An Empirical Analysis of Urbanization and Energy Consumption in the South Asian Association for Regional Cooperation Countries

by

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Abstract

Urbanization has posed some tremendous challenges which are related to environmental stresses through increased energy consumption. These challenges have drawn attention to the need to implement urbanization with sustainable energy consumption globally. The South Asian Association for Regional Cooperation is considered in the study during the period of 1975-2014 with time series data. The present study aims to investigate how urbanization can affect energy use and identify the urbanizing factors that cause energy consumption in this region. The data are analyzed by using simple statistics and econometric techniques, such as the ordinary least squares (OLS) method for country level, and fully modified least squares and Granger causality for this group of countries. The study has found that all urbanizing variables significantly affect energy consumption with different levels in different countries, as shown by the OLS method. Similarly, the results of the fully modified least squares (FMOLS) method indicate that all the variables are statistically significant at 1% level of significance except urban population growth, although the effects vary among variables. Moreover, there are three long-run causalities running from the gross domestic product to energy consumption, and from energy consumption to gross domestic product, and to the industrial share in the gross domestic product. Besides, in the short run, the causality the exercise explored is a bidirectional causality between the gross domestic product and the energy consumption, the gross domestic product and the industrial share in the gross domestic product, the energy consumption and the service share in the gross domestic product, the energy consumption and urban population. Green technology and energy efficiency technologies to use in the industries, encourage using public transportation, some restrictions on household-level energy use, and education for awareness about energy use and its consequences on the environment, sustainable energy and urbanization are potential policy recommendations.

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List of abbreviations and acronyms

ADF	Augmented Dickey–Fuller
ARDL	Autoregressive Distributed Lag
ASEAN	Association of Southeast Asian Nations
BRICS	Brazil, Russia, India, China, and South Africa
CFC	Chlorofluoro Carbon
CH_4	Methane

CO_2	Carbon Dioxide
EKC	Environmental Kuznets Curve
FE	Fixed Effect
FGLS	Feasible Generalised Least Squares
FMOLS	Fully Modified Least Squares
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IEA	International Energy Agency
IMF	International Monetary Fund
Kwh	Kilowatt-hour
MENA	Middle East and North Africa
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PVAR	Panel Vector Autoregressive
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goals
SEA	Sustainable Energy for All
Skm	Square Kilometer
$	US dollar
UN	United Nations
VECM	Vector Error-Correction Model
WDI	World Development Indicators

Chapter One

Introduction

1.1 Introduction

Urbanization and energy consumption are two aspects of modern economies with high potential to impact sustainable development. The present study is focused on the relationship between urbanization and energy consumption, and aims to investigate how the process of urbanization can affect the energy use in the South Asian Association for Regional Cooperation countries (SAARC), namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. The organization of this chapter is as follows. Section 1.2 provides the background of the study, and explains a few aspects of economic development and why energy resources are one of the driving factors of urbanization as well as of economic development. It also discusses the present scenario of energy resources use and how urban people are dependent on these resources. The problem statement of the study is discussed in Section 1.3. Section 1.4 outlines the research objective and the research questions of the study. Section 1.5 depicts a research hypothesis which is developed in terms of the main dependent and independent variables of the research, to explain how the findings of the study can be discussed. Section 1.6 analyses a conceptual framework to conduct the research. Significance of the study is explained by Section 1.7 and Section 1.8 shows how this study is organized.

1.2 Background of the study

Economic development is a continuous development process where economic growth, urbanization, migration, structural transformation, technological change, education, the environment and ethics are different parts of this process (Parikh and Shukla, 1995). “Economic growth is a process of simple increase, implying more of the same, while economic development is a process of structural change, implying something different if not something more” (Flammang, 1979, p. 50). As this author has argued, growth without development is impossible whereas development is possible without growth, and they are complementary in the long run but competitive in the short run (Flammang, 1979, p. 61). In addition, economic growth is a key indicator of economic development that shows increase in gross domestic product (GDP) of the country (Zheng and Walsh, 2019).

Urbanization is a demographic process where an increasing share of the national population lives within urban settlements (Arouri, Youssef, Nguyen-Viet and Soucat, 2014; Rahman, 2019). Urbanization is defined as the process in which the population migrates from rural to urban areas; in fact, the labor force transfers from the agricultural sector to the industrial and service sectors (Salim and Shafiei, 2014; Wang et al., 2016). Urbanization is one of the important indicators for sustainable development in any economy (which is linked with the UN Sustainable Development Goal 11- sustainable cities and communities). In addition, national economic development policy focuses on getting better quality of life for its citizens without reducing the energy resources of the country (that is related to SDG Goal 7- affordable and clean energy) (UN, 2015). However, the main objective of sustainable development is to ensure availability of resources for current generations development without sacrificing the availability of those resources for future generations, without causing environmental damage (Meadowcroft, 2000).

Agriculture and industry are two of the significant driving sectors of the economic growth as well as economic development of the country, and urbanization is a result of the structural change of these sectors (Jones, 1991). For example, modern agriculture or more agriculture production depends on more fertilizer, irrigation, insecticides, and modern equipment, that provide more food and raw materials to the market, compared to traditional agriculture; and these agricultural inputs are the products of industrial sectors (Jones, 1991). Urban people are the demand side to these agricultural products for their food and their industrial production. More importantly, more industrial production needs more inputs like labor, capital, technology, raw materials, and energy; these play an important role in the gross domestic product *(*Zheng and Walsh, 2019). However, urban people directly or indirectly provided labor force for industrial production, so more industrial production needs more labor force as a result of the higher density of urban areas. Urbanization and economic development are related, and the concentration of city resources like labor and capital is a part of this process (Rahman, 2019). Rahman (2019) explained that urbanization is considered as the engine for economic development, as 80% of the economic output originates in the urban regions where energy has a vital role to play. Energy is crucial for economic development in any country and an essential ingredient for improving the socio-economic conditions, getting education, raising income, improving life-styles and so on.

Urbanization leads to a series of challenges in natural resources and the ecological environment (Wu, Haob and Weng, 2019). Energy resources play a vital role in the process of urbanization. Most importantly, the urbanization process may be slowed down by insufficient energy. The consumption of energy in urban areas has significantly created an alarming situation for environmental degradation, especially the fossil-fuels-based energy use (Afridi, Kehelwalatenna, Naseem and Tahir, 2019; Wu et al., 2019). In addition, urbanization is a global phenomenon and an important factor for any country's growth process that requires immense energy sources but is also a threat to global warming and degradation of the environment (Abbasi, Parveen, Khan and Kamal, 2020).

The structural transformation of the economy causes fundamental changes in natural resources and influences energy demand in several ways (Rahman, 2019; Salim and Shafiei, 2014). For instance, urban life is expected to require more energy as a result of traveling to work by driving fuel-using vehicles, and also due to more constructing, operating, and maintaining municipal infrastructure and services including housing, water supply, roads and bridges as compared to rural living (Jones, 2004; Madlener and Sunak, 2011; Parikh and Shukla, 1995; Salim and Shafiei, 2014). On the other side, economic growth has also affected energy consumption indirectly through rises in the urbanization rate, and the pattern of energy use gradually changes in the urban areas (Bakirtas and Akpolat, 2018; Madlener and Sunak, 2011).

Urbanization is the precondition for development in any developing economy. Because from the period of the industrial revolution the industrial-urban inter-linkages have been the main way to the growth and economic development of the society (Behera and Dash, 2017). Energy resources are the main condition to running fast the industrial-urban inter-linkages. In recent decades, economic growth has led to a significant increase in energy consumption, and the energy demand has increased annually by 39% on average in the world (Mrabet, Alsamara, Saleh and Anwar, 2019, p. 832). According to the International Energy Agency (IEA) 2015, global energy resources supply consist mainly of natural gas (24%), coal (27%), oil (36%), hydro (6%), nuclear (6%) and renewable energy (about 1%), that means more than 80% of these energy resources are fossil fuels (Mrabet et al., 2019, p. 832). In addition, the process of urbanization depends on energy resources, and the consumption of nonrenewable energy is a cause of environmental degradation also (Wu et al., 2019). In contrast, renewable energy in such a small percentage represents a sustainable source of energy because it is undamaging to the environment, and this source is capable of increasing the energy security of a country by reducing its dependency on the conventional sources of energy (Mulali, Ozturk and Lean, 2015). Most of the renewable energy comes from combustible renewables and waste, such as hydroelectric power, nuclear power, solar power, and wind power (Cetin, Ecevit and Yucel, 2018; Mulali et al., 2015). However, economic growth has also affected energy consumption indirectly through rises in the urbanization rate.

1.3 Problem statement

Urbanization leads to the relative concentration of population as well as of economic activities in urban areas. As a result of migration from rural to urban areas, the labor force is transferred from the agricultural sector in the rural areas to the industrial and service sectors in the urban areas. This structural transformation of the economy causes many fundamental changes in natural resources and energy use as well (Salim and Shafiei, 2014). Existing studies have shown different impacts of urbanization on energy consumption, with plausible explanations for both the positive and the negative effects. The efficiency of energy saving depends on the relationship between urbanization management and city growth in urban areas (Ewing and Rong, 2008; Zhang and Zhao, 2016). Many studies have shown that urbanization is significantly correlated with energy consumption. Total energy consumption is made up of production plus imports, minus exports, minus international marine bunkers plus/minus stock changes, that means the total quantity of all energy necessary to satisfy a country's consumption (IEA, 2009). Total energy consumption of a country is the total energy used by that country. For example, at the national level, a higher level of urbanization was related to a higher level of energy use in 59 developing countries (Jones, 1991). Another study has shown that this correlation is true in 78 developed and developing countries (Parikh and Shukla, 1995). The main reason for this correlation is that the process of urbanization causes an increasingly urban population (Zhao and Zhang, 2018).

In particular, the majority of previous studies in different countries have shown that urbanization has a direct impact on energy consumption. For example, Parikh and Shukla (1995) showed that urbanization increases energy use per capita, noting three identifiable mechanisms behind it: energy conversion from one form to another, indirect energy consumption in goods-producing and transportation activities, and direct energy consumption in final uses such as transportation. Urbanization has increased energy consumption along three main pathways: urban spatial expansion, where urban sprawl has increased energy consumption in new buildings and the transport sector; urban motorization, which induces energy-intensive transportation; and the rising quality of energy-intensive lifestyles (Zhao and Zhang, 2018). Urban households consume 50% more energy than rural households per capita, which indicates that continued urbanization will promote the growth of national energy consumption (Zhao and Zhang, 2018). In addition, the USA is the first largest energy consumer in the world, followed by China for their ever-increasing fossil fuel combustion (Rao, Wu, Zhang and Liu, 2012).

The effect of urbanization on energy demand has been the subject of a number of recent studies. Some of these studies have found that energy demand responds positively to the changes in urbanization level (Bakirtas and Akpolat, 2018; Madlener and Sunak, 2011; Mrabet et al., 2019; Salim and Shafiei, 2014; Wu et al., 2019). Because urbanization is a transformation process, in which rural populations or workers shift into urban communities or become urban workers, it also produces a change in the character of socio-economic development of the economy (Salim and Shafiei, 2014; Wang et al., 2016). Jones (1991) found that the pattern of energy use changes in both the home and in the market in the urban areas, because if demand for necessary products increases for city dwellers, and these products are mostly provided by rural households, an increase in the energy used in their production is normal (Jones, 1991). The increased use of personal transportation is another cause for the rising energy usage (Parikh and Shukla, 1995; Salim and Shafiei, 2014). A large urban population represents a larger labor force for large-scale production, but inputs must be assembled from greater distances, and products must be sold over larger market areas, and this will have a positive effect on energy use through increasing use of different transport modes (Jones, 1991).

