes from energy consumption to carbon emissions in the long run. Urban population have no significant initial impacts but positive effects on the others, so the accelerating industrialization has positive effects on the energy use and carbon emissions.
26.	Shahbaz et al. (2012)	Per capita CO ₂ emissions, Per capita energy consumption, Real GDP and real GDP ² , Per capita trade openness (exports+ imports)	Unit root test by Clemente et al (1998) two-break test, The two-step procedure of ARDL bound test for co-integration, Gregory and Hansen(1996) co-integration	Pakistan(1971-2009)	There is long run relationship between the variables and Environmental Kuznets Curve (EKC) is supported. One way causal relationship running from economic growth to CO ₂ emissions. Energy consumption increases CO ₂ emissions in both

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
			test to examine the robustness of long run relationship, Granger causality test,		the short and long runs. Trade openness reduces CO ₂ emissions in the long run but it is insignificant in the short run.
27.	Fodha and Zaghdoud (2010)	Per capita CO ₂ Per capita SO ₂ , Per capita GDP	Three Unit root test ADF, PP and Kwiatkowski-Phillips-Schmidt-Shin (KPSS), Johansen Co-integration test in the context of VAR model.	Tunisia (1961-2004)	Long run relationship between the variables, Inverted U relationship between SO ₂ emissions and GDP has been found, Income has unidirectional causality to pollution both in long and short run
28.	Shahbaz et al. (2016)	CO ₂ Emissions (measured in kt) per capita, Energy intensity per capita, Real GDP per capita, per capita real domestic credit to private sector as a proxy for financial development	Zivot-Andrews unit root tests for Unit root problem of variables, Autoregressive distributed lag (ARDL) for long-run relationship, VECM Granger Causality approach for causal relationship Causality	Portugal (1971-2011)	Variables are Co-integrated for long-run relationship, Bi-directional causal relationship between energy intensity and CO ₂ emissions, Unidirectional causality from economic growth to energy intensity and also to CO ₂ emissions.
29.	Halicioglu (2009)	Per capita CO ₂ Emissions (in metric tons), Per capita commercial	Pesaran et. al (2001) procedure, Time series properties were checked by ADF	Turkey (1960-2005)	Significant long-run relationship between CO ₂ emissions, energy consumption, income and openness. Bi-directional causality

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		energy(kg of oil equivalent);Per capita real gross national Income and openness ratio used as proxy Foreign Trade	of Dickey and Fuller (1981) and Phillips-Perron (1998) unit root-testing procedures, Cointegration test- first step ARDL procedure, second step-bounds F-test to establish a long-run relationship between variables, Granger causality test		between CO ₂ emissions and income both in short and long run.
30.	Azlina (2012)	Energy consumption, aggregate output or GDP as proxy for Economic growth, energy price, the share of industry in GDP and Capital	Multivariate co-integration Analysis, ADF and Phillips-perron (PP) test to test stationarity, For long run relationship co-integration test, Vector Error Correction model (VECM) to assess the direction of causality, Granger causality test	Malayasia (1960 to 2009)	Stable long-run relationships among variables, Long-run Granger Causality running from economic development to energy consumption
31.	Ghosh (2010)	CO ₂ emissions from fuel	ARDL Bounds testing	India (1971-2006)	No long-run equilibrium relationship and long

S.L. No.	Name	Indicators	Methodology	Countries/ Country (Data Period)	Findings
1	2	3	4	5	6
		combustion (in Mtoe of CO ₂), Total primary energy supply(in Million tons of oil equivalent), Real GDP (in million rupees), Real investment (in million rupees), Employment (in millions)	approach complemented by Johansen-Juselius maximum likelihood procedure in a multivariate framework		term causality between carbon emissions and economic growth, however bi-directional short causality was found between them. Uni-directional Short-run causality from economic growth to energy supply and energy supply to carbon emissions, no causality from energy supply to economic growth
32.	Shahbaz et al. (2013)	Per capita CO ₂ emissions, Per capita energy consumption, Per capita real GDP	ADF test for Unit root, ARDL bounds test for co-integration	Romania (1980-2010)	Long run co-integration, Support EKC hypothesis both in short and long run.

Appendix-9 Microfit Output from ARDL Estimates

10/12/2021

Muhammad Nuzmul Hoque

10:38:41

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Autoregressive Distributed Lag Estimates
ARDL(1,0,2,2) selected based on Schwarz Bayesian Criterion
.....
Dependent variable is LEF
45 observations used for estimation from 1973 to 2017 n = 45
.....
Regressor          Coefficient          Standard Error          T-Ratio[Prob]
LEF(-1)            .55649                .10135                  5.4910[.000]
LU                 .0012934              .056401                 .022932[.982]
LGDP               -.79209                .24187                  -3.2748[.002]
LGDP(-1)           .53069                 .24106                  2.2015[.034]
LGDP(-2)           .45592                 .14817                  3.0770[.004]
LTO                .058973               .021470                 2.7468[.009]
LTO(-1)            -.048953              .028096                 -1.7424[.090]
LTO(-2)            .066622               .023460                 2.8399[.007]
C                  -1.6690               .73369                  -2.2748[.029]
.....
R-Squared          .98336                R-Bar-Squared          .97966
S.E. of Regression .026116                F-Stat. F(8,36)        265.9048[.000]
Mean of Dependent Variable -.53729                S.D. of Dependent Variable .18312
Residual Sum of Squares .024553                Equation Log-likelihood 105.2031
Akaike Info. Criterion 96.2031                Schwarz Bayesian Criterion 88.0731
DW-statistic       1.9578                Durbin's h-statistic .19282[.847]
.....

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Testing for existence of a level relationship among the variables in the ARDL mo

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F-statistic  95% Lower Bound  95% Upper Bound  90% Lower Bound  90% Upper Bound
15.4145      3.5028              4.7609           2.9227           3.9921

```

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W-statistic  95% Lower Bound  95% Upper Bound  90% Lower Bound  90% Upper Bound
61.6582     14.0113           19.0438          11.6907           15.9685

```

If the statistic lies between the bounds, the test is inconclusive. If it is above the upper bound, the null hypothesis of no level effect is rejected. If it is below the lower bound, the null hypothesis of no level effect can't be rejected. The critical value bounds are computed by stochastic simulations using 20000 replications.

Diagnostic Tests

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.....
* Test Statistics *          LM Version          *          F Version          *
.....
* A:Serial Correlation*CHSQ(1) = .026177[.871]*F(1,35) = .020372[.887]*
*
* B:Functional Form *CHSQ(1) = .18970[.663]*F(1,35) = .14817[.703]*
*
* C:Normality *CHSQ(2) = 2.2547[.324]*          Not applicable          *
*
* D:Heteroscedasticity*CHSQ(1) = .048253[.826]*F(1,43) = .046158[.831]*
.....

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A:Lagrange multiplier test of residual serial correlation
 B:Ramsey's RESET test using the square of the fitted values
 C:Based on a test of skewness and kurtosis of residuals
 D:Based on the regression of squared residuals on squared fitted values

Estimated Long Run Coefficients using the ARDL Approach
 ARDL(1,0,2,2) selected based on Schwarz Bayesian Criterion

 Dependent variable is LEF
 45 observations used for estimation from 1973 to 2017

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LU	.0029163	.12756	.022863[.982]
LGDP	.43858	.15864	2.7646[.009]
LTO	.17281	.056963	3.0337[.004]
C	-3.7632	1.0794	-3.4863[.001]

Testing for existence of a level relationship among the variables in the ARDL model

F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
15.4145	3.5028	4.7609	2.9227	3.9921

W-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
61.6582	14.0113	19.0438	11.6907	15.9685

If the statistic lies between the bounds, the test is inconclusive. If it is above the upper bound, the null hypothesis of no level effect is rejected. If it is below the lower bound, the null hypothesis of no level effect can't be rejected. The critical value bounds are computed by stochastic simulations using 20000 replications.

Error Correction Representation for the Selected ARDL Model
 ARDL(1,0,2,2) selected based on Schwarz Bayesian Criterion

 Dependent variable is dLEF
 45 observations used for estimation from 1973 to 2017

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dLU	.0012934	.056401	.022932[.982]
dLGDP	-.79209	.24187	-3.2748[.002]
dLGDP1	-.45592	.14817	-3.0770[.004]
dLTO	.058973	.021470	2.7468[.009]
dLTO1	-.066622	.023460	-2.8399[.007]
ecm(-1)	-.44351	.10135	-4.3761[.000]

List of additional temporary variables created:

dLEF = LEF-LEF(-1)

dLU = LU-LU(-1)

dLGDP = LGDP-LGDP(-1)

dLGDP1 = LGDP(-1)-LGDP(-2)

dLTO = LTO-LTO(-1)

dLTO1 = LTO(-1)-LTO(-2)

ecm = LEF -.0029163*LU -.43858*LGDP -.17281*LTO + 3.7632*C

R-Squared	.66222	R-Bar-Squared	.58715
S.E. of Regression	.026116	F-Stat. F(6,38)	11.7629[.000]
Mean of Dependent Variable	.011424	S.D. of Dependent Variable	.040645
Residual Sum of Squares	.024553	Equation Log-likelihood	105.2031
Akaike Info. Criterion	96.2031	Schwarz Bayesian Criterion	88.0731
DW-statistic	1.9578		

R-Squared and R-Bar-Squared measures refer to the dependent variable
 dLEF and in cases where the error correction model is highly
 restricted, these measures could become negative.

Testing for existence of a level relationship among the variables in the ARDL mode:

F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
15.4145	3.5028	4.7609	2.9227	3.9921

W-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
61.6582	14.0113	19.0438	11.6907	15.9685

If the statistic lies between the bounds, the test is inconclusive. If it is
 above the upper bound, the null hypothesis of no level effect is rejected. If
 it is below the lower bound, the null hypothesis of no level effect can't be
 rejected. The critical value bounds are computed by stochastic simulations
 using 20000 replications.

*ecm = LEF -.0029163*LU -.43858*LGDP -.17281*LTO + 3.7632*C*

Appendix-10- Eviews Output

Dependent Variable: LEF Method: ARDL Date: 12/25/21 Time: 23:43 Sample (adjusted): 1973 2017 45 Included observations: 45 after adjustments Maximum dependent lags: 2 (Automatic selection) Model selection method: Schwarz criterion (SIC) Dynamic regressors (2 lags, automatic): LU LGDP LTO Fixed regressors: C @TREND Number of models evaluated: 54 Selected Model: ARDL(1, 0, 2, 2)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LEF(-1)	0.469912	0.119727	3.924871	0.0004
LU	0.059297	0.070951	0.835748	0.4090
LGDP	-0.676505	0.254793	-2.655117	0.0119
LGDP(-1)	0.521376	0.238675	2.184457	0.0357
LGDP(-2)	0.465552	0.146820	3.170912	0.0032
LTO	0.065248	0.021770	2.997151	0.0050
LTO(-1)	-0.047737	0.027821	-1.715867	0.0950
LTO(-2)	0.066245	0.023219	2.852990	0.0072
C	-2.298973	0.868057	-2.648411	0.0120
@TREND	-0.003953	0.002984	-1.324379	0.1940
R-squared	0.984152	Mean dependent var	-0.537288	
Adjusted R-squared	0.980077	S.D. dependent var	0.183117	
S.E. of regression	0.025847	Akaike info criterion	-4.280148	
Sum squared resid	0.023382	Schwarz criterion	-3.878668	
Log likelihood	106.3033	Hannan-Quinn criter.	-4.130480	
F-statistic	241.5050	Durbin-Watson stat	1.880423	
Prob(F-statistic)	0.000000			
*Note: p-values and any subsequent tests do not account for model selection.				