Other studies have argued that urbanization could lead to a decrease in energy resources available (Ewing and Rong, 2008; Lariviere and Lafrance, 1999; Lin and Ouyang, 2014). They have argued that urbanization has led to lower per capita energy consumption through energy efficiency, mostly in developed countries like Canada, and the USA (Ewing and Rong, 2008; Lariviere and Lafrance, 1999). Lin and Ouyang (2014) also agreed with this statement by using the Environmental Kuznets Curve. They have found an inverted U-shaped relationship between energy demand and economic growth in the long run. Energy consumption increased as urbanization increased in the early stages, then, after energy consumption reached a peak level, an increase in urbanization was related to a decline of energy use. This was largely attributed to the enhancement of energy efficiency. Similarly, Poumanyvong and Kaneko (2010); Yassin and Aralas (2019) explained that urbanization could lead to an increase in social awareness and the economies of scales for urban public infrastructure to protect the environment by the ecological modernization theory. “Ecological modernization theory emphasizes not only economic modernization but also social and institutional transformations in explaining the effects of modernization on the environment” (Poumanyvong and Kaneko, 2010, p. 435). This theory argued that urbanization is a process of social restructuring which has encouraged a structural change from an industrial to a service-based economy and has indirectly reduced the negative impact on the environment (Poumanyvong and Kaneko, 2010; Yassin and Aralas, 2019).

In general, transportation and development of infrastructural demand are not the only reasons to require more energy in the urban areas (Madlener and Sunak, 2011; Parikh and Shukla, 1995). Another important reason is that a higher household income can ensure higher quality lifestyles; this makes the demand for energy to increase (Chikaraishi et al., 2015). Urban density is also a cause of energy demand growth (Shahbaz, Loganathan, Sbia and Afza, 2015). However, economic growth has also affected energy consumption indirectly through rises in the urbanization rate, and the changed pattern of energy use in the urban areas (Bakirtas and Akpolat, 2018; Madlener and Sunak, 2011; Shahbaz et al., 2015).

To conclude, urbanization has posed some tremendous challenges which are related to environmental stresses, through increased energy consumption (Zhang and Lin, 2012). These challenges have drawn global attention to the need of implementing urbanization with sustainable energy consumption in the world. As the above arguments indicate, more empirical analyses from different contexts are required in order to be able to generalize existing knowledge of the effects of urbanization on energy use.

It is predicted that 68% of the world's population will be urban citizens by 2050, much of which will occur in Africa and Asia, notably in the SARRC countries, which will add 20% more city dwellers by this period (UN, 2019). According to the International Monetary Fund (IMF) data, this region has represented 3% of the world's area, 21% of the world's population and 3.8% of the global economy, as of 2015 (SAARC, 2015). Additional urban infrastructure is needed to support the unprecedented growth of these countries, so it is a cause for more resource consumption, exerting additional pressure on the already fragile ecosystems of these countries (Wang et al., 2016). However, this region faces a threat of energy security, as it has not only a limited capacity of energy resources, mainly nonrenewable sources, but is also subject to/challenged by the volatile and higher prices of energy, urbanization, and population growth (Ahmad and Majeed, 2019). In addition, the use of mostly nonrenewable sources of energy is one of the main causes of carbon dioxide emissions and environmental degradation in the area (Afridi et al., 2019; Ahmad and Majeed, 2019). Rapid urbanization has posed some tremendous challenges which are related to environmental pressures, due to energy consumption (Zhang and Lin, 2012), and these challenges have drawn global attention.

The growth of urbanization in developing countries is higher compared to developed countries (Behera and Dash, 2017). Moreover, increasing demand for energy consumption in India, China, and other developing countries is a core concern for decreasing the existing reserves of energy, especially nonrenewable energy (Ewing and Rong, 2008). Most of the countries in this region are developing, especially Bangladesh, India, and Sri Lanka, and urbanization is an important indicator of socio-economic development. The aim of this study is to examine how urbanization affects energy consumption in the SAARC countries.

1.4 Research objective and questions

The overall objective of this research project is to establish an empirical nexus between urbanization and consumption of energy in SAARC countries. To attain the main objective, this study sets the following specific research questions as mentioned below:

a. What is the pattern of urbanization and what is the pattern of energy use in these countries?

b. Which urbanization factors are influencing the energy consumption at the country level?
c. Is there any causal relationship between urbanization factors and energy consumption at the aggregate level?

To answer the research questions, the study deals with two levels of impact of urbanization on energy consumption namely aggregate time series data for the national level and panel data (cross-sectional time series data) for the regional level. Firstly, it analyses time series aggregate data, both for trend in urbanization and energy use, and to identify the urbanization factors influencing consumption of energy at the national level. Secondly, it uses cross sectional time series data to measure the effects of urbanizing factors on energy consumption at the regional level.

1.5 Research hypothesis

The research hypothesis is designed in terms of the main research issue, and independent and dependent variables are identified from this hypothesis. In this study, urbanization is the independent variable and energy consumption is the dependent one. There are some indicators of urbanization such as urban area, population, urban employment etc. On the other hand, industrial usage, household usage and transport usage are the indicators of energy consumption. The research hypothesis of this study is that energy consumption is positively correlated with urbanization in the SAARC countries, as explained in Figure 1.1. The selection of the research design and appropriate research methods is very important for collection and assessment of the data relating to the major variables of the research. The research study will be conducted by using quantitative research with the adaptation of exploratory research investigation. Also, secondary data collection is used in this research in the form of a thorough literature review and the secondary data from the World Bank's database.

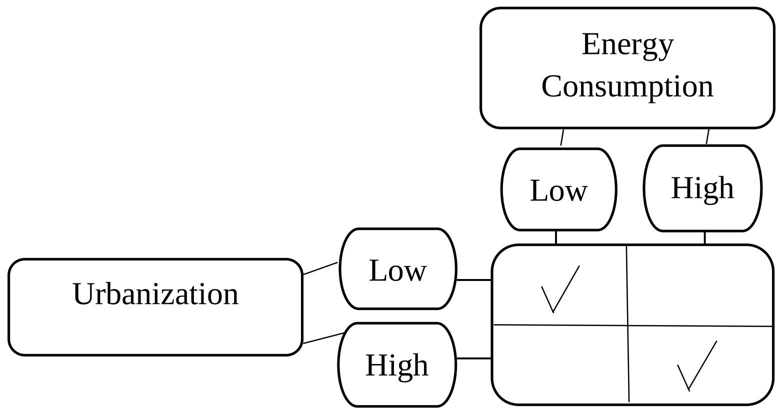

Figure 1.1: Research Hypothesis

Source: Author's own deign

According to Parikh and Shukla (1995), the process of urbanization and energy use per capita can always change. We have attempted to employ economic development theory to find out the impact of urbanization on energy consumption by investigating the changes in the urbanization process after using energy resources. So, the present research can be essential to identify how the process of urbanization can affect energy consumption and how it does not. Those factors are identified in this research as major research questions such as factors influencing the process of urbanization, and the urbanizing factors which affect energy usage. For an effective investigation, we can try to analyze these factors to understand how these factors may help to explore the impact of urbanization on increased energy consumption.

1.6 Conceptual framework

Economic growth is a major component of economic development of any country (Shahbaz et al., 2015). Economic development and growth lead to the process of urbanization, and energy has a vital role to play in both (Afridi et al., 2019; Parikh and Shukla, 1995). The process of urbanization mainly consists of two aspects, namely population urbanization and economic urbanization (Wang, Zeng, Huang, Shi and Zhan, 2018b). Urbanization also accompanies structural transformation, as the rural-urban migration leads to shifts in the labor force from the agricultural sector in rural areas to industrial and service sectors in urban areas (Salim and Shafiei, 2014; Wang et al., 2016). This structural transformation generally involves changes in four major urban factors: industrial and infrastructure; transportation, household services and the informal sector (Bento, Jacobsen and Liu, 2018; Kuralbayeval, 2019; Madlener and Sunak, 2011; Parikh and Shukla, 1995; Zhao and Zhang, 2018). Due to this structural transformation, the economy is able to meet increasingly various consumption demands through high-energy intensity production that replaces the low-energy intensity production (Madlener and Sunak, 2011; Sen, 2016; Wu et al., 2019). And this transformed production needs more new buildings and technologies, and overall infrastructural development (Madlener and Sunak, 2011).

However, the urbanization process is associated with an increased demand for housing of the more numerous urban population compared to rural areas population in the SAARC countries (Anser, Alharthi, Aziz and Wasim, 2020). In addition, an increase in urban population will increase the demand for public infrastructure such as roads, bridges, schools, hospitals, sewage channels, power plants etc. that consume more energy (Poumanyvong and Kaneko, 2010; Rahman, 2019; Madlener and Sunak, 2011). Movements of people and products from one place to another depend on modes of transport in the society, region, country, and the world

(Poumanyvong, Kaneko and Dhakal, 2012; Shahbaz et al., 2015). For example, Parikh and Shukla (1995); Poumanyvong et al. (2012); and Salim and Shafiei (2014) pointed out that there are two reasons why urbanization increases both the quantity of passengers and freight, and the distance over which passengers and freight travel. First, growth in urban population normally increases movements of passengers and freight. Second, expanded urban areas imply longer travel distances due to urbanization. In addition, urbanization causes a rise in income and standard of living, and leads to use of more individual transport by urban citizens compared to rural people in the developing countries like Bangladesh, India (Madlener and Sunak, 2011; Rahman, 2019; Shahbaz et al., 2015). Salim and Shafiei (2014) identified that the rural population shifts to the urban population by the process of urbanization; as a result, more energy is needed for household services of the increasing population in urban areas (Bakirtas and Akpolat, 2018; Chikaraishi et al., 2015; Shahbaz et al., 2015). For instance, assuming all things are equal, a 10% increase in urban population led to around 4.7% rise in per capita energy consumption in the country (Parikh and Shukla, 1995). More importantly, the running costs of cities, such as space heating, air conditioning and lighting in residential buildings, are high compared to the costs of other urban activities (Salim and Shafiei, 2014). In addition, household services are influenced by urban population growth and the higher living standards in urban life (Chikaraishi et al., 2015; Gasimli et al., 2019; Imai, 1997; Poumanyvong and Kaneko, 2010).

The informal sector is an important factor of urbanization, although the contribution of this sector is not measured properly in the economy (Madlener and Sunak, 2011; Kuralbayeval, 2019). As a result, energy consumption due to urbanization is difficult to measure and assess because of the informal sector. This sector is neither registered nor taxed by the government (Bento et al., 2018; Rahman, 2019).

Overall, urbanization and economic development increase per capita energy consumption, particularly of fossil fuels (Jones, 1991). Urban people are more likely to consume high amounts of energy and policy makers need to implement proper energy conservation and energy efficiency policies. However, economic development is also responsible for climate change and scarcity of energy resources.

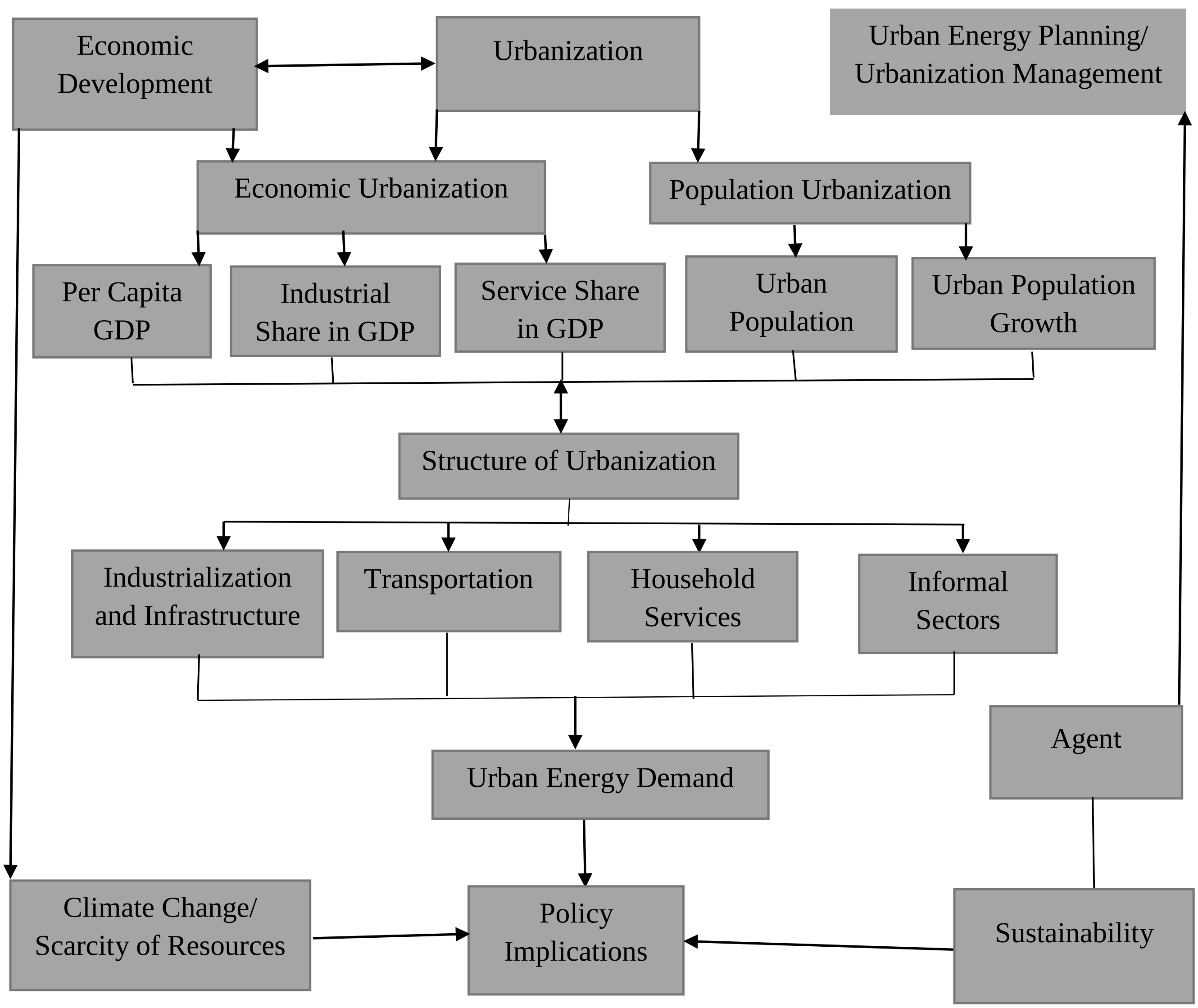

Figure 1.2: Conceptual Framework of Urbanization Impacts on Energy Consumption

Source: Adapted from Madlener and Sunak, 2011; Wang et al., 2018b

Energy management systems at the urban level vary from country to country and region to region. The energy demand will keep increasing in the coming years, as development targets and economic growth accelerate. This research uses a conceptual framework adapted from Madlener and Sunak, 2011; and Wang et al., 2018b. The major components of urbanization and energy consumption are integrated in Figure 1.2 to formulate the conceptual framework of the research. Figure 1.2 summarizes the main factors of urbanization which impact energy consumption and related issues of the economy. The problem statement of the research argues that urbanization is increasingly affecting energy consumption. However, as the conceptual framework shows, this relationship is a flow process easy to understand and model for policy making purposes aiming to increase energy conservation and efficient use as well as reduce environmental degradation without reducing economic development. Studying the impact of urbanization is also necessary in order to change the sustainable development indicators in the urban areas, which can be explained by the research findings.

1.7 Significance of the study

The study will provide an empirical relationship between urbanization and energy consumption in the SAARC countries. The existing literature about energy use and urbanization in numerous countries or regions of the world fails to identify the energy demand patterns. 'Energy demand depends on different socioeconomic factors as population, urbanization, industrialization, net capital income and development of technologies, etc. (Hasanuzzaman, Islam, Rahim and Yanping, 2020, p. 41). Energy demand refers to total energy demanded by the building (residential and commercial), industrial and transportation sectors of a country (Hasanuzzaman et al., 2020). Therefore, there is a gap in studying the changes in energy consumption brought about by urbanization. This is the case for countries in the South Asian Association for Regional

Cooperation (SAARC). However, the urbanization rate is faster than the generation of energy resources. The reality is that still a significant proportion of the total population of the world remains or lives in rural areas, especially in the South Asian region. Hence, how sustainable urbanization can be ensured in such a situation is a critical question.

The intended study will investigate the relationship between urbanization and energy consumption and the impact under different dimensions. This study aims to synthesize evidence concerning the role of sustainable urbanization in reducing energy consumption, particularly its role in making energy efficient technologies available, and in generating renewable energy resources to ensure sustainable development in the study area. This will be the main original contribution of this research. The urbanization–energy use relationship has been studied extensively in recent years, and while some researchers show that urbanization increases energy consumption, some others argue that urbanization can improve the efficient use of public infrastructure, resulting in less energy use. However, it is still less clear what sort of energy use is more likely to be affected by urbanization. Therefore, it is important to study the impact of urbanization on energy consumption in terms of renewable and non-renewable energy in order to measure how urbanization can affect sustainable energy use and where policy makers should focus their attention in this regard. Researchers of urbanization and energy resources faculties under different public and private institutions and organizations will also benefit from this research which will be undertaken in this study area. And lastly, the results of this research will be an invaluable resource for those who will work in this research area in the future.

1.8 Structure of the study

This study has been organized and divided into five chapters, which investigate the empirical relationship between urbanization and energy consumption in the SAARC countries. The content of each chapter is as follows:

Chapter One: A background, a problem statement, the research objective and questions, as well as research hypotheses are the main segments of this chapter. The background of the study is discussed in terms of the concepts of sustainable development, economic growth, and urbanization and energy resources. The problem statement shows the existing issues that can be investigated by the study. Study questions and hypotheses are also explained by the use of main dependent and independent variables, some major conditions are mentioned to assess under what conditions, the process of urbanization can affect energy consumption.

Chapter Two: This chapter is a literature review in which major concepts of the research are defined, such as sustainable development, environment degradation, economic growth, urbanization, demand for energy etc. There is a rich literature relating to urbanizing factors and their impact on the energy consumption in an economy, as well as relevant methods of analyzing the linkages between urbanizing factors and energy consumption patterns, and the empirical results of earlier studies, mainly in the study area. Some literature gaps will also be identified in this chapter.

Chapter Three: This chapter provides the research methodology of the study in detail. It also describes the research design and approaches, the specification of the model's equations and estimation techniques, the definition of different variables and the study area as well. The description of data is also presented in this chapter.

Chapter Four: The fourth chapter contains the findings and analysis of the collected data to answer the research questions. This is mainly the analysis and interpretation of the collected data to show how the pattern of energy consumption in an economy can be changed by the process of urbanization. The discussion of the findings and the research results will be presented in this chapter. The first part of this chapter investigates the trend of urbanization factors and energy consumption in the SAARC countries using aggregate time series data. In the second part of the chapter regression models are employed to estimate the impact of urbanization variables on energy consumption. In the latter part of the chapter a balanced panel data approach is applied to estimate the effect of urbanization on energy consumption in the SAARC region. Findings at every stage are compared with studies from other countries since studies of this type were not found in the literature for this region.

Chapter Five: The final chapter contains the study summary and policy implications of the study findings. The conclusion is explained in terms of the relation between research objectives and research findings. The chapter concludes with some policy suggestions and guidelines to this issue for the SAARC countries, and identifies the limitations of the study and proposes areas for future research.

Chapter Two

Review of the Literature

2.1 Introduction

This chapter provides the type of literature which has been reviewed, such as peer reviewed articles, books, government and international reports; as well as the time frame such as the literature published in the last 30 years, and the geographic frame (global, national, regional etc.). The review also focuses on the relevant literature on urbanization, energy resources, economic development etc., that helps to identify how urbanization is related to energy consumption in the SAARC countries. Relevant issues relating to this research are also described, so that we can develop an effective conceptual framework to conduct the research. Section 2.2 provides a brief overview of urbanization, energy resources, economy, and environmental issues. Section 2.3 reviews the different models utilized in analyzing urbanization impacts on energy and their findings. Gaps and weaknesses in the existing literature are discussed in Section 2.4, and Section 2.5 concludes this chapter.

2.2 Reviewing the literature

An increased rate of urbanization in developing countries is a challenging issue in the 21st century, most importantly for a significant number of developing countries in Africa and Asia (Madlener and Sunak, 2011). The urban population is expected to increase from 2.6 to 5.3 billion people in the next 40 years in developing countries (Madlener and Sunak, 2011, p. 45). Besides, in the developing country of the world urbanization is expected to more than triple, from 18% in 1950 to 67% in 2050 (Sadorsky, 2013). Recently, SAARC countries have focused on environment-friendly urbanization in their national planning, which is also consistent with the Goal 11 of the UN SDGs framework (UN, 2015). Furthermore, the urbanization and energy use relationship has been studied extensively in recent years, but there are only a few studies on the relationship between urbanization and energy consumption in the SAARC countries. The section is reviewing the literature it has documented about these questions: 1) What are the definitions of major issues? 2) What are the main factors of urbanization demand for energy that exist in different regions and country contexts? 3) Is there any relation between urbanization, energy consumption and economic growth or development? 4) How does the process of urbanization affect the environment through energy consumption? Does urbanization lead to efficient energy use?

This section will be divided into different subsections that should be identified such as a brief overview of urbanization and energy use; economic development in terms of urbanization and energy consumption; relation between urbanization and the environment; the empirical analysis of urbanization impacts on energy consumption.

2.2.1 Concepts of urbanization, energy resources and economic development

There are some useful concepts relating to the major research issues that need to be defined for the clarity of what we are going to investigate. It is very important to clarify those concepts transparently with appropriate definition for the discussion of the results and findings.

Urbanization

There is a vast literature defining urbanization. Urbanization is the process in which the population shifts from rural to urban areas, as a result the proportion of people gradually increases in urban areas (Parikh and Shukla, 1995). Other authors, Azam and Khan (2016), noted that urbanization is a process where a significant number of labor force is moving from an agro-based economy to an urban-based industrial economy. In this way, towns and cities are formed and become larger as more people begin living and working in urban areas. In addition, a transferring process occurs in which agro-based workers shift to industrial and service -based workers in the economy (Salim and Shafiei, 2014; Wang et al., 2016). Urbanization may have different meanings for the researchers, who have used it in different ways. “It can be narrowly defined as the physical growth of cities, i.e., the expansion of population size and of urbanized territories” (Chikaraishi et al., 2015, p. 302).