Breusch-Godfrey Serial Correlation LM Test:				
Null hypothesis: No serial correlation at up to 2 lags				
F-statistic	0.520435	Prob. F(2,33)	0.5991	
Obs*R-squared	1.375968	Prob. Chi-Square(2)	0.5026	
Test Equation: Dependent Variable: RESID Method: ARDL Date: 12/25/21 Time: 23:47 Sample: 1973 2017 Included observations: 45 Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEF(-1)	-0.006641	0.169303	-0.039226	0.9689
LU	-0.002938	0.072209	-0.040689	0.9678
LGDP	-0.033386	0.271607	-0.122921	0.9029
LGDP(-1)	0.058170	0.250613	0.232111	0.8179
LGDP(-2)	-0.008322	0.149246	-0.055760	0.9559
LTO	-0.003963	0.022441	-0.176605	0.8609
LTO(-1)	0.005332	0.028962	0.184098	0.8551
LTO(-2)	-0.002931	0.023728	-0.123515	0.9024
C	-0.104700	1.134413	-0.092295	0.9270
@TREND	-0.000166	0.003313	-0.049958	0.9605
RESID(-1)	0.083177	0.233713	0.355892	0.7242
RESID(-2)	-0.175499	0.194009	-0.904591	0.3722
R-squared	0.030577	Mean dependent var	1.15E-15	
Adjusted R-squared	-0.292564	S.D. dependent var	0.023052	
S.E. of regression	0.026208	Akaike info criterion	-4.222314	
Sum squared resid	0.022667	Schwarz criterion	-3.740537	
Log likelihood	107.0021	Hannan-Quinn criter.	-4.042712	
F-statistic	0.094625	Durbin-Watson stat	2.038171	
Prob(F-statistic)	0.999893			

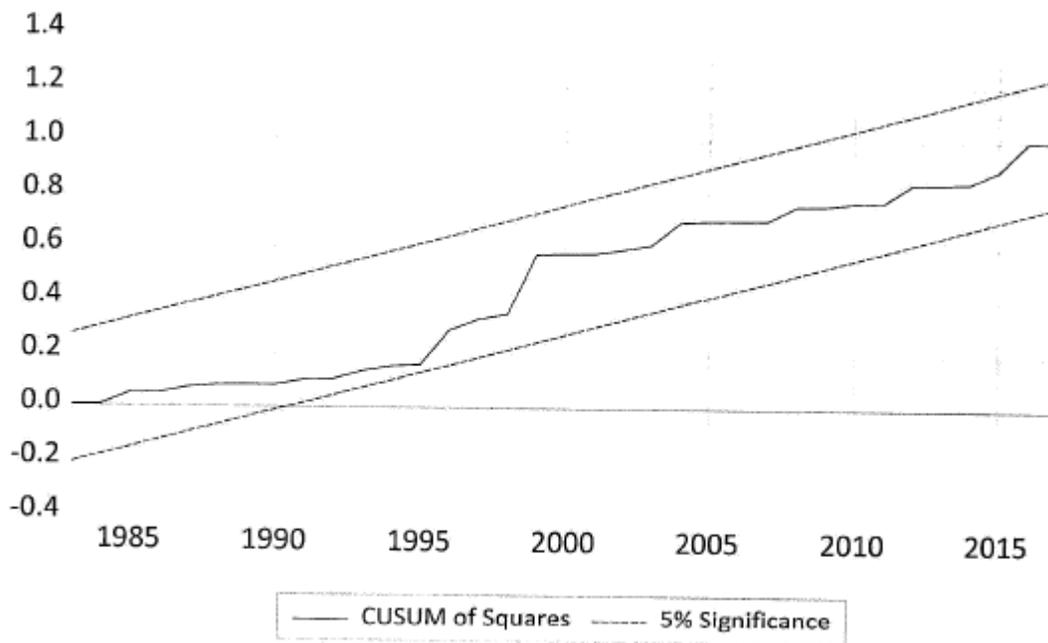
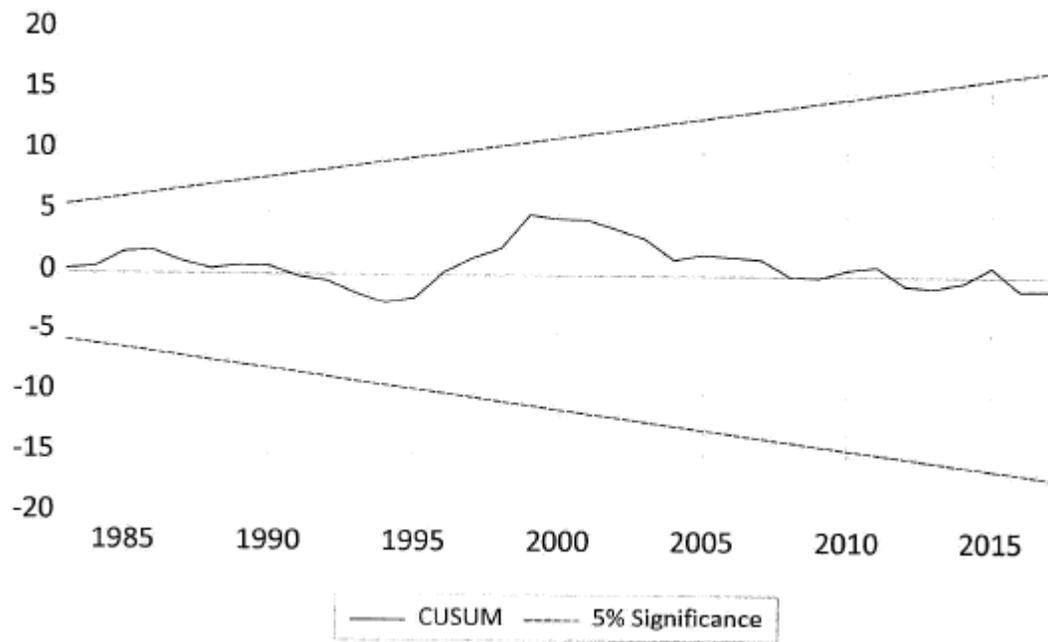
Heteroskedasticity Test: Breusch-Pagan-Godfrey				
Null hypothesis: Homoskedasticity				
F-statistic	0.319342	Prob. F(9,35)	0.9631	
Obs*R-squared	3.414831	Prob. Chi-Square(9)	0.9456	
Scaled explained SS	2.686755	Prob. Chi-Square(9)	0.9754	
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 12/25/21 Time: 23:49				
Sample: 1973 2017				
Included observations: 45				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.018329	0.030678	-0.597465	0.5540
LEF(-1)	-0.001795	0.004231	-0.424214	0.6740
LU	-0.001563	0.002507	-0.623153	0.5372
LGDP	0.008687	0.009005	0.964688	0.3413
LGDP(-1)	-0.004947	0.008435	-0.586482	0.5613
LGDP(-2)	-0.001165	0.005189	-0.224587	0.8236
LTO	0.000124	0.000769	0.161657	0.8725
LTO(-1)	-0.000799	0.000983	-0.812240	0.4221
LTO(-2)	9.85E-05	0.000821	0.120059	0.9051
@TREND	1.08E-05	0.000105	0.102197	0.9192
R-squared	0.075885	Mean dependent var	0.000520	
Adjusted R-squared	-0.161744	S.D. dependent var	0.000847	
S.E. of regression	0.000913	Akaike info criterion	-10.96555	
Sum squared resid	2.92E-05	Schwarz criterion	-10.56407	
Log likelihood	256.7250	Hannan-Quinn criter.	-10.81589	
F-statistic	0.319342	Durbin-Watson stat	2.242219	
Prob(F-statistic)	0.963095			

Ramsey RESET Test				
Equation: UNTITLED				
Omitted Variables: Squares of fitted values				
Specification: LEF LEF(-1) LU LGDP LGDP(-1) LGDP(-2) LTO LTO(-1) LTO(-2) C @TREND				
	Value	df	Probability	
t-statistic	1.096396	34	0.2806	
F-statistic	1.202085	(1, 34)	0.2806	
Likelihood ratio	1.563516	1	0.2112	
F-test summary:				
	Sum of Sq.	df	Mean Squares	
Test SSR	0.000798	1	0.000798	
Restricted SSR	0.023382	35	0.000668	
Unrestricted SSR	0.022583	34	0.000664	
LR test summary:				
	Value			
Restricted LogL	106.3033			
Unrestricted LogL	107.0851			
Unrestricted Test Equation:				
Dependent Variable: LEF				
Method: Least Squares				
Date: 12/25/21 Time: 23:50				
Sample: 1973 2017				
Included observations: 45				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LEF(-1)	0.210109	0.265334	0.791865	0.4339
LU	0.042522	0.072382	0.587461	0.5608
LGDP	-0.211180	0.494644	-0.426934	0.6721
LGDP(-1)	0.320494	0.300347	1.067078	0.2935
LGDP(-2)	0.293819	0.214398	1.370435	0.1795
LTO	0.022058	0.044978	0.490426	0.6270
LTO(-1)	-0.024789	0.034751	-0.713334	0.4805
LTO(-2)	0.027562	0.042200	0.653144	0.5181
C	-2.713295	0.944459	-2.872858	0.0070
@TREND	-0.006467	0.003757	-1.721294	0.0943
FITTED^2	-0.426205	0.388733	-1.096396	0.2806
R-squared	0.984694	Mean dependent var		-0.537288
Adjusted R-squared	0.980192	S.D. dependent var		0.183117
S.E. of regression	0.025772	Akaike info criterion		-4.270449
Sum squared resid	0.022583	Schwarz criterion		-3.828820
Log likelihood	107.0851	Hannan-Quinn criter.		-4.105814
F-statistic	218.7297	Durbin-Watson stat		1.851867
Prob(F-statistic)	0.000000			

ARDL Long Run Form and Bounds Test				
Dependent Variable: D(LEF)				
Selected Model: ARDL(1, 0, 2, 2)				
Case 5: Unrestricted Constant and Unrestricted Trend				
Date: 12/25/21 Time: 23:51				
Sample: 1971 2017				
Included observations: 45				
Conditional Error Correction Regression				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.298973	0.868057	-2.648411	0.0120
@TREND	-0.003953	0.002904	-1.324379	0.1940
LEF(-1)*	-0.530088	0.119727	-4.427491	0.0001
LU**	0.056297	0.070801	0.835748	0.4090
LGDP(-1)	0.310423	0.130984	2.369932	0.0234
LTO(-1)	0.083756	0.018986	4.411337	0.0001
D(LGDP)	-0.678505	0.254793	-2.665117	0.0119
D(LGDP(-1))	-0.485552	0.146820	-3.170912	0.0032
D(LTO)	0.065248	0.021770	2.997151	0.0050
D(LTO(-1))	-0.068245	0.023219	-2.862990	0.0072
* p-value incompatible with t-Bounds distribution.				
** Variable interpreted as $Z = Z(-1) + D(Z)$.				
Levels Equation				
Case 5: Unrestricted Constant and Unrestricted Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LU	0.111862	0.137319	0.814615	0.4208
LGDP	0.589605	0.153035	3.826624	0.0005
LTO	0.158003	0.046249	3.416330	0.0016
EC = LEF - (0.1118*LU + 0.5896*LGDP + 0.1580*LTO)				
F-Bounds Test				
Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	9.360728	10%	3.47	4.45
k	3	5%	4.01	5.07
		2.5%	4.52	5.62
		1%	5.17	6.36
Finite Sample: n=45				
Actual Sample Size	45	10%	3.74	4.78
		5%	4.45	5.56
		1%	6.053	7.458
t-Bounds Test				
Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-4.427491	10%	-3.13	-3.84
		5%	-3.41	-4.16
		2.5%	-3.65	-4.42
		1%	-3.96	-4.73

ARDL Error Correction Regression				
Dependent Variable: D(LEF)				
Selected Model: ARDL(1, 0, 2, 2)				
Case 5: Unrestricted Constant and Unrestricted Trend				
Date: 12/25/21 Time: 23:53				
Sample: 1971 2017				
Included observations: 45				
ECM Regression				
Case 5: Unrestricted Constant and Unrestricted Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.298973	0.357836	-6.424646	0.0000
@TREND	-0.003953	0.001137	-3.474871	0.0014
D(LGDP)	-0.676505	0.214176	-3.158636	0.0033
D(LGDP(-1))	-0.465552	0.136489	-3.410906	0.0016
D(LTO)	0.065248	0.019220	3.394850	0.0017
D(LTO(-1))	-0.066245	0.018742	-3.534621	0.0012
CointEq(-1)*	-0.530088	0.083006	-6.386125	0.0000
R-squared	0.678337	Mean dependent var	0.011424	
Adjusted R-squared	0.627548	S.D. dependent var	0.040645	
S.E. of regression	0.024805	Akaike info criterion	-4.413482	
Sum squared resid	0.023382	Schwarz criterion	-4.132445	
Log likelihood	106.3033	Hannan-Quinn criter.	-4.308714	
F-statistic	13.35802	Durbin-Watson stat	1.880423	
Prob(F-statistic)	0.000000			
* p-value incompatible with t-Bounds distribution.				
F-Bounds Test Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	9.390728	10%	3.47	4.45
k	3	5%	4.01	5.07
		2.5%	4.52	5.62
		1%	5.17	6.36
t-Bounds Test Null Hypothesis: No levels relationship				
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-6.386125	10%	-3.13	-3.84
		5%	-3.41	-4.16
		2.5%	-3.65	-4.42
		1%	-3.96	-4.73

VAR Granger Causality/Block Exogeneity Wald Tests			
Date: 12/25/21 Time: 23:57			
Sample: 1971 2017			
Included observations: 44			
Dependent variable: LEF			
Excluded	Chi-sq	df	Prob.
LU	0.061731	2	0.9696
LGDP	6.545127	2	0.0379
LTO	5.736331	2	0.0568
All	15.14433	6	0.0192
Dependent variable: LU			
Excluded	Chi-sq	df	Prob.
LEF	0.635082	2	0.7279
LGDP	13.96369	2	0.0009
LTO	11.26577	2	0.0036
All	35.43111	6	0.0000
Dependent variable: LGDP			
Excluded	Chi-sq	df	Prob.
LEF	6.534272	2	0.0381
LU	0.648960	2	0.7229
LTO	6.461512	2	0.0395
All	20.25216	6	0.0025
Dependent variable: LTO			
Excluded	Chi-sq	df	Prob.
LEF	2.195126	2	0.3337
LU	0.456893	2	0.7958
LGDP	4.974439	2	0.0831
All	10.83831	6	0.0935



Appendix-11-Secondary Data from WB and GFN

Year	EF	GDP	U	TO
1971	0.497989765	474.4632052	7.901	40.1917985
1972	0.512936923	401.4604965	8.221	46.00673475
1973	0.56634126	408.606343	8.553	25.04097861
1974	0.516671444	440.6035864	9.034	14.60842818
1975	0.542969794	414.6047996	9.836	14.20456236
1976	0.528217689	428.3799305	10.701	18.13269188
1977	0.512704137	428.9869654	11.63	12.21884152
1978	0.540003674	447.2395447	12.629	15.39276781
1979	0.518814315	456.1453802	13.701	16.49742076
1980	0.537434885	447.6949235	14.851	20.48254338
1981	0.503533486	467.5867082	15.801	9.883831347
1982	0.52000886	465.2500644	16.212	10.22442403
1983	0.502920593	470.9053141	16.631	9.756572902
1984	0.506584222	480.8311003	17.06	8.845923499
1985	0.526794884	484.0480192	17.496	9.195556419
1986	0.508143761	491.1358177	17.941	8.535083594
1987	0.502645208	496.4328768	18.395	8.603521368
1988	0.501859263	495.4038232	18.859	9.105251729
1989	0.509692958	496.7616469	19.33	10.03013476
1990	0.50258273	512.0965895	19.811	10.60270675
1991	0.487206151	517.763692	20.257	9.062802649
1992	0.497957668	533.8879689	20.61	8.679501324
1993	0.48287274	547.051417	20.966	10.71972197
1994	0.472767383	556.2988647	21.328	10.03770831
1995	0.496031578	572.4384537	21.693	13.54685617
1996	0.514803956	585.7169371	22.064	14.52327608
1997	0.524745964	599.2275335	22.438	14.83621401
1998	0.533675234	617.2923441	22.818	15.12310156
1999	0.584951113	633.1827346	23.202	14.77854081
2000	0.583126056	653.80864	23.59	15.68699765
2001	0.590903904	674.1669727	24.096	16.96271348
2002	0.591033089	687.3833075	24.756	15.83594584
2003	0.594077759	707.605094	25.429	15.80447076
2004	0.593720789	732.7488409	26.114	27.79281549
2005	0.617568198	769.1359804	26.809	36.49400142
2006	0.644620104	809.4736327	27.517	41.37716533

Year	EF	GDP	U	TO
2007	0.676540432	856.0459472	28.237	44.3711105
2008	0.681761222	897.1890238	28.968	42.50955875
2009	0.717796772	931.9865061	29.709	39.84874048
2010	0.760108197	972.9096877	30.462	38.04454637
2011	0.791364246	1024.021957	31.225	46.17975
2012	0.76621849	1078.287546	31.993	48.27436084
2013	0.792363905	1129.993548	32.762	46.32597466
2014	0.831719845	1184.863283	33.535	44.56336358
2015	0.883604665	1248.45331	34.308	42.08599631
2016	0.837087388	1322.694812	35.083	38.00795839
2017	0.857697199	1394.781379	35.858	36.41202272
EF	Ecological Footprint	Global Hecter per capita		
GDP	GDP per capita (constant 2015 US\$)	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2015 U.S. dollars.		
U	Urban population (% of total population)	Urban population refers to people living in urban areas as defined by national statistical offices. The data are collected and smoothed by United Nations Population Division.		
TO	Trade Openness	(Export + Import) as percentage of GDP		
	Exports of goods and services (constant 2015 US\$)	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in constant 2015 prices, expressed in U.S. dollars.		

Year	EF	GDP	U	TO
	Imports of goods and services (constant 2015 US\$)	Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. Data are in constant 2015 prices, expressed in U.S. dollars.		

Appendix-12-SPSS Outputs

□ Variables Entered/Removed^a

Model	Variables Entered	Variables Removed	Method
1	Electricity Bill		. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
2	Free Standing no Running Water		. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
3	Below Average Dummy		. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
4	Multistory Apartment		. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
5	Free Standing Running Water		. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
6	More trash dummy		. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
7	Mush more trash dummy		. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).

8	Average Income Dummy	. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
9	Rickshaw	. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
10	Old Newspapers dummy	. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
11	Same trash dummy	. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
12	Just me	. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).
13	Unwanted Metal Dummy	. Stepwise (Criteria: Probability-of-F- to-enter <= .050, Probability-of-F- to-remove >= .100).

a. Dependent Variable: EF

Model Summaryⁿ

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.375 ^a	.141	.139	2.28204	
2	.429 ^b	.184	.180	2.22675	
3	.487 ^c	.237	.232	2.15513	
4	.537 ^d	.288	.282	2.08361	

5	.573 ^e	.328	.321	2.02679	
6	.603 ^f	.364	.356	1.97316	
7	.635 ^g	.404	.395	1.91274	
8	.649 ^h	.422	.412	1.88554	
9	.655 ⁱ	.429	.419	1.87505	
10	.661 ^j	.438	.426	1.86339	
11	.667 ^k	.445	.432	1.85343	
12	.672 ^l	.451	.438	1.84434	
13	.675 ^m	.456	.441	1.83835	1.870

a. Predictors: (Constant), Electricity Bill

b. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water

c. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy

d. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment

e. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water

f. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy

g. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy

h. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy

i. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw

j. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy

k. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy

l. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy, Just me

m. Predictors: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more

trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy, Just me, Unwanted Metal Dummy

n. Dependent Variable: EF

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	425.375	1	425.375	81.682	<.001 ^b
	Residual	2593.441	497	5.208		
	Total	3018.816	498			
2	Regression	554.486	2	277.243	55.914	<.001 ^c
	Residual	2464.329	497	4.958		
	Total	3018.816	498			
3	Regression	715.096	3	238.365	51.321	<.001 ^d
	Residual	2303.720	496	4.645		
	Total	3018.816	498			
4	Regression	869.815	4	217.454	50.088	<.001 ^e
	Residual	2149.001	495	4.341		
	Total	3018.816	498			
5	Regression	989.521	5	197.904	48.177	<.001 ^f
	Residual	2029.295	494	4.108		
	Total	3018.816	498			
6	Regression	1099.392	6	183.232	47.063	<.001 ^g
	Residual	1919.424	493	3.893		
	Total	3018.816	498			
7	Regression	1218.793	7	174.113	47.590	<.001 ^h
	Residual	1800.023	492	3.659		
	Total	3018.816	498			
8	Regression	1273.182	8	159.148	44.764	<.001 ⁱ
	Residual	1745.634	491	3.555		
	Total	3018.816	498			
9	Regression	1296.068	9	144.008	40.960	<.001 ^j
	Residual	1722.748	490	3.516		
	Total	3018.816	498			
10	Regression	1320.904	10	132.090	38.042	<.001 ^k

	Residual	1697.912	489	3.472		
	Total	3018.816	498			
11	Regression	1342.437	11	122.040	35.526	<.001 ^l
	Residual	1676.379	488	3.435		
	Total	3018.816	498			
12	Regression	1362.234	12	113.520	33.372	<.001 ^m
	Residual	1656.581	487	3.402		
	Total	3018.816	498			
13	Regression	1376.361	13	105.874	31.328	<.001 ⁿ
	Residual	1642.454	486	3.380		
	Total	3018.816	498			

a. Dependent Variable: EF

b. Predictors: (Constant), Electricity Bill

c. Predictors: (Constant), Electricity Bill, Free Standing no Running Water

d. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy

e. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment

f. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water

g. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy

h. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy, Mush more trash dummy

i. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy

j. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw

k. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy

l. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy

m. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy, Just me

n. Predictors: (Constant), Electricity Bill, Free Standing no Running Water, Below Average Dummy, Multistory Apartment, Free Standing Running Water, More trash dummy, Mush more trash dummy,

Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy, Just me, Unwanted Metal Dummy

		Coefficients ^a								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	5.746	.139		41.443	<.001	5.474	6.019		
	Electricity Bill	.001	.000	.375	9.038	<.001	.000	.001	1.000	1.000
2	(Constant)	5.994	.144		41.701	<.001	5.712	6.276		
	Electricity Bill	.001	.000	.358	8.811	<.001	.000	.001	.993	1.007
	Free Standing no Running Water	-1.452	.285	-.208	-5.103	<.001	-2.011	-.893	.993	1.007
3	(Constant)	6.545	.168		39.025	<.001	6.215	6.874		
	Electricity Bill	.000	.000	.296	7.270	<.001	.000	.001	.927	1.079
	Free Standing no Running Water	-1.660	.278	-.237	-5.976	<.001	-2.205	-1.114	.977	1.023
	Below Average Dummy	-1.295	.220	-.240	-5.880	<.001	-1.727	-.862	.923	1.083
4	(Constant)	6.985	.178		39.213	<.001	6.635	7.335		
	Electricity Bill	.000	.000	.255	6.387	<.001	.000	.001	.899	1.112
	Free Standing no Running Water	-2.021	.275	-.289	-7.343	<.001	-2.562	-1.480	.930	1.075
	Below Average Dummy	-1.333	.213	-.247	-6.261	<.001	-1.752	-.915	.922	1.084
	Multistory Apartment	-1.453	.243	-.235	-5.970	<.001	-1.931	-.974	.931	1.074
5	(Constant)	7.931	.246		32.181	<.001	7.447	8.415		
	Electricity Bill	.000	.000	.196	4.850	<.001	.000	.000	.833	1.201
	Free Standing no Running Water	-2.919	.315	-.417	-9.261	<.001	-3.538	-2.300	.671	1.491
	Below Average Dummy	-1.018	.215	-.189	-4.729	<.001	-1.441	-.595	.854	1.170
	Multistory Apartment	-2.411	.296	-.390	-8.149	<.001	-2.993	-1.830	.595	1.680
	Free Standing Running Water	-1.385	.257	-.279	-5.398	<.001	-1.890	-.881	.511	1.958
6	(Constant)	7.758	.242		32.037	<.001	7.282	8.233		
	Electricity Bill	.000	.000	.168	4.226	<.001	.000	.000	.818	1.223
	Free Standing no Running Water	-2.929	.307	-.419	-9.547	<.001	-3.532	-2.327	.671	1.491
	Below Average Dummy	-1.009	.210	-.187	-4.816	<.001	-1.421	-.597	.854	1.171
	Multistory Apartment	-2.368	.288	-.383	-8.218	<.001	-2.935	-1.802	.595	1.681