On the contrary, “urbanization can be defined broadly as an interrelated process of economic, demographic, political, cultural, technological, environmental and social changes, which involves the concentration of population and economic activities in urban areas” (Chikaraishi et al., 2015, p. 302; Salim and Shafiei, 2014). The impacts of urbanization on the energy consumption is explained by this later concept of urbanization because energy use depends on the relationships between urban growth and human activities such as increases in production and consumption, the rising use of motor vehicles and other household energy usage, etc. (Chikaraishi et al., 2015; Salim and Shafiei, 2014). The growth and structure of the economy can be measured by the urbanization process (Gasimili et al., 2019). However, it is difficult to identify whether economic growth causes urbanization or urbanization causes economic growth, although there is a strong relationship between urbanization and economic growth (Gasimili et al., 2019; Kasman and Duman, 2015).

Human activities, especially in urban areas, are responsible for increasing global warming (Afridi et al., 2019). Madlener and Sunak (2011) explained that urban growth has significantly arisen in less developed countries compared to more developed countries between 1970 and 2010, and it is projected that the urban population will almost double with the highest average urban growth rate of 3.3% per annum between 2010 and 2050 in less developed countries. More importantly, about 83% of the world's urban population in 2050 will live in less developed regions, as the urban growth rate of Africa and Asia is higher than for the rest of less developed countries. Urban areas cover only 2% of the world surface, but they represent about 75% of the world's consumption of resources and produce 70% of the world CO_2 emissions (Madlener and Sunak, 2011; Pacione, 2009). Moreover, the worldwide urban energy demand is dominated by fossil fuels and individual transport is the major factor of urban energy demand in the world.

Azam and Khan (2016) examined the relationship between urbanization and environmental degradation in four SAARC countries, namely Bangladesh, India, Pakistan and Sri Lanka. The study has found that almost 24% more people lived in urban areas between the years 1950 and 2014 in the world, and it was projected that 66% of the world's population would be in urban areas in 2050, according to the United Nations data. More importantly, in Africa and Asia urban populations represented almost 40% and 48% respectively of their total populations in 2014, but the percentages are expected to increase up to 56% and 64% respectively by 2050. The ongoing urbanization process is expected to add 2.5 billion people to the world's urban inhabitants by 2050, with around 90% of the rise occurring in Asia and Africa.

A similar study by Afridi et al. (2019) in the SAARC countries, pointed out that more than 20% of the world's population lives in this region, and the average urban population in these countries represents 34%. However, the urban population grew by 130 million over the period 2001 to 2011 and it is expected to rise by almost 250 million by 2030 in this region. The growth has led to an increase in the demand for energy that depends on traditional energy sources.

Energy consumption

Energy is defined as an indispensable input for the survival of human beings on earth (Halder, Paul, Joardder and Sarker, 2015). Dincer (2000) identified energy as the convertible currency of technology. Energy consumption plays a vital role in the economic growth process directly and/or as a complement to the factors of production labor and capital (Apergis and Payne, 2012). The demand for energy is increasing sharply due to economic growth, rapid urbanization, and industrial development; and the standard of living is greatly affected by the level of energy consumption of any country (Halder et al., 2015; Sinha and Shahbaz, 2018). There are mainly two sources of energy, namely non-renewable and renewable energy that are used to meet the increasing energy demand in the world.

Natural gas, oil, and coal are the main sources of non-renewable energy (Figure 2.1), and about three-fourth of the world's energy is produced from these sources' primary energy consumption (Ghorashi and Rahimi, 2011; Halder et al., 2015). Thomas, Greenstone and Knittel (2016), assess that the world has 50 more years of oil and gas reserves, however the production of gas and oil will drop to roughly 40- 60% by 2030 compared to 1970s (Finley, 2012; Kahia, Aïssa, and Charfeddine, 2016). In addition, oil and coal exploitation have ultimately led to forest destruction, biodiversity extinction and natural disasters (Kahia et al., 2016). However, the management of nonrenewable energy resources has been another major concern with regard to regional economic development and environmental protection for their demand, supply and allocation among various users related issues (Liu, Huang, Fuller, Chakma, and Guo, 2000). Jebli, Youssef and Ozturk (2016) have found that the consumption of non-renewable energy (oil, coal, and natural gas) and economic growth are positively correlated.

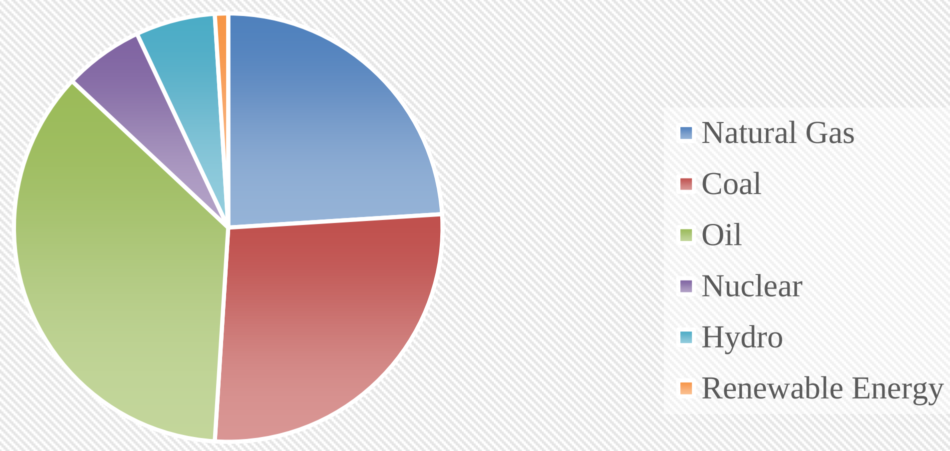

Figure 2.1: Global Energy Resource

Source: Mrabet et al., 2019

Energy security is a problem facing not only energy importing countries but also energy producing countries due to the environmental consequences of producing and using fossil fuels, energy prices are volatile, and the geopolitical climate surrounding fossil fuel production in the world (Apergis and Payne, 2012; Apergis, Payne, Menyah and Rufael, 2010; Kahia et al., 2016). One of the most important factors is the transition to sustainable energy resources that can contribute to achieving sustainable development (Dincer, 2000). A secure and sustainable supply of energy resources is a necessary but not a sufficient condition for development within a society. Energy security and environmental challenges issues can lead to increase in energy efficiency use and the search to find alternative sustainable energy sources to replace non-renewable energies (Apergis et al., 2010). Renewable energy sources are considered the most effective sources that provide some solutions to the problems of energy security, of sustainable development and environmental degradation (Lotz and Dogan, 2018). In addition, a study by Tahvonen and Salo, (2001) explained that many of the renewable energy forms are presently in use and have been in use since before the industrial revolution. “In fact, the transition between renewable and nonrenewable energy forms may follow a pattern where at an early developmental stage economy uses mainly renewable energy. Later the share of renewable energy declines as the share of fossil fuels increases” (Tahvonen and Salo, 2001, p. 1381).

Renewable energy is derived from natural sources such as sunlight, water and wind, sources which are replenished at a higher rate than they are consumed (Falcone and Beardsmore, 2015; SEA, 2013). “The main difference between renewable energy sources and fossil fuels or solid minerals is that, during the lifetime of the project, the renewable energy source is being replenished” (Falcone and Beardsmore, 2015, p. 7). A renewable energy source is the primary energy (e.g. sun, wind, biomass, earth heat, river flow, tides, waves) available for extraction of (and conversion into) energy products (Ghorashi and Rahimi, 2011; UNFC, 2014).

Renewable energies are produced from the resources that are reproduced continuously by natural means, and can be reused due to their environmentally-friendly and sustainable properties (Halder et al., 2015). Another advantage of renewable energy is to give access to energy to remote rural areas where there is abundance of natural resources, without having to extend the national grid (Lotz and Dogan, 2018). Renewable energy is projected to be the fastest growing world energy source, because almost 13.1% of the world total primary energy is already supplied by this source in 2004 (Apergis et al., 2010). More importantly, globally electricity generation by renewable energy will grow by an average of 3% per year and renewable energy consumption will increase by 2.6% per year over the period 2007 to 2035. Hydroelectricity and wind energy are projected as the largest shares in total renewable electricity generation at a percentage of 54% and 26%, respectively (Apergis and Payne, 2012).

South Asia is one of the regions in the world as lowest ranked to per capita energy consumption and produced electricity with less than 50% of their available potential (Mudakkar et al., 2013). However, most SAARC countries mainly used energy from nonrenewable sources (oil, natural gas, and coal) that are a source of threat to the environment, although they have a lot of renewable energy sources such as wind, solar, hydro, biogas. Due to the lack of investment to introduce renewable energy technologies, they continue to rely on non-renewable sources (Zeb, Salar, Awan, Zaman and Shahbaz, 2014).

Economic development

The process of economic development is related to the movements of the economic growth, urbanization, migration, structural transformation, technological change, the environment and so on (Parikh and Shukla, 1995). Economic growth (real GDP), the relative prices of energy (REP), foreign direct investment (FDI) and financial development indicators are important determinants of economic development, as well as energy consumption (Mudakkar et al., 2013). Multiple factors are responsible for increased energy consumption such as the high level of urbanization, growing population, accelerating economic activities, increasing industrial activity and running a large number of vehicles, all of which lead to economic development (Afridi et al., 2019).

Sustainable economic development is vital to improving social welfare (Azam, Khan, Zaman and Ahmad, 2015). Azam et al. (2015) explained that one of the central goals of sustainable development is to promote a healthy economy that produces many resources to meet population needs and the needs of next generations on the one hand and enhances environmental quality on the other hand. Moreover, sustainable development aims to confirm availability of sufficient supplies of energy to diminish the adverse effects of energy use to desirable levels to help consumers to fulfill their demands with less energy input through healthier energy efficiency. Energy sources refer to where the energy is acquired from the environment and provided to the economy (i.e., coal, mine, oil, solar, wind and water on the turbine, etc.).

Energy is an important driving factor of economic growth, industrialization, urbanization as well as overall economic development (Ahmad and Majeed 2019; Imran and Siddiqui, 2010). With the rapid increase in the world population, urbanization and industrial activities, these factors cause increased demand for energy (Ahmad and Majeed 2019), because, according to economic theory, land, labor and capital are the main factors of production, and they all require energy; more recently, technology is also added to the factors of production (Imran and Siddiqui, 2010). But energy can also be mentioned as a production factor apart from labor and capital. Furthermore, energy is a key player in the production processes because it can directly be used to produce a final product (Azam and Khan, 2016; Imran and Siddiqui, 2010). All production and many consumption activities require energy as an essential input (Imran and Siddiqui, 2010). Demand for all consumption is increased, as a result, the increase in energy demand causes an increase in carbon dioxide emissions, one of the leading sources of environmental degradation also (Ahmad and Majeed, 2019).