	Free Standing Running Water	-1.401	.250	-.282	-5.605	<.001	-1.891	-.910	.511	1.958
	More trash dummy	1.196	.225	.193	5.312	<.001	.754	1.638	.975	1.025
7	(Constant)	7.603	.236		32.179	<.001	7.139	8.068		
	Electricity Bill	.000	.000	.134	3.430	<.001	.000	.000	.799	1.252
	Free Standing no Running Water	-2.836	.298	-.405	-9.518	<.001	-3.421	-2.250	.669	1.495
	Below Average Dummy	-1.030	.203	-.191	-5.069	<.001	-1.429	-.631	.854	1.171
	Multistory Apartment	-2.247	.280	-.363	-8.019	<.001	-2.797	-1.696	.591	1.691
	Free Standing Running Water	-1.339	.242	-.269	-5.523	<.001	-1.815	-.863	.510	1.962
	More trash dummy	1.401	.221	.226	6.335	<.001	.966	1.835	.949	1.053
	Mush more trash dummy	2.029	.355	.205	5.713	<.001	1.331	2.726	.941	1.062
8	(Constant)	7.905	.245		32.222	<.001	7.423	8.387		
	Electricity Bill	.000	.000	.099	2.501	.013	.000	.000	.757	1.320
	Free Standing no Running Water	-2.655	.297	-.379	-8.929	<.001	-3.239	-2.071	.653	1.532
	Below Average Dummy	-1.488	.232	-.276	-6.414	<.001	-1.944	-1.032	.636	1.572
	Multistory Apartment	-2.141	.278	-.346	-7.716	<.001	-2.687	-1.596	.586	1.707
	Free Standing Running Water	-1.101	.247	-.221	-4.463	<.001	-1.586	-.616	.479	2.089
	More trash dummy	1.444	.218	.233	6.615	<.001	1.015	1.873	.947	1.056
	Mush more trash dummy	2.087	.350	.211	5.958	<.001	1.399	2.776	.940	1.064
	Average Income Dummy	-.864	.221	-.159	-3.911	<.001	-1.298	-.430	.713	1.402
9	(Constant)	8.095	.255		31.727	<.001	7.594	8.597		
	Electricity Bill	.000	.000	.086	2.183	.030	.000	.000	.746	1.340
	Free Standing no Running Water	-2.560	.298	-.366	-8.590	<.001	-3.145	-1.974	.642	1.557
	Below Average Dummy	-1.456	.231	-.270	-6.298	<.001	-1.910	-1.002	.634	1.577
	Multistory Apartment	-2.007	.281	-.324	-7.145	<.001	-2.559	-1.455	.565	1.769
	Free Standing Running Water	-.983	.250	-.198	-3.941	<.001	-1.474	-.493	.462	2.163
	More trash dummy	1.472	.217	.238	6.774	<.001	1.045	1.899	.945	1.059
	Mush more trash dummy	2.105	.349	.213	6.041	<.001	1.420	2.790	.939	1.065
	Average Income Dummy	-.919	.221	-.169	-4.163	<.001	-1.353	-.485	.707	1.415
	Rickshaw	-.457	.179	-.092	-2.551	.011	-.809	-.105	.887	1.128
10	(Constant)	8.140	.254		32.033	<.001	7.641	8.640		
	Electricity Bill	.000	.000	.109	2.719	.007	.000	.000	.712	1.405
	Free Standing no Running Water	-2.602	.297	-.372	-8.774	<.001	-3.185	-2.019	.641	1.561

	Below Average Dummy	-1.458	.230	-.270	-6.348	<.001	-1.909	-1.007	.634	1.577
	Multistory Apartment	-2.000	.279	-.323	-7.163	<.001	-2.548	-1.451	.565	1.769
	Free Standing Running Water	-1.016	.248	-.204	-4.091	<.001	-1.504	-.528	.461	2.168
	More trash dummy	1.493	.216	.241	6.907	<.001	1.068	1.917	.943	1.060
	Mush more trash dummy	2.092	.346	.211	6.039	<.001	1.411	2.772	.939	1.065
	Average Income Dummy	-.930	.219	-.171	-4.239	<.001	-1.361	-.499	.706	1.416
	Rickshaw	-.486	.178	-.098	-2.725	.007	-.837	-.136	.883	1.132
	Old Newspapers dummy	-.940	.352	-.095	-2.674	.008	-1.631	-.250	.911	1.098
11	(Constant)	7.818	.284		27.564	<.001	7.261	8.376		
	Electricity Bill	.000	.000	.108	2.712	.007	.000	.000	.712	1.405
	Free Standing no Running Water	-2.623	.295	-.375	-8.889	<.001	-3.203	-2.043	.640	1.562
	Below Average Dummy	-1.326	.234	-.246	-5.657	<.001	-1.787	-.866	.602	1.661
	Multistory Apartment	-1.955	.278	-.316	-7.026	<.001	-2.502	-1.408	.563	1.776
	Free Standing Running Water	-.994	.247	-.200	-4.021	<.001	-1.479	-.508	.461	2.171
	More trash dummy	1.759	.240	.284	7.334	<.001	1.288	2.230	.758	1.319
	Mush more trash dummy	2.363	.361	.239	6.543	<.001	1.653	3.073	.854	1.170
	Average Income Dummy	-.847	.221	-.156	-3.839	<.001	-1.281	-.414	.691	1.448
	Rickshaw	-.512	.178	-.104	-2.879	.004	-.861	-.163	.880	1.136
	Old Newspapers dummy	-.928	.350	-.094	-2.652	.008	-1.615	-.241	.911	1.098
	Same trash dummy	.505	.202	.100	2.504	.013	.109	.901	.720	1.390
12	(Constant)	7.784	.283		27.543	<.001	7.228	8.339		
	Electricity Bill	.000	.000	.111	2.789	.005	.000	.000	.711	1.406
	Free Standing no Running Water	-2.578	.294	-.368	-8.761	<.001	-3.156	-2.000	.638	1.569
	Below Average Dummy	-1.355	.234	-.251	-5.801	<.001	-1.814	-.896	.601	1.665
	Multistory Apartment	-1.910	.278	-.308	-6.880	<.001	-2.455	-1.364	.560	1.784
	Free Standing Running Water	-.959	.246	-.193	-3.895	<.001	-1.443	-.475	.459	2.178
	More trash dummy	1.773	.239	.286	7.428	<.001	1.304	2.242	.758	1.320
	Mush more trash dummy	2.380	.359	.240	6.620	<.001	1.674	3.086	.854	1.171
	Average Income Dummy	-.876	.220	-.161	-3.981	<.001	-1.308	-.443	.689	1.452
	Rickshaw	-.511	.177	-.103	-2.892	.004	-.859	-.164	.880	1.136
	Old Newspapers dummy	-.921	.348	-.093	-2.647	.008	-1.605	-.237	.911	1.098

	Same trash dummy	.500	.201	.099	2.490	.013	.105	.894	.720	1.390
	Just me	3.169	1.314	.081	2.412	.016	.588	5.751	.989	1.011
13	(Constant)	7.795	.282		27.667	<.001	7.241	8.349		
	Electricity Bill	.000	.000	.109	2.748	.006	.000	.000	.711	1.407
	Free Standing no Running Water	-2.547	.294	-.364	-8.674	<.001	-3.124	-1.970	.636	1.573
	Below Average Dummy	-1.324	.233	-.245	-5.673	<.001	-1.782	-.865	.598	1.672
	Multistory Apartment	-1.902	.277	-.307	-6.874	<.001	-2.445	-1.358	.560	1.785
	Free Standing Running Water	-.931	.246	-.187	-3.785	<.001	-1.414	-.448	.458	2.185
	More trash dummy	1.780	.238	.288	7.482	<.001	1.313	2.248	.758	1.320
	Mush more trash dummy	2.451	.360	.248	6.809	<.001	1.744	3.159	.846	1.182
	Average Income Dummy	-.857	.219	-.158	-3.903	<.001	-1.288	-.425	.687	1.455
	Rickshaw	-.510	.176	-.103	-2.893	.004	-.856	-.164	.880	1.136
	Old Newspapers dummy	-.944	.347	-.095	-2.719	.007	-1.626	-.262	.910	1.099
	Same trash dummy	.479	.200	.094	2.390	.017	.085	.873	.718	1.393
	Just me	3.130	1.310	.080	2.390	.017	.557	5.703	.989	1.011
	Unwanted Metal Dummy	-.836	.409	-.070	-2.045	.041	-1.640	-.033	.961	1.041

a. Dependent Variable: EF

Excluded Variables^a

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics		
						Tolerance	VIF	Minimum Tolerance
1	Male	.104 ^b	2.514	.012	.112	.999	1.001	.999
	Below Average Dummy	-.209 ^b	-4.992	<.001	-.219	.938	1.066	.938
	Average Income Dummy	-.044 ^b	-1.050	.294	-.047	.978	1.022	.978
	Rickshaw	-.152 ^b	-3.615	<.001	-.160	.957	1.045	.957
	Auto Rickshaw (CNG)	.020 ^b	.476	.634	.021	.973	1.028	.973
	Rented Car	.164 ^b	3.730	<.001	.165	.870	1.150	.870
	Primary Dummy	.037 ^b	.888	.375	.040	1.000	1.000	1.000
	High School Dummy	.032 ^b	.777	.438	.035	.986	1.014	.986
	College Dummy	.101 ^b	2.434	.015	.109	.997	1.003	.997
	Graduate dummy	.080 ^b	1.921	.055	.086	1.000	1.000	1.000
	Post Graduate Dummy	-.072 ^b	-1.744	.082	-.078	1.000	1.000	1.000
	House construction dummy	.121 ^b	2.857	.004	.127	.947	1.056	.947
	Bottle Dummy	.045 ^b	1.076	.282	.048	.969	1.032	.969
	Old Newspapers dummy	-.066 ^b	-1.530	.127	-.068	.924	1.082	.924

	Old used unwanted cloths dummy	.022 ^b	.532	.595	.024	.991	1.009	.991
	Unwanted Metal Dummy	-.078 ^b	-1.878	.061	-.084	.996	1.004	.996
	Less Trash Dummy	-.192 ^b	-4.678	<.001	-.205	.980	1.020	.980
	Same trash dummy	-.010 ^b	-.244	.808	-.011	1.000	1.000	1.000
	More trash dummy	.199 ^b	4.842	<.001	.212	.977	1.023	.977
	Mush more trash dummy	.192 ^b	4.661	<.001	.205	.972	1.028	.972
	Just me	.087 ^b	2.103	.036	.094	.999	1.001	.999
	2-3	-.025 ^b	-.597	.551	-.027	.977	1.024	.977
	4-6	-.018 ^b	-.437	.663	-.020	.975	1.026	.975
	7-9	.062 ^b	1.471	.142	.066	.964	1.037	.964
	Free Standing no Running Water	-.208 ^b	-5.103	<.001	-.223	.993	1.007	.993
	Free Standing Running Water	.004 ^b	.105	.916	.005	.979	1.021	.979
	Multistory Apartment	-.171 ^b	-4.133	<.001	-.182	.978	1.023	.978
	Duplex row house with 2-4	.183 ^b	4.487	<.001	.197	1.000	1.000	1.000
	Cost of cooking	.095 ^b	2.221	.027	.099	.932	1.072	.932
2	Male	.126 ^c	3.115	.002	.139	.989	1.011	.983
	Below Average Dummy	-.240 ^c	-5.880	<.001	-.255	.923	1.083	.923
	Average Income Dummy	-.024 ^c	-.592	.554	-.027	.969	1.032	.969
	Rickshaw	-.155 ^c	-3.794	<.001	-.168	.957	1.045	.950
	Auto Rickshaw (CNG)	.019 ^c	.460	.646	.021	.973	1.028	.966
	Rented Car	.178 ^c	4.147	<.001	.183	.867	1.154	.862
	Primary Dummy	.035 ^c	.852	.394	.038	1.000	1.000	.993
	High School Dummy	.036 ^c	.875	.382	.039	.986	1.015	.979
	College Dummy	.100 ^c	2.474	.014	.110	.997	1.003	.990
	Graduate dummy	.073 ^c	1.794	.073	.080	.998	1.002	.992
	Post Graduate Dummy	-.068 ^c	-1.689	.092	-.076	1.000	1.000	.993
	House construction dummy	.099 ^c	2.362	.019	.105	.935	1.069	.935
	Bottle Dummy	.095 ^c	2.265	.024	.101	.924	1.082	.924
	Old Newspapers dummy	-.075 ^c	-1.787	.075	-.080	.922	1.084	.920
	Old used unwanted cloths dummy	.018 ^c	.454	.650	.020	.991	1.009	.984
	Unwanted Metal Dummy	-.074 ^c	-1.834	.067	-.082	.996	1.005	.989
	Less Trash Dummy	-.209 ^c	-5.220	<.001	-.228	.975	1.026	.972
	Same trash dummy	.007 ^c	.160	.873	.007	.993	1.007	.987
	More trash dummy	.201 ^c	5.029	<.001	.220	.977	1.023	.971
	Mush more trash dummy	.187 ^c	4.637	<.001	.204	.972	1.029	.967
	Just me	.081 ^c	2.007	.045	.090	.998	1.002	.992

	2-3	-.041 ^c	-.995	.320	-.045	.971	1.030	.968
	4-6	-.013 ^c	-.327	.744	-.015	.974	1.027	.969
	7-9	.055 ^c	1.323	.186	.059	.963	1.038	.959
	Free Standing Running Water	-.084 ^c	-1.914	.056	-.086	.846	1.182	.846
	Multistory Apartment	-.227 ^c	-5.572	<.001	-.243	.932	1.073	.932
	Duplex row house with 2-4	.157 ^c	3.901	<.001	.173	.981	1.019	.974
	Cost of cooking	.108 ^c	2.585	.010	.115	.929	1.076	.924
3	Male	.113 ^d	2.881	.004	.128	.986	1.015	.920
	Average Income Dummy	-.167 ^d	-3.770	<.001	-.167	.766	1.306	.729
	Rickshaw	-.120 ^d	-2.963	.003	-.132	.931	1.074	.898
	Auto Rickshaw (CNG)	.018 ^d	.451	.652	.020	.973	1.028	.903
	Rented Car	.136 ^d	3.191	.002	.142	.836	1.196	.833
	Primary Dummy	.033 ^d	.842	.400	.038	1.000	1.000	.923
	High School Dummy	.017 ^d	.423	.672	.019	.979	1.021	.917
	College Dummy	.066 ^d	1.658	.098	.074	.973	1.027	.901
	Graduate dummy	.054 ^d	1.377	.169	.062	.992	1.008	.917
	Post Graduate Dummy	-.082 ^d	-2.082	.038	-.093	.996	1.004	.920
	House construction dummy	.024 ^d	.568	.570	.026	.838	1.193	.828
	Bottle Dummy	.040 ^d	.964	.335	.043	.872	1.146	.871
	Old Newspapers dummy	-.080 ^d	-1.973	.049	-.088	.922	1.085	.865
	Old used unwanted cloths dummy	.053 ^d	1.328	.185	.060	.970	1.030	.904
	Unwanted Metal Dummy	-.055 ^d	-1.387	.166	-.062	.988	1.012	.916
	Less Trash Dummy	-.185 ^d	-4.735	<.001	-.208	.963	1.038	.912
	Same trash dummy	-.033 ^d	-.830	.407	-.037	.965	1.036	.897
	More trash dummy	.200 ^d	5.183	<.001	.227	.977	1.023	.907
	Mush more trash dummy	.189 ^d	4.851	<.001	.213	.972	1.029	.903
	Just me	.085 ^d	2.175	.030	.097	.998	1.002	.923
	2-3	-.020 ^d	-.509	.611	-.023	.963	1.038	.910
	4-6	-.020 ^d	-.497	.619	-.022	.973	1.027	.903
	7-9	.045 ^d	1.114	.266	.050	.961	1.040	.900
	Free Standing Running Water	-.026 ^d	-.596	.551	-.027	.798	1.253	.798
	Multistory Apartment	-.235 ^d	-5.970	<.001	-.259	.931	1.074	.899
	Duplex row house with 2-4	.128 ^d	3.221	.001	.143	.962	1.039	.905
	Cost of cooking	.064 ^d	1.555	.121	.070	.895	1.117	.884
4	Male	.085 ^e	2.212	.027	.099	.969	1.032	.896
	Average Income Dummy	-.186 ^e	-4.359	<.001	-.192	.762	1.313	.727

	Rickshaw	-.098 ^e	-2.493	.013	-.111	.922	1.084	.881
	Auto Rickshaw (CNG)	.012 ^e	.307	.759	.014	.972	1.029	.876
	Rented Car	.116 ^e	2.816	.005	.126	.830	1.204	.817
	Primary Dummy	.028 ^e	.736	.462	.033	.999	1.001	.899
	High School Dummy	.029 ^e	.750	.453	.034	.976	1.024	.890
	College Dummy	.063 ^e	1.644	.101	.074	.973	1.028	.899
	Graduate dummy	.050 ^e	1.307	.192	.059	.991	1.009	.899
	Post Graduate Dummy	-.067 ^e	-1.760	.079	-.079	.992	1.008	.899
	House construction dummy	.110 ^e	2.539	.011	.114	.761	1.315	.761
	Bottle Dummy	.066 ^e	1.625	.105	.073	.863	1.159	.863
	Old Newspapers dummy	-.070 ^e	-1.767	.078	-.079	.920	1.087	.838
	Old used unwanted cloths dummy	.043 ^e	1.115	.265	.050	.969	1.032	.896
	Unwanted Metal Dummy	-.063 ^e	-1.657	.098	-.074	.987	1.014	.898
	Less Trash Dummy	-.161 ^e	-4.221	<.001	-.187	.951	1.052	.891
	Same trash dummy	-.033 ^e	-.853	.394	-.038	.965	1.036	.897
	More trash dummy	.191 ^e	5.095	<.001	.223	.975	1.025	.883
	Mush more trash dummy	.177 ^e	4.689	<.001	.206	.969	1.032	.879
	Just me	.075 ^e	1.987	.047	.089	.996	1.004	.898
	2-3	.007 ^e	.171	.864	.008	.950	1.052	.888
	4-6	-.039 ^e	-1.003	.316	-.045	.967	1.034	.873
	7-9	.047 ^e	1.214	.225	.055	.961	1.040	.874
	Free Standing Running Water	-.279 ^e	-5.398	<.001	-.236	.511	1.958	.511
	Duplex row house with 2-4	.083 ^e	2.096	.037	.094	.919	1.088	.889
	Cost of cooking	.030 ^e	.744	.457	.033	.876	1.142	.867
5	Male	.080 ^f	2.147	.032	.096	.969	1.033	.510
	Average Income Dummy	-.138 ^f	-3.204	.001	-.143	.716	1.397	.480
	Rickshaw	-.065 ^f	-1.683	.093	-.076	.897	1.115	.497
	Auto Rickshaw (CNG)	.031 ^f	.823	.411	.037	.963	1.038	.506
	Rented Car	.063 ^f	1.499	.134	.067	.772	1.295	.475
	Primary Dummy	.027 ^f	.739	.460	.033	.999	1.001	.511
	High School Dummy	.020 ^f	.537	.591	.024	.975	1.026	.510
	College Dummy	.042 ^f	1.128	.260	.051	.963	1.039	.505
	Graduate dummy	.056 ^f	1.510	.132	.068	.991	1.010	.510
	Post Graduate Dummy	-.061 ^f	-1.645	.101	-.074	.991	1.009	.510
	House construction dummy	.053 ^f	1.218	.224	.055	.708	1.413	.475
	Bottle Dummy	.051 ^f	1.278	.202	.057	.858	1.165	.508
	Old Newspapers dummy	-.084 ^f	-2.177	.030	-.098	.916	1.092	.509

	Old used unwanted cloths dummy	.052 ^f	1.388	.166	.062	.967	1.034	.510
	Unwanted Metal Dummy	-.049 ^f	-1.319	.188	-.059	.982	1.019	.508
	Less Trash Dummy	-.153 ^f	-4.114	<.001	-.182	.949	1.053	.510
	Same trash dummy	-.043 ^f	-1.143	.254	-.051	.963	1.038	.509
	More trash dummy	.193 ^f	5.312	<.001	.233	.975	1.025	.511
	Mush more trash dummy	.168 ^f	4.569	<.001	.202	.967	1.034	.510
	Just me	.066 ^f	1.791	.074	.080	.994	1.007	.510
	2-3	-.001 ^f	-.031	.975	-.001	.949	1.054	.510
	4-6	-.030 ^f	-.798	.425	-.036	.965	1.036	.510
	7-9	.052 ^f	1.382	.168	.062	.961	1.041	.510
	Duplex row house with 2-4	-.071 ^f	-1.454	.147	-.065	.576	1.735	.320
	Cost of cooking	.044 ^f	1.112	.267	.050	.872	1.146	.509
6	Male	.062 ^g	1.705	.089	.077	.960	1.042	.510
	Average Income Dummy	-.149 ^g	-3.537	<.001	-.157	.715	1.399	.480
	Rickshaw	-.074 ^g	-1.968	.050	-.088	.895	1.117	.497
	Auto Rickshaw (CNG)	.034 ^g	.921	.357	.042	.963	1.038	.506
	Rented Car	.072 ^g	1.763	.079	.079	.771	1.297	.475
	Primary Dummy	.013 ^g	.366	.714	.017	.994	1.007	.511
	High School Dummy	.033 ^g	.908	.364	.041	.970	1.031	.510
	College Dummy	.053 ^g	1.446	.149	.065	.960	1.042	.505
	Graduate dummy	.054 ^g	1.510	.132	.068	.990	1.010	.510
	Post Graduate Dummy	-.049 ^g	-1.371	.171	-.062	.988	1.013	.510
	House construction dummy	.031 ^g	.726	.468	.033	.701	1.427	.475
	Bottle Dummy	.062 ^g	1.591	.112	.072	.856	1.168	.508
	Old Newspapers dummy	-.091 ^g	-2.427	.016	-.109	.915	1.093	.508
	Old used unwanted cloths dummy	.044 ^g	1.196	.232	.054	.965	1.036	.510
	Unwanted Metal Dummy	-.054 ^g	-1.489	.137	-.067	.981	1.019	.508
	Less Trash Dummy	-.104 ^g	-2.706	.007	-.121	.864	1.158	.510
	Same trash dummy	.040 ^g	.997	.319	.045	.814	1.229	.509
	Mush more trash dummy	.205 ^g	5.713	<.001	.249	.941	1.062	.510
	Just me	.071 ^g	1.988	.047	.089	.993	1.007	.510
	2-3	.020 ^g	.534	.593	.024	.938	1.066	.510
	4-6	-.010 ^g	-.268	.789	-.012	.955	1.047	.510
	7-9	.011 ^g	.294	.769	.013	.917	1.090	.510
	Duplex row house with 2-4	-.095 ^g	-2.005	.045	-.090	.571	1.750	.319
	Cost of cooking	.055 ^g	1.443	.150	.065	.870	1.150	.509
7	Male	.050 ^h	1.414	.158	.064	.956	1.046	.509

	Average Income Dummy	-.159 ^h	-3.911	<.001	-.174	.713	1.402	.479
	Rickshaw	-.078 ^h	-2.121	.034	-.095	.895	1.117	.496
	Auto Rickshaw (CNG)	.016 ^h	.439	.661	.020	.956	1.047	.505
	Rented Car	.091 ^h	2.289	.023	.103	.766	1.306	.473
	Primary Dummy	.001 ^h	.035	.972	.002	.990	1.010	.510
	High School Dummy	.041 ^h	1.164	.245	.052	.969	1.032	.509
	College Dummy	.065 ^h	1.819	.069	.082	.957	1.045	.504
	Graduate dummy	.067 ^h	1.922	.055	.086	.987	1.014	.509
	Post Graduate Dummy	-.037 ^h	-1.041	.298	-.047	.983	1.017	.509
	House construction dummy	.049 ^h	1.166	.244	.053	.697	1.434	.473
	Bottle Dummy	.080 ^h	2.124	.034	.095	.850	1.176	.507
	Old Newspapers dummy	-.087 ^h	-2.410	.016	-.108	.915	1.093	.507
	Old used unwanted cloths dummy	.049 ^h	1.387	.166	.062	.964	1.037	.509
	Unwanted Metal Dummy	-.079 ^h	-2.247	.025	-.101	.967	1.034	.507
	Less Trash Dummy	-.062 ^h	-1.618	.106	-.073	.826	1.211	.509
	Same trash dummy	.117 ^h	2.905	.004	.130	.740	1.351	.508
	Just me	.076 ^h	2.175	.030	.098	.992	1.008	.509
	2-3	.038 ^h	1.048	.295	.047	.931	1.074	.509
	4-6	-.001 ^h	-.020	.984	-.001	.953	1.050	.509
	7-9	.008 ^h	.216	.829	.010	.917	1.091	.509
	Duplex row house with 2-4	-.112 ^h	-2.433	.015	-.109	.569	1.757	.319
	Cost of cooking	.052 ^h	1.404	.161	.063	.869	1.150	.507
8	Male	.056 ⁱ	1.604	.109	.072	.955	1.048	.478
	Rickshaw	-.092 ⁱ	-2.551	.011	-.114	.887	1.128	.462
	Auto Rickshaw (CNG)	.062 ⁱ	1.691	.092	.076	.871	1.148	.478
	Rented Car	.066 ⁱ	1.662	.097	.075	.743	1.346	.454
	Primary Dummy	.012 ⁱ	.337	.736	.015	.984	1.016	.478
	High School Dummy	.039 ⁱ	1.118	.264	.050	.968	1.033	.478
	College Dummy	.055 ⁱ	1.562	.119	.070	.952	1.051	.475
	Graduate dummy	.050 ⁱ	1.437	.151	.065	.969	1.032	.477
	Post Graduate Dummy	-.053 ⁱ	-1.534	.126	-.069	.969	1.032	.477
	House construction dummy	.027 ⁱ	.653	.514	.029	.684	1.462	.453
	Bottle Dummy	.037 ⁱ	.949	.343	.043	.764	1.309	.479
	Old Newspapers dummy	-.089 ⁱ	-2.497	.013	-.112	.915	1.093	.477
	Old used unwanted cloths dummy	.053 ⁱ	1.528	.127	.069	.963	1.038	.478
	Unwanted Metal Dummy	-.073 ⁱ	-2.083	.038	-.094	.964	1.037	.477
	Less Trash Dummy	-.048 ⁱ	-1.258	.209	-.057	.818	1.223	.479
	Same trash dummy	.095 ⁱ	2.357	.019	.106	.722	1.385	.478