There are three sectors in the economy of any country, namely, agriculture, manufacturing and services. Sen (2016) explained that structural transformation is not only an important factor of economic growth but also a core condition of economic development. Structural transformation is the movement of workers from low-productivity sectors such as agriculture to high-productivity sectors such as manufacturing and services in the country. This movement leads to an increase in aggregate productivity and income in the economy (Sen, 2016), but also an increase in energy consumption. For example, Tang and Shahbaz (2013) assessed the causal relationship between electricity consumption and real output at the aggregate and sectoral levels using annual data from 1972 to 2010 in Pakistan. The results revealed that there is a unidirectional causality running from electricity consumption to real output at the aggregate level in Pakistan. However, at the sectoral levels, this relationship is also consistent for the manufacturing and services sectors, while not for the agricultural sector. Similarly, Imran and Siddiqui (2010) examined the causal relationship between energy consumption (EC) and economic growth (EG) in the case of three SAARC countries i.e., Bangladesh, India, and Pakistan, by using the data from 1971 to 2008. The results showed that there was a direct/positive relationship between energy consumption and economic growth in the long run.

2.2.2 Factors of urbanization

The urbanization and energy consumption relationship has been the subject of some recent studies. Some of these studies have found that energy demand responds positively to the changes in urbanization level (Jones, 2004; Madlener and Sunak, 2011; Mrabet et al., 2019; Parikh and Shukla, 1995; Wu et al., 2019). Other studies argue that urbanization could lead to a decrease in energy use (Ewing and Rong, 2008; Lariviere and Lafrance, 1999; Lin and Ouyang, 2014). The majority of previous studies in different countries has shown that urbanization has a direct impact on energy consumption. For example, Parikh and Shukla (1995), Zhao and Zhang (2018), identified three main reasons why urbanization increases energy use per capita: demand for industries and infrastructure; demand for transportation; and household demand to increase the quality of life. It is a common phenomenon to see an upward energy demand for urbanization from developed to developing economies. In this section, I will analyze how energy-use is affected by urbanization.

Industrialization and infrastructure

Urbanization is a transformation process in which rural populations or laborers/labor force shift into urban communities or activities; it is also a factor of socio-economic development of the economy (Salim and Shafiei, 2014; Wang et al., 2016). This structural transformation of the economy requires more energy consumption to meet various consumers demands, because the production shifts from low-energy intensity production to high-energy intensity production (Madlener and Sunak, 2011; Wu et al., 2019). This transformed production is affected by new buildings, new technologies, and overall industrialization (Madlener and Sunak, 2011). The extent of urban areas depends on industrial development. Because the process of urbanization becomes the main driving force that shapes the economic structure, due to its positive effect, it promotes the development of the industrial sector (Yassin and Aralas, 2019).

However, the rapid growth of production and manufacturing, which are the major components of industrialization, will occur in the extended urban areas. Although economic growth by industrialization is fast in Asian countries, structural transformation and economic performance are not equally positive (Sen, 2016). According to Azam and Khan (2016), the industrial sector is responsible for the extent of urban areas and increasing urban density leads to decreasing population density in rural areas and the agricultural sector. Economic growth and industrialization have encouraged fast population growth and urbanization growth in Asia. Moreover, energy is one of the factors of production and plays a crucial role in the economic development and growth process. As a result, urban population is a significant variable for energy usage at the macro-level of energy consumption.

Chen, Lu and Zhang (2009) suggested that industrialization and high economic growth rates have increased the population growth rate and resulted in fast urbanization in the Asian region. In this connection, Rahman (2019) explained that industrial growth simultaneously leads to economic development by cross-sectoral growth, and to enlarged urban areas in Bangladesh. He pointed out that the development of Bangladesh has occurred mainly through industrialization which increased urbanization and, finally, increased energy demand. More importantly, buildings are responsible for approximately 40% of total energy demand in urban areas. So, industrialization is a part of urbanization, which works mainly depending on the supply of energy and its efficient use.

Transportation

The demand for transport is positively correlated with urbanization through population and quantitative growth in GDP (Poumanyvong et al., 2012). Economic growth is also related to urbanization as an important factors in explaining increased travel demand and transport energy use in recent years (Rahman, 2019). However, movements of people, goods, and information increase due to motorized transport modes and have positive effects on economic development (that mean qualitative improvement in quality of life, health, education, etc.) in our modern society (Poumanyvong et al., 2012; Shahbaz et al., 2015). It is a fact that if the population is large, transport demand increases. And economic growth leads to an increase in vehicle ownership and mobility demands, as a result of increasing transport energy consumption. Urban citizens use more private transportation compared to rural people (Shahbaz et al., 2015), and product shipments rise through transportation; as a result, energy demand increases (Jones, 1991; Parikh and Shukla, 1995). On the other side, as urbanization causes a rise in incomes and standards of living, it leads to increased motorized individual transport, implying greater energy demand and emissions also (Rahman, 2019).

Salim and Shafiei (2014) have found that transporting goods and services now accounts for 30% of global energy consumption due both to the policy of unlimited economic growth and to globalization, a share that increases with the spatial and functional differentiation of economies and the shift from rural to urban lifestyles. Due to increases in travel distances and mobility of passengers and freight in urban areas more energy is likely to be consumed.

Poumanyvong et al. (2012) explained that economic growth increases transport demand in the country, directly related to urbanization. They found that about 80% of the global gross domestic product (GDP) in 2007 was produced in cities. In addition, use of transport is influenced by growth of urbanized population. There are two points of view concerning urbanization which increases both the quantity of passengers and freight, and the distance over which passengers and freight are transported. First, the growth in urban population increases movements of passengers and freight. Second, urban areas extended, imply longer travel distances due to urbanization.

Using a sample of 59 countries, Jones (2004) examined the effect of urbanization on energy consumption. Jones (2004) argued that urbanization increases transport demand in three ways. First, it facilitates economic specialization, the expansion of production and market territories by supplying labor force and consumers, and by increasing the division of labor. This increases movements of raw materials, semi-finished products and finished products. Second, most food consumed in urban areas comes from outside of urban areas and is transported by different fuel-using transport modes. Third, residential areas and workplaces are often separated in urban areas.

Household services

Urbanization is an essential indicator of the structural transformation of the economy caused by natural resources use. Most importantly, sufficient energy needs to be provided for household services in urban areas (Chikaraishi et al., 2015; Salim and Shafiei, 2014). A study identified that the rural population shifts to the urban population by the process of urbanization; as a result, the urban population increases, and the energy consumption also rises (Bakirtas and Akpolat, 2018). Urban density is also a source of energy demand growth (Shahbaz et al., 2015). Jones (1991) has found that a 10% increase in the proportion of the population living in cities increased per capita energy consumption nearly 7%, holding constant per capita income and industrialization. Parikh and Shukla (1995) observed that a 10% increase in urban population leads to a 4.7% rise in per capita energy consumption in the country.

Salim and Shafiei (2014) explained that there are several causes of increased energy usage due to urbanization. Their study found that the direct ‘running costs’ of cities are higher for functions like space heating, air conditioning and lighting in residential buildings compared to other urban activities. This scenario is almost the same in the SAARC countries, as explained by Afridi et al. (2019). They have found that among the SAARC countries, India has the largest share of urban population owing to its higher population of the SAARC countries. Pakistan and Bangladesh have the second and third highest urban population in the SAARC region. Both these countries have very large populations. The large population exerts high pressure on energy demand in the urban areas that have more facilities and opportunities compared to the rural areas. As a result, these countries are the main contributors to CO_2 emissions and the quality of their environments has deteriorated significantly.

The urbanization process is associated with an increase in energy-intensive lifestyles and demand for housing (Anser et al., 2020). Poumanyvong and Kaneko (2010) argued that an increase in urban population will increase the economies of scale for public infrastructure such as schools, hospitals, and electricity production which tend to lower the environmental damages by the "compact city" theory (Burton, 2000; Poumanyvong and Kaneko, 2010). Another important consideration is that per capita household expenditure depends on the per capita household income that is higher in urban areas compared to the countryside. This high-income level may ensure higher quality lifestyles in the end (Chikaraishi et al., 2015). The higher living standards in urban areas increase directly or indirectly the energy consumption and, as a result, intensifying global warming (Gasimli et al., 2019).

Poumanyvong and Kaneko (2010) investigated the effects of urbanization on energy use and CO_2 emissions by different income groups in 99 countries over the period 1975- 2005. The findings suggested that the impact of urbanization on energy consumption and/or carbon emissions is positive for all income groups, but this effect is more pronounced in the high-income countries group than in the other income groups countries. Similarly, Imai (1997) demonstrated that population and urbanization increase energy demand. However, his causality analysis designated urbanization as a cause of population density and energy consumption upsurge.

Cities are also centers of indirect energy consumption including most obviously those resources required to produce food and other biomass energy (Salim and Shafiei, 2014). With lower percentages of population engaged in agricultural activities and the need to supply food to larger non-agricultural populations, primary sector activities become more resource and energy intensive (Jones, 1991).

Other factors

Sometimes energy consumption is affected by informal markets or sectors, especially those sectors which are significant contributors to the process of urbanization in developing countries (Madlener and Sunak, 2011). Kuralbayeval (2019) examined the effects of tax reforms on reducing unemployment by these sectors in developing countries. These sectors generate economic activities, such as employment, income, and others, that are also a component of urbanization as well as of energy consumption in these countries (Kuralbayeval, 2019). The informal sector activity is defined as that economic activity which is neither registered nor taxed by the government, and also not included in GDP (Madlener and Sunak, 2011). Also, the informal sector refers to a sector that creates unregulated jobs and purchases energy from the formal sector. So, this sector quickly includes energy taxes in terms of environmental taxes as well as national taxes for the development of urban areas (Bento et al., 2018).

In addition, urbanization is always the core of the socio-economic development process, as all development hubs such as finance, communication, and transportation are located in the cities of any economy (Gasimli et al., 2019). A study by Azam et al. (2015) has found that urbanization growth has a significantly positive effect on energy consumption. Similarly, Gasimli et al. (2019) showed that there is long-term relationship between energy consumption, trade, urbanization and carbon emissions in Sri Lanka. However, the increasing density of the urban population will cause the deterioration of air quality due to, for instance, the increase in electricity consumption, number of automobiles, and the loss of tree cover as a result of urban development (Mulali et al., 2015). In conclusion, the urbanization process can be linked to both economic development and energy consumption, and subsequently will increase CO_2 emissions (Abbasi et al., 2020). On the other hand, the high urbanization densities will benefit the environment as a result of increased social awareness and the economies of scales for urban public infrastructure (Poumanyvong and Kaneko, 2010; Yassin and Aralas, 2019).

2.2.3 Relation among economic development, urbanization, industrialization and energy consumption

Urbanization is an indicator of economic development, particularly in developing economies where urban density depends on urban structures and energy demand (Madlener and Sunak, 2011). Economic development and growth generate both increasing urbanization and energy consumption through the raising demand for goods and services consumption and increasing production of commodities (Bakirtas and Akpolat, 2018). Urban areas may also be expected to house energy-intensive economic activities such as manufacturing, transportation, and other economic development activities (Poumanyvong et al., 2012; Shahbaz et al., 2015; Wang, Fang, Guan, Pang and Ma, 2014). Parikh and Shukla (1995) explored the different effects of urbanization, economic structure, population density, and economic growth on energy consumption across both developed and developing economies. They have found that urbanization, economic structure, and economic growth augment energy consumption, while population density lowers energy consumption (Shahbaz et al., 2015).