	Just me	.083 ⁱ	2.418	.016	.109	.990	1.011	.477
	2-3	.041 ⁱ	1.159	.247	.052	.931	1.074	.478
	4-6	.002 ⁱ	.055	.956	.002	.952	1.050	.478
	7-9	.007 ⁱ	.186	.853	.008	.917	1.091	.478
	Duplex row house with 2-4	-.072 ⁱ	-1.541	.124	-.069	.535	1.871	.282
	Cost of cooking	.049 ^j	1.337	.182	.060	.869	1.151	.476
9	Male	.050 ^j	1.415	.158	.064	.949	1.054	.462
	Auto Rickshaw (CNG)	-.003 ^j	-.067	.946	-.003	.463	2.160	.444
	Rented Car	.019 ^j	.419	.676	.019	.548	1.826	.452
	Primary Dummy	.005 ^j	.135	.893	.006	.978	1.023	.462
	High School Dummy	.048 ^j	1.387	.166	.063	.959	1.043	.461
	College Dummy	.054 ^j	1.558	.120	.070	.952	1.051	.459
	Graduate dummy	.049 ^j	1.412	.159	.064	.969	1.032	.461
	Post Graduate Dummy	-.061 ^j	-1.769	.077	-.080	.962	1.039	.460
	House construction dummy	.039 ^j	.939	.348	.042	.676	1.479	.434
	Bottle Dummy	.058 ^j	1.462	.145	.066	.737	1.357	.462
	Old Newspapers dummy	-.095 ^j	-2.674	.008	-.120	.911	1.098	.461
	Old used unwanted cloths dummy	.049 ^j	1.413	.158	.064	.961	1.041	.461
	Unwanted Metal Dummy	-.072 ^j	-2.088	.037	-.094	.964	1.037	.461
	Less Trash Dummy	-.050 ^j	-1.317	.188	-.059	.817	1.223	.462
	Same trash dummy	.101 ^j	2.527	.012	.114	.720	1.389	.462
	Just me	.083 ^j	2.433	.015	.109	.990	1.011	.461
	2-3	.032 ^j	.909	.364	.041	.921	1.086	.462
	4-6	.007 ^j	.190	.850	.009	.950	1.053	.462
	7-9	.013 ^j	.351	.726	.016	.913	1.095	.462
	Duplex row house with 2-4	-.057 ^j	-1.210	.227	-.055	.525	1.907	.267
	Cost of cooking	.061 ^j	1.665	.097	.075	.856	1.168	.461
10	Male	.053 ^k	1.530	.127	.069	.947	1.056	.461
	Auto Rickshaw (CNG)	-.003 ^k	-.069	.945	-.003	.463	2.160	.443
	Rented Car	.007 ^k	.157	.875	.007	.542	1.844	.450
	Primary Dummy	.000 ^k	.004	.997	.000	.975	1.025	.461
	High School Dummy	.041 ^k	1.176	.240	.053	.952	1.050	.459
	College Dummy	.061 ^k	1.753	.080	.079	.947	1.056	.458
	Graduate dummy	.062 ^k	1.793	.074	.081	.952	1.051	.459
	Post Graduate Dummy	-.060 ^k	-1.752	.080	-.079	.962	1.039	.459
	House construction dummy	.030 ^k	.731	.465	.033	.672	1.489	.432
	Bottle Dummy	.022 ^k	.516	.606	.023	.636	1.572	.460
	Old used unwanted cloths dummy	.045 ^k	1.286	.199	.058	.959	1.043	.460

	Unwanted Metal Dummy	-.075 ^k	-2.185	.029	-.098	.963	1.038	.460
	Less Trash Dummy	-.046 ^k	-1.225	.221	-.055	.816	1.225	.461
	Same trash dummy	.100 ^k	2.504	.013	.113	.720	1.390	.461
	Just me	.082 ^k	2.427	.016	.109	.990	1.011	.460
	2-3	.041 ^k	1.154	.249	.052	.914	1.094	.461
	4-6	-.001 ^k	-.035	.972	-.002	.943	1.060	.461
	7-9	.011 ^k	.297	.767	.013	.913	1.096	.461
	Duplex row house with 2-4	-.040 ^k	-.842	.400	-.038	.514	1.947	.266
	Cost of cooking	.053 ^k	1.446	.149	.065	.850	1.177	.460
11	Male	.047 ^l	1.367	.172	.062	.943	1.061	.461
	Auto Rickshaw (CNG)	-.001 ^l	-.015	.988	-.001	.463	2.161	.442
	Rented Car	.006 ^l	.120	.905	.005	.542	1.845	.449
	Primary Dummy	.003 ^l	.084	.933	.004	.974	1.026	.461
	High School Dummy	.038 ^l	1.090	.276	.049	.951	1.052	.459
	College Dummy	.057 ^l	1.645	.101	.074	.945	1.058	.458
	Graduate dummy	.063 ^l	1.839	.067	.083	.952	1.051	.458
	Post Graduate Dummy	-.059 ^l	-1.715	.087	-.077	.962	1.040	.458
	House construction dummy	.021 ^l	.501	.616	.023	.666	1.502	.432
	Bottle Dummy	.009 ^l	.223	.824	.010	.627	1.595	.460
	Old used unwanted cloths dummy	.042 ^l	1.231	.219	.056	.958	1.044	.460
	Unwanted Metal Dummy	-.071 ^l	-2.070	.039	-.093	.961	1.041	.459
	Less Trash Dummy	.090 ^l	1.403	.161	.063	.273	3.660	.241
	Just me	.081 ^l	2.412	.016	.109	.989	1.011	.459
	2-3	.061 ^l	1.706	.089	.077	.876	1.141	.460
	4-6	-.012 ^l	-.354	.723	-.016	.928	1.078	.460
	7-9	.004 ^l	.104	.918	.005	.907	1.102	.461
	Duplex row house with 2-4	-.042 ^l	-.890	.374	-.040	.514	1.947	.266
	Cost of cooking	.054 ^l	1.476	.141	.067	.850	1.177	.460
12	Male	.054 ^m	1.553	.121	.070	.938	1.066	.459
	Auto Rickshaw (CNG)	-.006 ^m	-.115	.909	-.005	.462	2.165	.441
	Rented Car	.009 ^m	.199	.843	.009	.541	1.847	.448
	Primary Dummy	.007 ^m	.192	.848	.009	.972	1.028	.459
	High School Dummy	.041 ^m	1.181	.238	.053	.950	1.053	.457
	College Dummy	.059 ^m	1.715	.087	.078	.945	1.059	.456
	Graduate dummy	.064 ^m	1.861	.063	.084	.952	1.051	.457
	Post Graduate Dummy	-.058 ^m	-1.713	.087	-.077	.962	1.040	.457
	House construction dummy	.014 ^m	.346	.729	.016	.663	1.509	.431
	Bottle Dummy	.014 ^m	.331	.741	.015	.626	1.598	.458

	Old used unwanted cloths dummy	.045 ^m	1.302	.194	.059	.957	1.045	.458
	Unwanted Metal Dummy	-.070 ^m	-2.045	.041	-.092	.961	1.041	.458
	Less Trash Dummy	.085 ^m	1.325	.186	.060	.273	3.665	.241
	2-3	.065 ^m	1.822	.069	.082	.875	1.143	.459
	4-6	-.004 ^m	-.113	.910	-.005	.918	1.089	.459
	7-9	.004 ^m	.126	.900	.006	.907	1.103	.459
	Duplex row house with 2-4	-.048 ^m	-1.032	.302	-.047	.512	1.953	.266
	Cost of cooking	.058 ^m	1.598	.111	.072	.848	1.179	.458
13	Male	.057 ⁿ	1.639	.102	.074	.936	1.068	.457
	Auto Rickshaw (CNG)	.000 ⁿ	-.001	.999	.000	.461	2.171	.440
	Rented Car	.004 ⁿ	.090	.928	.004	.540	1.852	.447
	Primary Dummy	.019 ⁿ	.538	.591	.024	.946	1.057	.457
	High School Dummy	.038 ⁿ	1.111	.267	.050	.948	1.054	.456
	College Dummy	.058 ⁿ	1.687	.092	.076	.944	1.059	.455
	Graduate dummy	.062 ⁿ	1.816	.070	.082	.951	1.051	.455
	Post Graduate Dummy	-.061 ⁿ	-1.777	.076	-.080	.961	1.040	.455
	House construction dummy	.010 ⁿ	.231	.818	.010	.661	1.514	.430
	Bottle Dummy	-.003 ⁿ	-.070	.944	-.003	.602	1.662	.457
	Old used unwanted cloths dummy	.039 ⁿ	1.130	.259	.051	.950	1.053	.457
	Less Trash Dummy	.087 ⁿ	1.366	.173	.062	.273	3.666	.240
	2-3	.059 ⁿ	1.638	.102	.074	.867	1.154	.457
	4-6	.000 ⁿ	.006	.995	.000	.915	1.093	.457
	7-9	.007 ⁿ	.195	.846	.009	.906	1.104	.458
	Duplex row house with 2-4	-.049 ⁿ	-1.047	.296	-.047	.512	1.953	.266
	Cost of cooking	.061 ⁿ	1.676	.094	.076	.847	1.181	.457

a. Dependent Variable: EF

b. Predictors in the Model: (Constant), Electricity Bill

c. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water

d. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy

e. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment

f. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water

g. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy

h. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy

i. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy

j. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw

k. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy

l. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy

m. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy, Just me

n. Predictors in the Model: (Constant), Electricity Bill, Freee Standing no Running Water, Below Average Dummy, Multistory Apartment, Freee Standing Running Water, More trash dummy, Mush more trash dummy, Average Income Dummy, Rickshaw, Old Newspapers dummy, Same trash dummy, Just me, Unwanted Metal Dummy

Collinearity Diagnostics^a

Model	Dimension	Eigenvalue	Condition Index	(Constant)	Electricity Bill	Variance Proportions												
						Free Standing no Running Water	Below Average Dummy	Multistory Apartment	Free Standing Running Water	More trash dummy	Mush more trash dummy	Average Income Dummy	Rickshaw	Old Newspapers dummy	Same trash dummy	Just me	Unwanted Metal Dummy	
1	1	1.677	1.000	.16	.16													
	2	.323	2.278	.84	.84													
2	1	1.872	1.000	.11	.11	.08												
	2	.832	1.500	.01	.13	.79												
	3	.296	2.516	.87	.76	.13												
3	1	2.140	1.000	.06	.06	.05	.06											
	2	.882	1.558	.00	.00	.65	.23											
	3	.772	1.665	.00	.30	.17	.31											
	4	.206	3.223	.93	.63	.13	.40											
4	1	2.336	1.000	.04	.05	.03	.05	.04										
	2	1.024	1.510	.00	.01	.43	.04	.26										
	3	.772	1.739	.00	.28	.12	.37	.00										

	4	.692	1.838	.00	.06	.24	.22	.51											
	5	.176	3.646	.95	.60	.18	.32	.19											
5	1	2.72 9	1.000	.02	.03	.01	.04	.01	.02										
	2	1.05 7	1.607	.00	.02	.33	.06	.00	.06										
	3	1.00 2	1.651	.00	.00	.05	.00	.37	.04										
	4	.770	1.883	.00	.28	.13	.26	.01	.00										
	5	.360	2.755	.02	.27	.02	.64	.07	.22										
	6	.083	5.748	.96	.40	.45	.00	.54	.66										
6	1	2.98 7	1.000	.01	.03	.01	.03	.01	.02	.03									
	2	1.07 6	1.666	.00	.02	.28	.09	.00	.05	.04									
	3	1.00 6	1.723	.00	.00	.01	.00	.38	.05	.01									
	4	.855	1.869	.00	.08	.22	.15	.00	.00	.27									
	5	.634	2.170	.01	.24	.01	.08	.00	.01	.64									
	6	.360	2.882	.02	.26	.02	.64	.07	.23	.00									
	7	.082	6.028	.95	.37	.45	.00	.54	.65	.01									
7	1	3.06 3	1.000	.01	.02	.01	.03	.01	.02	.03	.01								
	2	1.07 7	1.686	.00	.03	.27	.10	.00	.05	.02	.02								
	3	1.03 0	1.725	.00	.01	.01	.00	.15	.02	.05	.44								
	4	.995	1.754	.00	.00	.02	.00	.23	.04	.08	.21								
	5	.855	1.893	.00	.07	.22	.15	.00	.00	.27	.00								
	6	.542	2.377	.01	.21	.00	.10	.00	.02	.54	.30								
	7	.356	2.933	.02	.31	.02	.61	.07	.21	.00	.02								
	8	.082	6.125	.95	.34	.45	.00	.54	.65	.01	.01								
8	1	3.32 4	1.000	.01	.02	.01	.01	.01	.01	.02	.01	.02							
	2	1.16 3	1.691	.00	.00	.17	.12	.01	.03	.01	.00	.08							
	3	1.03 0	1.796	.00	.01	.00	.00	.14	.01	.05	.45	.00							
	4	.997	1.826	.00	.01	.01	.00	.22	.05	.06	.22	.00							
	5	.864	1.961	.00	.02	.32	.12	.00	.00	.10	.00	.05							

	6	.818	2.015	.00	.10	.00	.00	.01	.03	.29	.01	.23					
	7	.527	2.510	.01	.33	.00	.02	.00	.00	.46	.30	.02					
	8	.198	4.099	.03	.13	.12	.69	.14	.38	.00	.01	.55					
	9	.079	6.476	.96	.39	.37	.03	.47	.48	.01	.01	.04					
9	1	3.92 2	1.000	.01	.01	.00	.01	.01	.01	.01	.01	.01	.02				
	2	1.18 2	1.822	.00	.01	.14	.11	.01	.02	.02	.01	.09	.01				
	3	1.04 5	1.938	.00	.02	.02	.00	.13	.03	.02	.39	.00	.01				
	4	.998	1.983	.00	.01	.00	.00	.18	.04	.08	.27	.00	.00				
	5	.885	2.105	.00	.04	.29	.07	.01	.00	.19	.01	.02	.01				
	6	.825	2.181	.00	.08	.03	.01	.01	.03	.21	.01	.27	.00				
	7	.528	2.727	.01	.32	.00	.02	.00	.00	.47	.30	.02	.00				
	8	.363	3.289	.00	.01	.01	.29	.03	.00	.00	.00	.09	.72				
	9	.177	4.711	.03	.09	.19	.46	.25	.50	.00	.01	.45	.19				
	10	.077	7.138	.96	.41	.31	.03	.38	.38	.00	.00	.06	.04				
10	1	3.99 8	1.000	.01	.01	.00	.01	.01	.01	.01	.01	.01	.02	.01			
	2	1.22 0	1.810	.00	.04	.04	.11	.00	.02	.02	.02	.03	.02	.14			
	3	1.11 0	1.898	.00	.02	.16	.01	.01	.00	.00	.06	.08	.00	.22			
	4	1.04 0	1.960	.00	.00	.00	.00	.21	.04	.02	.25	.00	.00	.01			
	5	.978	2.022	.00	.00	.01	.00	.09	.02	.20	.33	.00	.00	.04			
	6	.855	2.162	.00	.00	.25	.08	.02	.02	.00	.00	.20	.00	.02			
	7	.702	2.387	.00	.02	.01	.00	.00	.02	.49	.11	.05	.00	.34			
	8	.485	2.871	.01	.40	.00	.04	.00	.00	.25	.20	.04	.00	.19			
	9	.359	3.338	.00	.03	.01	.26	.03	.00	.00	.00	.08	.72	.02			
	10	.177	4.758	.03	.10	.19	.46	.24	.50	.00	.01	.45	.19	.00			
	11	.077	7.211	.96	.38	.31	.03	.37	.38	.00	.00	.06	.04	.00			
11	1	4.31 3	1.000	.00	.01	.00	.01	.00	.01	.01	.00	.01	.01	.00	.01		
	2	1.22 0	1.880	.00	.03	.05	.11	.00	.02	.01	.02	.03	.02	.13	.00		
	3	1.16 1	1.927	.00	.02	.12	.01	.00	.01	.03	.09	.03	.00	.13	.06		

4	1.066	2.012	.00	.00	.02	.00	.21	.04	.02	.03	.03	.00	.10	.02		
5	1.005	2.072	.00	.00	.00	.00	.00	.00	.25	.42	.00	.00	.01	.02		
6	.887	2.205	.00	.01	.00	.01	.13	.01	.06	.11	.06	.00	.15	.09		
7	.849	2.254	.00	.00	.25	.07	.00	.03	.02	.03	.15	.00	.00	.02		
8	.606	2.668	.00	.18	.04	.04	.00	.00	.06	.00	.11	.00	.42	.07		
9	.362	3.453	.00	.10	.01	.22	.03	.00	.04	.03	.07	.61	.04	.01		
10	.298	3.802	.00	.32	.01	.01	.00	.00	.42	.22	.00	.21	.01	.43		
11	.168	5.062	.01	.02	.28	.45	.31	.59	.01	.00	.40	.12	.00	.07		
12	.065	8.169	.98	.30	.21	.08	.30	.28	.08	.04	.10	.03	.00	.20		
12 1	4.317	1.000	.00	.01	.00	.01	.00	.01	.01	.01	.00	.01	.01	.00	.01	.00
2	1.225	1.877	.00	.04	.04	.10	.00	.02	.01	.02	.02	.02	.14	.00	.02	
3	1.164	1.926	.00	.02	.13	.01	.00	.01	.03	.08	.04	.00	.11	.06	.01	
4	1.070	2.009	.00	.00	.01	.00	.21	.03	.01	.04	.03	.00	.06	.02	.05	
5	1.010	2.068	.00	.00	.01	.00	.00	.00	.22	.28	.00	.00	.00	.02	.20	
6	.990	2.088	.00	.00	.01	.00	.00	.00	.04	.15	.00	.00	.07	.00	.63	
7	.885	2.209	.00	.01	.01	.01	.13	.01	.05	.09	.08	.00	.13	.08	.02	
8	.842	2.265	.00	.00	.23	.06	.00	.04	.03	.03	.13	.00	.00	.03	.05	
9	.605	2.671	.00	.18	.04	.04	.00	.01	.06	.00	.11	.00	.42	.07	.00	
10	.361	3.456	.00	.10	.01	.22	.03	.00	.04	.04	.07	.61	.04	.01	.00	
11	.298	3.804	.00	.32	.01	.01	.00	.00	.42	.22	.00	.21	.01	.43	.00	
12	.167	5.078	.01	.02	.28	.45	.31	.59	.01	.00	.41	.12	.00	.07	.01	
13	.064	8.185	.98	.30	.22	.08	.31	.29	.08	.04	.10	.03	.00	.20	.00	
13 1	4.377	1.000	.00	.01	.00	.01	.00	.01	.01	.01	.00	.01	.01	.00	.01	.00
2	1.251	1.870	.00	.03	.04	.09	.00	.03	.01	.00	.02	.01	.14	.01	.01	.08
3	1.172	1.933	.00	.02	.05	.00	.02	.00	.04	.15	.01	.01	.11	.07	.02	.03
4	1.125	1.973	.00	.00	.10	.02	.10	.00	.00	.04	.07	.00	.08	.00	.00	.13
5	1.015	2.077	.00	.00	.01	.00	.06	.02	.09	.13	.00	.00	.01	.01	.37	.06
6	1.009	2.082	.00	.00	.01	.00	.00	.00	.17	.19	.00	.00	.01	.02	.38	.00
7	.918	2.184	.00	.01	.00	.01	.16	.04	.05	.00	.02	.00	.00	.05	.16	.15

8	.853	2.266	.00	.00	.20	.06	.01	.02	.00	.01	.18	.00	.06	.00	.04	.06
9	.794	2.348	.00	.00	.04	.01	.00	.00	.05	.18	.01	.01	.19	.04	.00	.44
10	.595	2.713	.00	.18	.04	.05	.00	.01	.05	.00	.11	.00	.35	.08	.00	.05
11	.361	3.483	.00	.10	.01	.22	.03	.00	.04	.03	.07	.60	.04	.02	.00	.00
12	.298	3.831	.00	.32	.01	.01	.00	.00	.42	.22	.00	.21	.01	.43	.00	.00
13	.167	5.114	.01	.02	.28	.45	.31	.59	.01	.00	.41	.12	.00	.07	.01	.00
14	.064	8.242	.98	.30	.22	.08	.31	.28	.08	.04	.10	.03	.00	.19	.00	.00

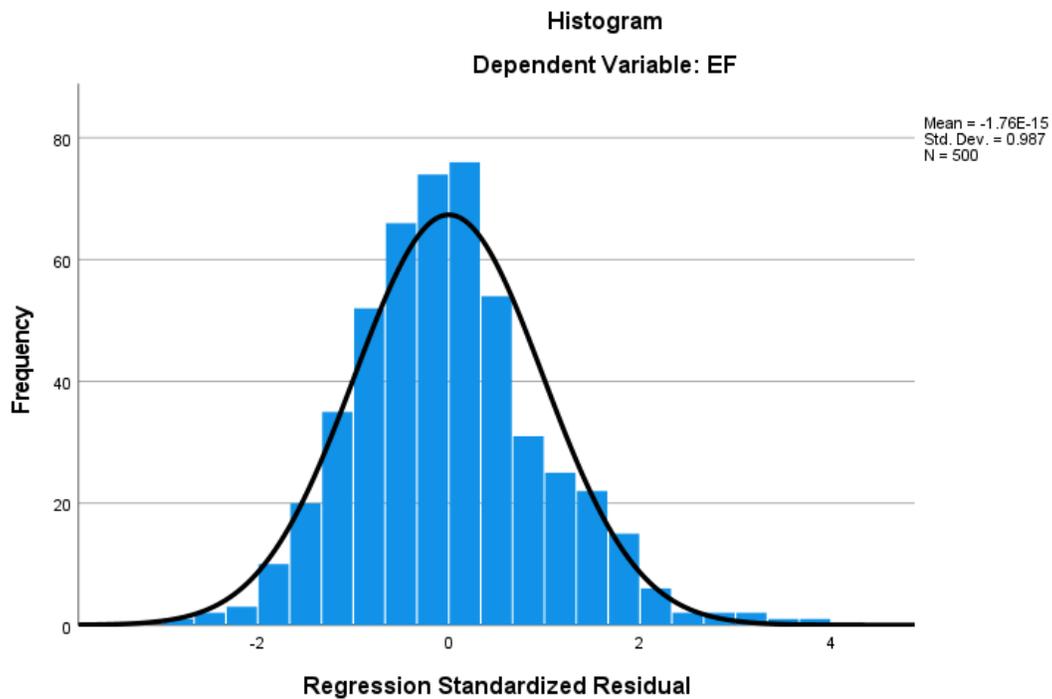
a. Dependent Variable: EF

Residuals Statistics^a

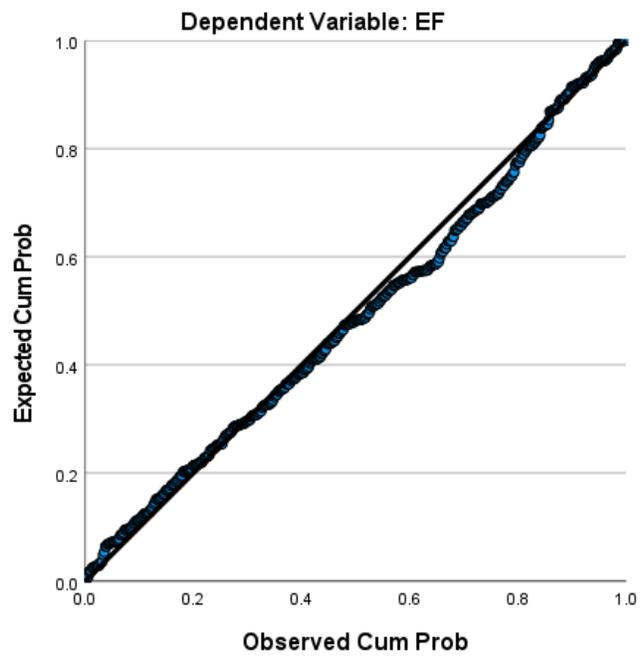
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.2537	11.9927	6.5946	1.66079	498
Residual	-5.18659	6.86509	.00000	1.81425	498
Std. Predicted Value	-2.012	3.250	.000	1.000	498
Std. Residual	-2.821	3.734	.000	.987	498