Shahbaz, Khan and Tahir (2012) investigated the relationship between energy consumption and economic growth by incorporating a number of growth variables in the case of China over the period 1971–2011. The results of the study revealed a unidirectional causal relationship running from energy consumption to economic growth. There is also a bidirectional causality between trade and energy consumption; capital and energy consumption; financial development and economic growth, and international trade and economic growth (Shahbaz et al., 2012). Similar findings by Azam et al. (2015) have shown that foreign direct investment (FDI) inflows, economic growth, trade openness and a high human development index have positive and statistically significant impacts on energy consumption.

Sadorsky (2013) explained that energy intensity tends to highly correlated with developed countries than developing countries but income, urbanization and industrialization etc. affect energy intensity also. As a result, it is difficult to measure to the impacts of urbanization on energy intensity because on the one side, urbanization increases energy consumption through increase of consumption and production; it leads to increase in energy efficiency through economies of scale on the other side (Sadorsky, 2013). More importantly, economies of scale and increasing consumption and production are directly or indirectly connected to the industrialization. And the relationship between urbanization and industrialization has become an important factor not only restricting the development of the economy but energy use also (Luo, Xiang and Wang, 2020).

Industrialization refers to an increase in industrial activity that leads to higher energy usage because higher value added manufacturing uses more energy than does traditional agriculture or basic manufacturing (Sadorsky, 2013), or simply defines the process of transformation from traditional agriculture to modern industry (Luo et al., 2020). The process of industrialization can promote the realization of urbanization, promote the growth of urban population, and the improvement of urban functions (Luo et al., 2020). So, the process of industrialization is parallel with the process of urbanization. Similarly, urban growth is an outcome of industrialization and connected with local economic development (Storper and Scott, 2009). Although Luo et al., 2020 explained that the relationship between urbanization and industrialization is an endogenous change and more coordinated in the developed economy but it is an exogenous change with excessive urbanization or lagging urbanization in the in the developing economy. Vollrath, Jedwab and Gollin, 2016 found that in the last few decades the patterns of urbanization did not show parallel pattern with the process of industrialization in the developing country. For example, Nigeria has urbanized same as China as in percentage of city dwellers but the industrial development is not as much as the growth of urbanization (Vollrath et al., 2016). So, the dynamic relationship between urbanization and industrialization is the key to the sustainable development of urbanization (Luo et al., 2020).

Zeb et al. (2014) investigated the relationship among energy consumption, carbon dioxide emissions, natural resource depletion, GDP and poverty in a number of SAARC countries (Bangladesh, India, Nepal, Pakistan and Sri Lanka) over the period of 1975-2010. The results found that GDP and poverty have a positive impact while carbon dioxide emission has a negative impact on energy production. Similarly, an increase in renewable energy production led to a decrease in carbon emissions, whereas, natural resource depletion increased carbon emissions in selected the SAARC region. Subsequently, an increase in energy production led to an increase in GDP which further increased carbon dioxide emissions in the SAARC region. Similarly, a study conducted by Akhmat, Zaman, Shukui, Irfan and Khan (2014) in the same region, has found that environmental indicators have shown significant long -term equilibrium with electric power consumption in this region.

Cetin et al. (2018) examined the relationship between urbanization and CO_2 emissions in Turkey using time series data throughout 1960-2014. Economic growth is a proxy of urbanization and energy consumption represented by CO_2 emissions. The empirical findings revealed that CO_2 emissions are primarily affected by economic growth. The result implied that a 1% rise in per capita energy consumption increases per capita CO_2 emissions by 0.42%. The structural change of the economy, through industrialization and urbanization processes has caused a steady increase in the level of CO_2 emissions in Turkey. They have also pointed out that globally 78% of energy-related CO_2 emissions were produced by 20 countries in the world, whereas the United States, China and India combined contribute more than half of total global emissions. Due to the increasing economic growth and population in the less developed countries, energy demand has increased faster than for other countries (Ahmad and Majeed, 2019). For example, increasing economic growth rate caused a higher demand for energy in South Asian countries. South Asian countries achieved the highest economic growth rate of 6.9% in 2018 and the expected average growth rate is 7.1% for 2019-2020 in most of the South Asian region (Ahmad and Majeed, 2019; WDI, 2018).

Besides, the growth of urbanization in developing countries is higher compared to developed countries (Behera and Dash, 2017). Energy demand is expected to be affected dramatically by the growth and density of urban areas in developing countries. Some studies have investigated the impacts of urbanization on energy consumption in developing countries or regions (Bakirtas and Akpolat, 2018; Behera and Dash, 2017; Ewing and Rong, 2008; Jones, 1991; Parikh and Shukla, 199; Wu et al., 2019; Zhang and Zhao, 2016; Zhao and Zhang, 2018). Bakirtas and Akpolat (2018) have examined the causal relationship between energy consumption, urbanization, and economic growth in new emerging-market countries namely, Colombia, India, Indonesia, Kenya, Malaysia, and Mexico. “It is claimed that these six countries can replace BRICS because these markets seem good governance and sustainable growth and also because these are tipped to provide some of the most exciting growth opportunities for consumer goods manufacturers” (Bakirtas and Akpolat, 2018, p. 110). Therefore, this brings about an accelerating process of an increase in energy consumption.

Moreover, the increased demand for energy consumption of India, China, and other developing countries is a core concern for decreasing reserves of energy, especially nonrenewable energy (Ewing and Rong, 2008). Urban households consume 50% more energy per capita than rural households, which indicates that continued urbanization promotes the growth of national energy consumption, in countries like China (Shahbaz et al., 2015). Besides, the USA is the first, and China is the second-largest energy consumer in the world for its ever-increasing fossil fuel combustion (Rao et al., 2012). Most notably, recently a large number of studies investigated only the relationships between Chinese urbanization and energy consumption by covering possibly all different dimensions and aspects (Bilgili, Koçak, Bulut and Kuloglu, 2017; Lin and Ouyang, 2014; Wanga, 2014; Wang, Chen, Kang, Li and Guo, 2018a; Wang et al., 2019; Wu et al., 2019; Yang, Liu, Lin and Li, 2019; Zhang and Lin, 2012; Zheng and Walsh, 2019).

2.2.4 Urbanization and environmental issues

A number of studies have explored empirically the linkage between urbanization and environmental degradation in connection with various explanatory variables, and taking into account different regions and countries, and novel econometric techniques, but the results are mixed (Abbasi et al., 2020). Climate change is a core issue of all other aspects, namely economic, cultural and ecological issues in the world, that are caused by fossil fuels consumption (Gasimli et al., 2019). In Gasimli et al., 2019 study, carbon emission is a proxy for environmental degradation, that is directly related with economic growth, by using time series data in Sri Lanka. However, unplanned urbanization, due to its close link with economic, social, and environmental issues, can worsen environmental degradation and sustainable economic growth of the country (Abbasi et al., 2020).

Abbasi et al. (2020) explained that human activities are mainly (more than 95%) responsible for the rise in global temperature, which is due globally to the growth in both urbanization and globalization in the last two decades. In the world, 55% of people lived in urban areas in 2018, and the number is projected to grow to 68% by 2050, whereas approximately 90% of the projected growth will occur in Asia and Africa. It is presumed that 80% of the world carbon emissions can be due to urban populations. The study also found a positive and significant impact of urbanization and energy consumption on CO_2 emissions, indicating that urban development and high energy consumption are barriers to improving environmental quality in the long run.

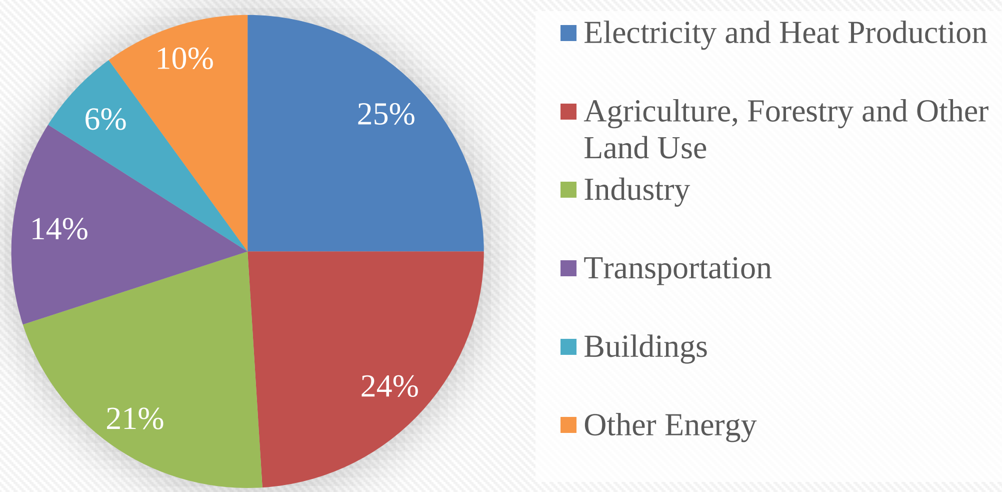

Figure 2.2: Global Greenhouse Gas Emissions by Economic Sector

Source: Rehman and Rashid, 2017

The growth of urbanization has brought several challenges and pressures on the environment (Ewing and Rong, 2008; Poumanyvong et al., 2012; Shahbaz et al., 2015; Wu et al., 2019; Zhang and Lin, 2012). The process of urbanization is highly dependent on the supply of and use of energy. On the contrary, environmental pollution caused by the consumption of energy, especially fossil fuels-based energy, has also become a major bottleneck of urbanization (Wu et al., 2019). Figure 2.2 shows the contribution of different economic sectors to GHG emissions. Electricity and heat production share the major portion (25%) of this emission process and is mainly caused by the burning of coal, oil and natural gas for producing heat and electricity.

The average global temperature is projected to rise between 1.1°C and 6.4°C within this century; and a large number of areas in the world already suffer from reduced sea ice droughts and other extreme climatic events (Ewing and Rong, 2008). On the other side, the transport sector used more than half of oil-based fuel and produced about one-quarter of energy-related emissions in the world (Poumanyvong et al., 2012). So, the transport sector plays a significant role in reducing environmental sustainability (Poumanyvong et al., 2012). In addition, Shahbaz et al. (2015) identified that high urban density exerts pressure on the economic patterns of resource use and environmental quality in the world.

However, half of the world population is living in urban areas, and urban cities consumed more than 50% of the overall energy and produced over 60% carbon dioxide (CO_2) emissions, which contributes to global warming (IEA, 2012; Shahbaz et al., 2015, p. 683). Meanwhile, CO_2 emissions are rapidly increasing from developing countries, especially from China, India, and the ASEAN (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) region since 2005; these countries accounted for almost 50% of the world's CO_2 emissions (Shahbaz et al., 2015, p. 684; WDI, 2012). Figure 2.3 shows carbon dioxide emissions in the SAARC countries in different years. It is evident that CO_2 emission is increasing in the SAARC region; it was just 8% in 1990 while it increased to 19% in 2008 showing an increase of about 11% (Zeb et al., 2014).

It is clear that per capita energy use, as well as greenhouse gas emissions, continuously rise, and advanced technologies cannot achieve sustainable growth in energy use without using renewable energy resources (Ewing and Rong, 2008). The sustainable environment and energy security become core and challenging issues for the well-structured urban planning in any country or economy.