a. Dependent Variable: EF

Charts

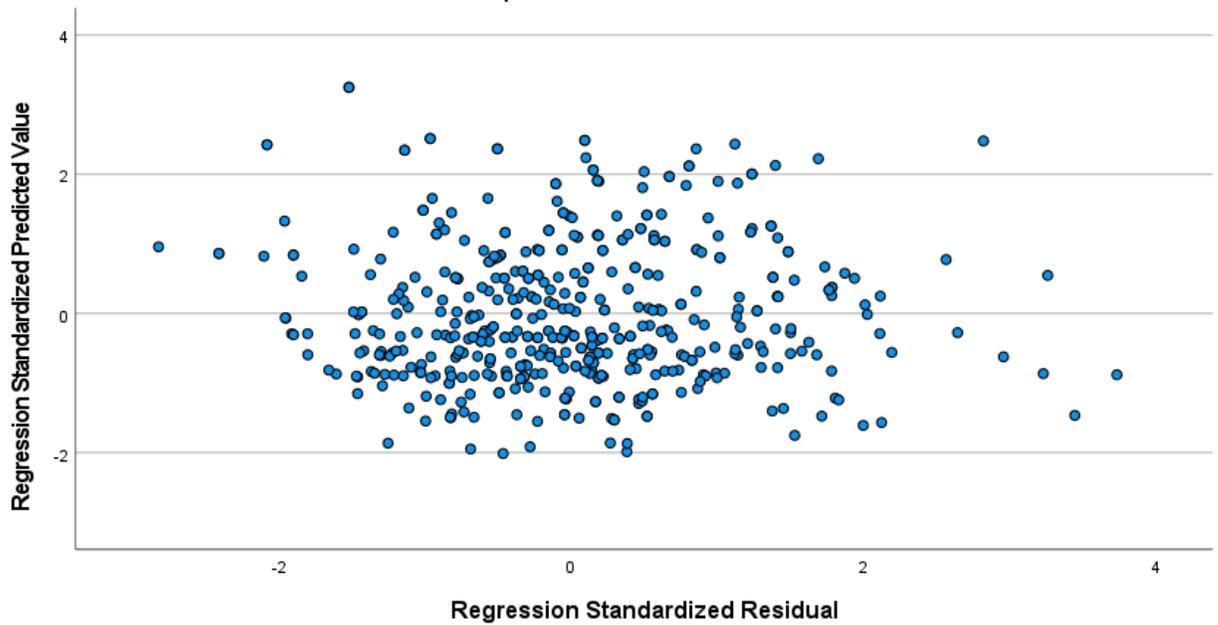


Normal P-P Plot of Regression Standardized Residual



Scatterplot

Dependent Variable: EF



Appendix-13 Interview Data Analysis

Goal level	Theme	Design Criteria Level	
Goal	Sustainable dimension	Sub-Theme	Code
Sustainable urban development for Bangladesh	Social	Equity	24 407 Women and children friendly city
			24 412-413 Proper distribution of benefit
		Education	05 134- need to build awareness in different level, 20 121 Awareness with alternatives
			13 356-People awareness
			07 77 Awareness of urban community
			22 143- Skill manpower for urbanization boom
			19 68 Education for using the traffic/road infrastructure
			19 49 Knowledge developemnt through curriculum
			19 90 Curriculum change/inclusion
			1959 training for general people
			06 337 Training for Mosque's Imam, 06 320- educating the youth, 06 327-educating the school teachers
		Safety and Security	24 405-406 Safe city

Goal level	Theme	Design Criteria Level			
Goal	Sustainable dimension	Sub-Theme	Code		
		Transportation	<p>Mass transportation (13 651- Public transport 13 685, 01 30 high demand for public transport, 01 32- law quality public transport, 01 187- Quality public transport, 23 236- ensuring safety in public transport, 23 249- public</p>	Bus	<p>24 337-339 Chain Bus service , 24 343-346 Corporate body for bus services , 09 210-Bus-transport, 13 598- 605-BRT 15 524, 13 578-High quality Bus 13 635-Quality bus and sustainability, 13 663-Public buses, 08 106 Franchise bus, 26 107, 119- ppp for transport, 14 204 School bus services, 14 208 Office bus, 19 153 systematic bus network, 04 196- High number and more frequent bus, 19 180 Number of buses vs office time, 19 164- More double decor bus, safety and security, 01 176- Short distance public transport stoppage.</p>

Goal level	Theme	Design Criteria Level				
Goal	Sustainable dimension	Sub-Theme	Code			
			transport and land use pattern, 25 404 public transport as good option, 25 425-quality public transport passengers, 25 430-Public transport expansion project, 15 533- Gender responsive public transport, 04 192-Reforming the present policy for introducing public transport, 04 194- private companies of	Train	24 351- Metro rail 04 190, 04 207, 17 143, 24 353-354 Double railway , 09 215- Rail 06 256, 22 285, 04 207, Demo train,	13 648-MRT , 13 593, 13 575, 13 586, 13 593, 13 648, 08 106, 09 210, 05 281, 25 407, 18 351, 12 299, 15 524, 14 220, 04 185, 19 427, MRT, 09 226 MRT supportive transportation , 01 172- Positioning of MRT stations, 01 175-walking facilities around the MRT stations, 01 179- para transit for MRT, 22 287-MRT and urban

Goal level	Theme	Design Criteria Level				
Goal	Sustainable dimension	Sub-Theme	Code			
			public transport)			transportation , 17 143- Metro rail/sky rail/ MRT-6, 01 167-Good Feeder services, 09 226-MRT supportive transportation

Goal level	Theme	Design Criteria Level			
Goal	Sustainable dimension	Sub-Theme	Code		
			Water	09 259- Advocating traditional water transport, 23 264 Waterways, 06 260- Water boat-based transportation, 22 374- Road with canal	
			Private transportation	01 184 Restrictions for private cars, 05 247 Ensuring private car alternatives, 05 253 Parking restrictions for private cars, 13 675- Low Private car users , 23 226 need policy for discouraging private car	
		NMV	Rickshaw	13 665-NMV 25 448 Rickshaw as public transport, 25 527 - incentive for NMV and public transport users, 13 686-NMV 17 187, 17 189-separate lane for NMV, 19 446- separate lane for NMV in new cities, 08 124- NMV in small towns, 08 124- NMV in local neighborhoods in large town, 18 427 Need of Mindset for NMV .	
			Bike	14 234- Drivers awareness for bike lane, 18 422, 23 243- Bike lane in new cities, 23 276- Bike lane in some places, 18 451- No space for separate bike lanes, 18 437 Advocating bike 12 333, 15 605 Disadvantage of Bike, 15 621	
		Pedestrian Facilities	23 277-Declare some places as pedestrian zone with flyover , 22 388- Walking habit development, 24 376-378 Foot path		

Goal level	Theme	Design Criteria Level	
Goal	Sustainable dimension	Sub-Theme	Code
	Environmental	Waste generation and management	07 85 Integrated waste management
			01 118- Citizen engagement in waste management 14 153,
			06 159 Need for a comprehensive waste management program
			05 141- Cultural shift for waste management
			06 165 Need to invest in waste management infrastructure
			13 696- Environmental priority
		Land use	06 58 Land ownership co-operative
			24 383-384 City ventilation
			24 384-392 Green and blue space balance
			23 322 Nature based planning
			09 272- Blue and green development 22 347 Green and blue network approach 13 444- Green and water
			24 379-381 Plantation in road

Goal level	Theme	Design Criteria Level				
Goal	Sustainable dimension	Sub-Theme	Code			
			06 58- land ownership co-operative			
		Freshwater	15 676 Rainwater use			
	Economic	Affordability	13 611- 632 planning according to Country's affordability			
			06 68 Sweet water export			
			06 54-Mechanized agriculture,			
		Consumption patterns	Food consumption	12 67-Diversification of food 12 122, 04 80, 17 104	25 181- Food donation	
				09 93-less process food 05 105, 2389, 13 279, 25 141, 25 151, 18 176, 15 218, 06 118, 1497, 04 71, 20 6024 129-131 Processed food, 4 129-131 Processed food , 08 65- Favoring unprocessed food, 14 97- 90% no process food, 14 107- Process food as a hoby	25 187- Unused food storage	
				25 295- Reuse of food 25 300, 25 306, 12 162		
				25 333-Unused food distribution		
				12 88 Food bank setting up, 12 172, 12 193		

Goal level	Theme	Design Criteria Level		
Goal	Sustainable dimension	Sub-Theme	Code	
				12 103 Food problem as opportunity
				12 139 Promoting traditional healthy food
				12 147 Urban sustainability by traditional food taking
				12 160 Awareness of food waste, 12 166- Mindset change for food waste
				12 190- Citizen engagement in food waste management
				15 261 Accountability for food wasting
				15 268 Food waste monitoring
				06 148 Rule of media for healthy food
				24 131-133 Rice and bread 08 53 Rice-based food consumption 15 163 Rice as staple food 2080, 13 291-traditional food taking
			Energy consumption	13 393- increased energy consumption, 23 180-increased energy consumption level,

Goal level	Theme	Design Criteria Level	
Goal	Sustainable dimension	Sub-Theme	Code
			3 406 energy intensive building structure, 06 179 more income more energy use, 15 366 energy hungry city, 23 184- A/C artificial ventilation, 13 452-increased use of A/C, 25 388- more A/C use
			09 177- Multi-metering system for energy pricing
			13 498-Incentive 13 528
			15 245 no incentive for solar energy
			15 461 model development for RE 15 467 Showcausing, 15 469 Model for less power consuming equipment, 15 503 Responsibilities of companies
			06 189 -Power price mechanism to promote less and diverse energy use
			06- energy labelling options
			14 168 People awareness for clean energy
			19 366-Energy use data base

Goal level	Theme	Design Criteria Level			
Goal	Sustainable dimension	Sub-Theme	Code		
				15 382- Govt. offices roof top for solar panels	
				15 405- Low cost solar panels	
				06 298- solar power at least for hot water	
				04 165 Agriculture and solar plant	
	Institutional	Planning	Decentralization 24 212-213 , 08 42, 12 43, 22 322, 22 433, 2030, 19 113, 1936.		
			24 215-222 City readiness and development		
			13 698 inclusive affordable planning		
			23 317 Gender sensitive planning		
			13 696-Environmental priority		
			24 410-412 Ecofriendly development		
			Implementation	09 298-Law enforcement 04 269 Strictly law enforcement	

Goal level	Theme	Design Criteria Level	
Goal	Sustainable dimension	Sub-Theme	Code
			07 144 Partnership for implementing the plan
			09 304-Political support
			13 357-Penalty 13 365-Penalty
		Governance	08 135 Good urban governance 05 322, 05 326, 05 329,
			19 227- Good governance, 19 463.
			19 436 Public heroes
			25 597 -Urbanization as neutral/nonpolitical agenda