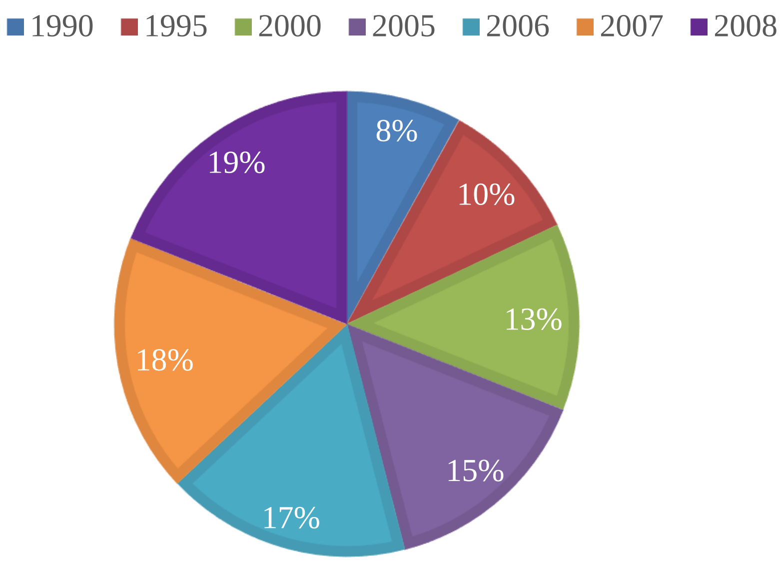

Figure 2.3 : CO_2 Emmisions of SAARC Countries

Source: Zeb et al., 2014

The efficiency of energy savings depends on the relationship between urbanization management and city growth in urban areas (Ewing and Rong, 2008; Zhang and Zhao, 2016). Many studies have concluded that urbanization is significantly correlated with energy consumption, as already discussed above. Also, energy consumption is positively associated with urbanization at the national level, as has been found by Jones (1991) using a sample of 59 developing countries; and by Parikh and Shukla (1995) using a sample of 78 developed and developing countries. On the other hand, urbanization has led to lower per capita energy consumption through energy efficiency, mostly in developed countries like Canada, and USA (Ewing and Rong, 2008; Lariviere and Lafrance, 1999). Similar study, Lin and Ouyang (2014) shown that urbanization growth and energy consumption both increased to the peak point of energy consumption and then energy use was decreased with growing urbanization in the long term, it was possible due to to the enhancement of energy efficiency. For example, each urban citizen consumes 11% less energy for transport than the average resident in the USA (Poumanyvong et al., 2012).

Parikh and Shukla (1995) explained that the fact that economic development has positive impacts on the production of greenhouse gases in the world is a contested issue. Rapid urbanization is a part of economic development, and a cause of increasing environmental degradation. As a result, economic development and urbanization face critical pressure from the international community. There are four most important greenhouse gases that are significant contributors to environmental degradation, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO), and the chloroflourocarbons (CFC). CO_2 is sourced from cement, liquid fuel, solid fuel, gas and gas flaring. More importantly, the use of fossil fuels and cement is directly related to the heightened transportation and construction requirements of urbanization. However, deforestation is a cause of land use change, that is added carbon dioxide to the atmosphere. Methane comes from municipal solid waste, from livestock, coal mining, pipeline leakage and wet rice agriculture. The municipal solid waste component of CH_4 emissions is likely to be associated with measures of the magnitude of the urban population. In addition, discharges of CFCs are more likely to vary with particular types of consumption associated with high income levels. Figure 2.4 shows greenhouse gas emissions by different gases in the world. Carbon dioxide is the main component in greenhouse gas (GHG) emissions and is mainly caused by the burning of fossil fuels in Figure 2.4. However, Fluorinated gases (F-gases) contributes only 2%

in GHG emissions in Figure 2.4. F-gases are man-made gases that consists of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).

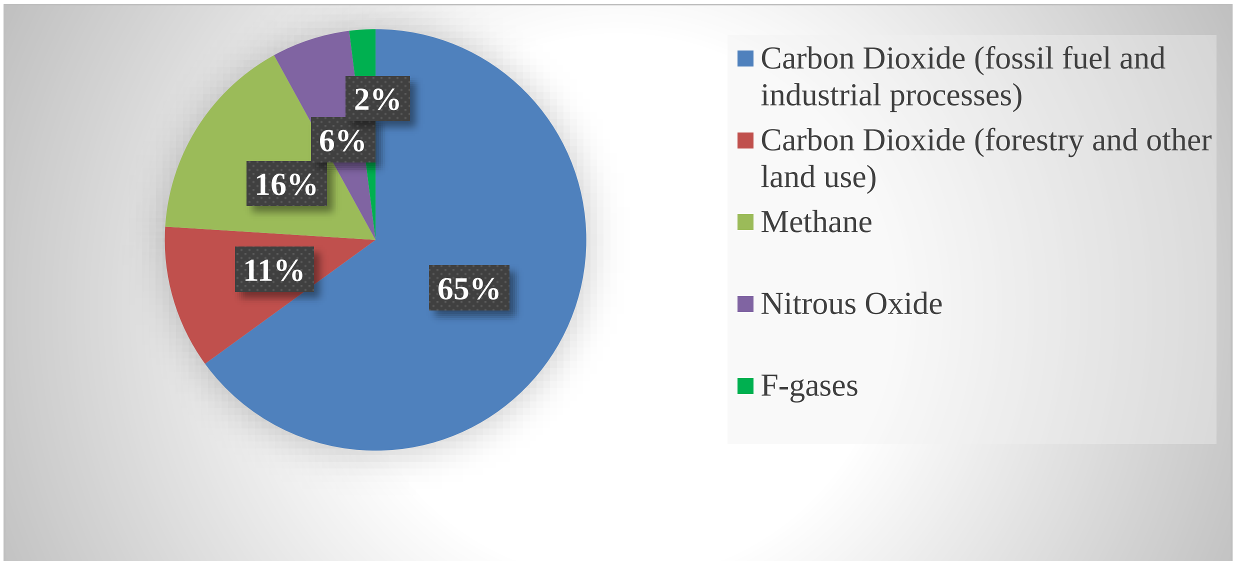

Figure 2.4: Global Greenhouse Gas Emissions by Gas

Source: Rehman and Rashid, 2017

Chary and Bohara (2010) have found that energy consumption has increased by 52% between 1993 and 2003 in SAARC countries, which has raised the carbon emissions levels. Non-renewable energy (mainly coal) is the primary source of energy, a significant contributor to increasing carbon emissions in this region. These authors argued that SAARC countries, namely India, Pakistan, Bangladesh and Nepal, could achieve reduced carbon emissions by reducing their energy consumption through technological improvements in the energy sector. Rehman and Rashid (2017) investigated the role of energy consumption on environmental degradation for emerging and frontier Asian markets. They used CO_2 emissions, GDP and population growth with energy consumption as additional determinants of environmental degradation. Developing countries mainly depend on energy extracted from oil and natural gas, and developed countries have extended in industrialized sectors to increase energy consumption. Both these categories of countries are producing more carbon dioxide emissions causing an environmental degradation.

Anser et al. (2020) pointed out that urbanization changes patterns of resource use through the transition to modern fuels. And there is a positive relationship between the urbanization rate and emissions, owing to the more pollution-intensive consumption patterns of those in urban areas. They found that if the population size increased by 1%, residential carbon emissions increased by 1.16% due to increased demand for residential energy. Furthermore, due to the demand for housing, agricultural land is being converted into residential areas, which has harmed the environment and increased carbon emissions levels.

Zhu and Peng (2012) referred to three different channels through which urbanization affects CO_2 emissions. First, an increase in the city's population will increase residential consumption and energy demand, thereby producing a surge in CO_2 emissions. Second, urbanization generally boosts demand for housing and naturally raises the demand for housing material, which is known as the major source of CO_2 emissions. Thirdly, the clearing of trees and grassland activities, as demand for housing will increase, which determine emission of the carbon stored in the trees.

2.3 Different methods and approaches

Different methods and approaches (both qualitative and quantitative) for estimating the impact of urbanization on energy consumption are found in the literature. Some studies are only based on descriptive analysis, and some studies are conducted using time series analysis for estimating the parameters (Poumanyvong, et al., 2012; Salim and Shafiei, 2014; Shahbaz et al., 2015; Wanga, 2014; Wu et al., 2019). On the one side, some studies are done only based on analysis, for example, Ewing and Rong (2008); Imai (1997); Jones (1991); Kuralbayeva (2019); Madlener and Sunak (2011); Ghorashi and Rahimi (2011); Dicer (2000), and Halder et al. (2015) who used simple analysis methods with common statistical techniques in their research to investigate the effects of urbanization on energy demand.

Most of the researchers have used empirical methods for testing some set hypotheses because the impact of urbanization on energy consumption has a long-run effect or causality that is examined by time series analysis in most of the studies. For example, Poumanyvong, et al., 2012; Salim and Shafiei, 2014; Shahbaz et al., 2015; Wanga, 2014; Wu et al., 2019; Zhang and Lin, 2012; and Zheng and Walsh, 2019, investigated the different aspects of urbanization and energy consumption using time series/panel data analysis. More empirical analyses from different contexts are required to be able to generalize existing knowledge of the effects of urbanization on energy use.

However, Anser et al. (2020); Poumanyvong et al. (2012); Poumanyvong and Kaneko (2010); Shahabaz et al. (2015); Zhang and Lin, (2012); and Yassin and Aralas (2019), applied the model named Stochastic Impacts by Regression Population, Affluence and Technology (STIRPAT) for investigating the impact of urbanization on energy consumption in different areas of the world. Similarly, Salim and Shafiei (2014, p. 583) used the STIRPAT model adopted by Dietz and Rosa (1997) for predicting the effects of urbanization on both renewable and nonrenewable type of energy use and estimating causal effects. Besides, Bakirtas and Akpolat (2018) used the Dumitrescu and Hurlin (2012) panel Granger causality test to examine the causal relationship between energy consumption, urbanization, and economic growth. And Wang et al. (2019) employed the geographically weighted regression (GWR) model to examine the impact of urbanization on energy use as well as on CO_2 emissions. An overview of the methods used by different studies is provided in Table 2.1. As Table 2.1 shows, more empirical studies are needed to analyze specific ways through which urbanization affects energy consumption in the South Asian region.

Table 2. 1: Summary of Different Methods and Results in Existing Literature

Authors	Period/ Study Area	Variables	Methodology	Long-run causality
Azam and Khan (2016)	1982-2013 SAARC countries	CO_2, GDP, URB, EC, TP	Johansen cointegration, OLS	Not investigated
Cetin et al. (2018)	1980-2014 Turkey	CO_2, EG, URB, EC	ARDL, Toda-Yamamoto test, EKC	URB → CO_2
Abbasi et al. (2020)	1982-2017	CO_2, URB, EC	Panel cointegration, Granger causality	URB ↔ EN; EC → CO_2
Rahman (2019)	34 years Bangladesh	EC, EG, URB	ARDL, Granger causality	URB ↔ EC
Mulali et al. (2015)	1990-2013 23European countries	CO_2, EG, URB, FD, REP	Pedroni cointegration, OLS, VECM	EG → CO_2
Gasimil et al. (2019)	1978-2014 Sri Lanka	CO_2, EG, URB, Y, TR	Bounds testing, EKC	EG → CO_2
Zhu and Peng (2012)	1987-2008 China	CO_2, TP, URB, HS	STIRPAT	Not investigated
Yassin and Aralas (2019)	1990-2016 34 Asian countries	CO_2, URB	STIRPAT	Not examined
Azam et al. (2015)	1980-2012 3 Asian countries	EC, UBR, FD, EG, TR, HDI	Sundry test, OLS	Not examined
Afridi et al. (2019)	1980-2016 SAARC countries	CO_2, Y, TR, URB, EC	KEC, FE	URB → CO_2
Chary and Bohara (2010)	1971-2005 4 SAARC countries	CO_2, Y, EC	ARDL, Granger causality	Y, EC→CO_2
Imran and Siddiqui (2010)	1971-2008 3 SAARC countries	EC, EG	Granger causality	EG → EC
Ahmad and Majeed (2019)	1990-2014 5 SAARC countries	CO_2, RE, NRE, TR, URB	FMOLS	Not investigated

Table 2. 1: Summary of Different Methods and Results in Existing Literature				
Mudakkar et al. (2013)	1975-2011 5 SAARC countries	EN, EG, FDI, FD	Granger causality	EC → FDI
Tang and Shahbaz (2013)	1972-2010 Pakistan	EC, GDP	Granger causality	Not investigated
Shahbaz et al. (2012)	1971-2011 China	EC, EG	ARDL, Granger causality	EC → EG
Shahbaz et al. (2016)	1970-2011 Malaysia	URB, EC, TR	ARDL, VECM Granger causality	URB → EC
Poumanyvong et al. (2012)	1975-2005	URB, TE TP, SIG,SSG	STIRPAT	Not investigated
Salim and Shafiei (2014)	1980-2011 OECD countries	URB, TP, EC	STIRPAT, Granger causality	Not investigated
Wu et al. (2019)	2005-2015 China	URB, EC	ARDL, PVAR	Not examined
Zhang and Lin (2012)	1995-2010 China	URB, GDP, TP, EN	STIRPAT, FGLS	URB → EC
Apergis and Payne (2012)	1990-2007 80 countries	GDP, RE, NRE, L	Pedroni heterogeneous	GDP ↔ RE, NRE
Jebli et al. (2016)	1980-2010 25 OECD countries	CO_2, GDP, EC, TR	FMOLS, KEC, Granger causality	EC→ CO_2
Kahia et al. (2016)	1980-2012 MENA countries	EG, RE, NRE, L	FMOLS, Granger causality	EG ↔ RE
Lotz and Dogan (2018)	1980-2011 10 Sub-Saharan African countries	CO_2, RE, NRE, Y, TR	Granger causality	RE → CO_2
Sinha and Shahbaz (2018)	1971-2015 India	CO_2, RE, NRE	KEC, ARDL	RE → CO_2

Source: Author's own design from existing literature

Note: *URB, GDP, GDP*^{2}, CO_2, *EC, TO, FD, GOV, TP, REP, Y, HS, HDI, EG, RE, NRE, FDI, SIG, SSG, TO, L, NE denote urbanization, per capita real GDP, the square of per capita real GDP, carbon emissions, energy consumption, trade openness, financial development, government effectiveness, total population, renewable electricity production, income, household size, human development index, economic growth, renewable energy, nonrenewable energy,* *foreign direct investment, share of industry in GDP/industrialization, share of services in GDP, transport energy, labor force, nuclear energy respectively. → and ↔ indicate unidirectional causality and bidirectional causality, respectively.*

2.4 Gaps and weaknesses in the existing literature

Urbanization and energy use relationship has been studied extensively in recent years. This review of the existing literature (Table 2.1) has outlined some gaps or weaknesses. The general gaps are summarized below:

- Earlier studies explained the relationship between urbanization and energy consumption by focusing on developed countries where the process of urbanization is almost completed. The very few studies of developing countries have increased in number recently, and China is an identified country where this issue works with different aspects. The results, however, are not homogeneous because of different urbanization systems, socio-economic conditions, and availability and accessibility of energy resources and technological states.
- Most of the economic studies on the impact of urbanization on energy consumption have focused on energy as a whole, including all energy types in one category. Therefore, there is scope for further area or country-specific studies with particular focus on specific types of energy, namely renewable and nonrenewable energy. However, the number of studies on important types such as renewable and nonrenewable energy sources is very limited.
- Most of the past cross-sectional studies are based on country or bi-country level data. Moreover, the results from those studies were not robust because of insufficient statistical

and diagnostic tests. Previous studies using cross-sectional time series are very limited and have not analyzed the different energies in a region.

- In the case of SAARC, there are few studies, mostly focused on India as a country but empirical studies are very scarce.

2.5 Conclusion

This literature review has provided definitions of the major concepts to clarify the actual meaning of the terms used in this research. It is very important to define the relevant concepts, such as urbanization, economic development, and energy resources, in order to relate the research findings with the research purpose. Urbanization does not only affect energy usage but also the economic development in the economy. The major research objective is to identify the relationship between urbanization and energy use in the South Asian region. However, existing literature is less clear about what type of energy is more likely to be affected by urbanization. Existing literature is also reviewed in terms of the major research methods so that we can understand the theories and explanations made by other authors in the chosen field.

Chapter Three

Methodology

3.1 Introduction

Methodology means a way of solving research problems systematically. Research methodology consists of what type of data (primary or secondary and quantitative or qualitative) and how data has been collected, as well as the techniques used for data analysis in the study. This chapter focuses on the selection of research methods and approaches. It attempts to justify why a particular method is chosen, and why this has been useful for the research. Research methods and approaches, data collection techniques, data analysis methods and study area are discussed in this chapter. It is attempted to discuss the importance of particular research methods and data collection techniques in relevance to the major research objectives and questions. Actually, both the conceptual framework and the methodology help to provide a guideline for the research.

Accordingly, this chapter is organized as follows. Section 3.2 outlines research methods and approaches. Section 3.3 and Section 3.4 outline the study area and source of data, respectively. Section 3.5 outlines the methodology used for measuring the trend of urbanization and energy consumption. Section 3.6 outlines the methodology used to estimate the effects of urbanization on energy consumption at the country level. Section 3.7 outlines the methodology used to analyze the 3rd research question at the aggregate level and Section 3.8 concludes this chapter.

3.2 Research methods and approaches

The application of quantitative research method can be essential to investigate the relationship between urbanization and energy consumption. We also choose to apply an exploratory research approach to find out how energy consumption is fostered by the process of urbanization in the SAARC countries. This section outlines in detail the methodology used in answering below the research questions. There are two common methods, namely qualitative method and quantitative method, that can be used for the research (McCusker and Gunaydin, 2015; Punch, 2013).

It is considered that the application of qualitative research method is related to understanding the experiences and attitudes of some aspect of social life but something in economic, business as well as social issues needs to be measured that can be effectively conducted by applying qualitative methods (McCusker and Gunaydin, 2015; Shields and Twycross, 2003). “Qualitative methods aim to answer questions about the ‘what’, ‘how’ or ‘why’ of a phenomenon rather than ‘how many’ or ‘how much’, which are answered by quantitative methods” (McCusk and Gunaydin, 2015, p. 537). A quantitative method allows a deductive approach that enables the researcher to test a hypothesis. More importantly, the quality of data is essential for quantitative research. If the data are not of high quality, all statistical calculations will be either wrong or of inferior quality (McCusker and Gunaydin, 2015).

As the study aims to examine the effects of urbanization on energy consumption in the SAARC countries, over the time period 1985-2014, a deductive reasoning approach will be used in this research. Because a deductive approach is related to design of a research strategy to test a hypothesis in quantitative analysis. Deductive approach is offered to examine causal relationships between variables, whereas the inductive approach is concerned with the new ideas emerging from the data (Kothari, 2004). The study provides a hypothesis as to the probable results, then works to get enough data to prove or not that hypothesis and sets up experimental design with dependent and independent variables. Empirical research is appropriate when proof is sought that certain variables affect other variables in some way, and empirical studies is considered to be the most powerful support possible for a given hypothesis (Kothari, 2004; Vanderstoep and Johnson, 2008). Besides, there are eight members in the SARRC region over the period of 40 years, that is defined a large N study, that most suitable for testing the hypothesis is quantitative analysis. The design of the study is provided in Table 3.1.

Table 3.1: Design of the Study

Objective	To examine how urbanization affects energy consumption in the SAARC countries.	Type of Question/ Approach/ Study
Question	1. What are the trend urbanization and energy consumption?	Descriptive
	2. Which urbanization factors are influencing the energy consumption at the country level?	Explanatory
	3. Is there a causal relationship between urbanization factors and energy consumption at the aggregate level?	Explanatory
Hypothesis	There is a causal effect relationship between urbanization and energy consumption.	Deductive
Study Area	Eight Countries-Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka with 30 years	Large- N

Source: Author's own design

The selection of research design and appropriate methods is very important to collect and assess data relating to the major variables of the research. The research study is conducted by the quantitative research method with the adaptation of exploratory research investigation. Secondary data collection method is used in this research.

3.3 Study area

The South Asian Association for Regional Cooperation (SAARC) provides a platform for the peoples of South Asia. The main objective of this organization is to work together for improving their quality of life through socio-economic and cultural development in the region (SARRC, 1985). There are seven founder members, namely Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka, in this association established in 1985, and Afghanistan joined in 2005 (SARRC, 2007). According to International Monetary Fund (IMF) data, this region represents

3% of the world's area, 21% of the world's population and 3.8% of the global economy, as of 2015 (SARRC, 2015). India is the largest country in South Asia. It is the second-most populous country, containing 17.50% of the world's population and the seventh-largest country by land area in the world (SAARC, 2015). According to number of population Pakistan is the second largest country in this region followed by Bangladesh, Afghanistan, Nepal, Sri Lanka, Bhutan and Maldives (SAARC, 2015).

Recently, the SAARC countries have included an increased concern about environmentally-friendly urbanization in their national development planning (Khwaja, Umer, Shaheen, Sherazi, and Shaheen, 2012; LGED, 2017; Kawsar, 2012) which is also consistent with the proposed major targets set in the 2015 UN Sustainable Development Goals (SDG) framework, especially goals 7 and 11 (2016-2030) which are directly linked to sustainable energy and safe urbanization (UN, 2015).

Table 3.2: Features of the Study Area

	Population (%)		**Total area**	**Sectoral share of GDP (%)**		
Country	Rural	Urban	(Skm.)	Agricultural	Industrial	Service & others
Afghanistan	75.20	24.80	652860	20.63	22.12	57.24
Bangladesh	65.70	34.30	147630	14.78	26.83	58.39
Bhutan	61.32	38.68	38394	16.71	41.33	41.96
India	67.22	32.78	3287259	16.17	27.35	56.48
Maldives	61.47	38.53	300	5.56	10.68	83.75
Nepal	81.44	18.56	147180	29.38	13.72	56.90
Pakistan	63.97	36.03	796100	23.82	19.09	57.09
Sri Lanka	81.74	18.26	65610	8.18	27.17	64.65

Source: The World Development Indicators (May 28, 2020)

However, there is no consensus as yet on how urbanization could affect energy consumption in ways that can promote sustainable development. Furthermore, there are only a few studies on the SAARC countries concerning this issue that focus on urban density in the empirical literature. This South Asian area has been selected purposively as a study area due to a lack of research on this topic in the area, and also because the researcher is interested and familiar with this area. Main features of the study area are provided in Table 3.2.

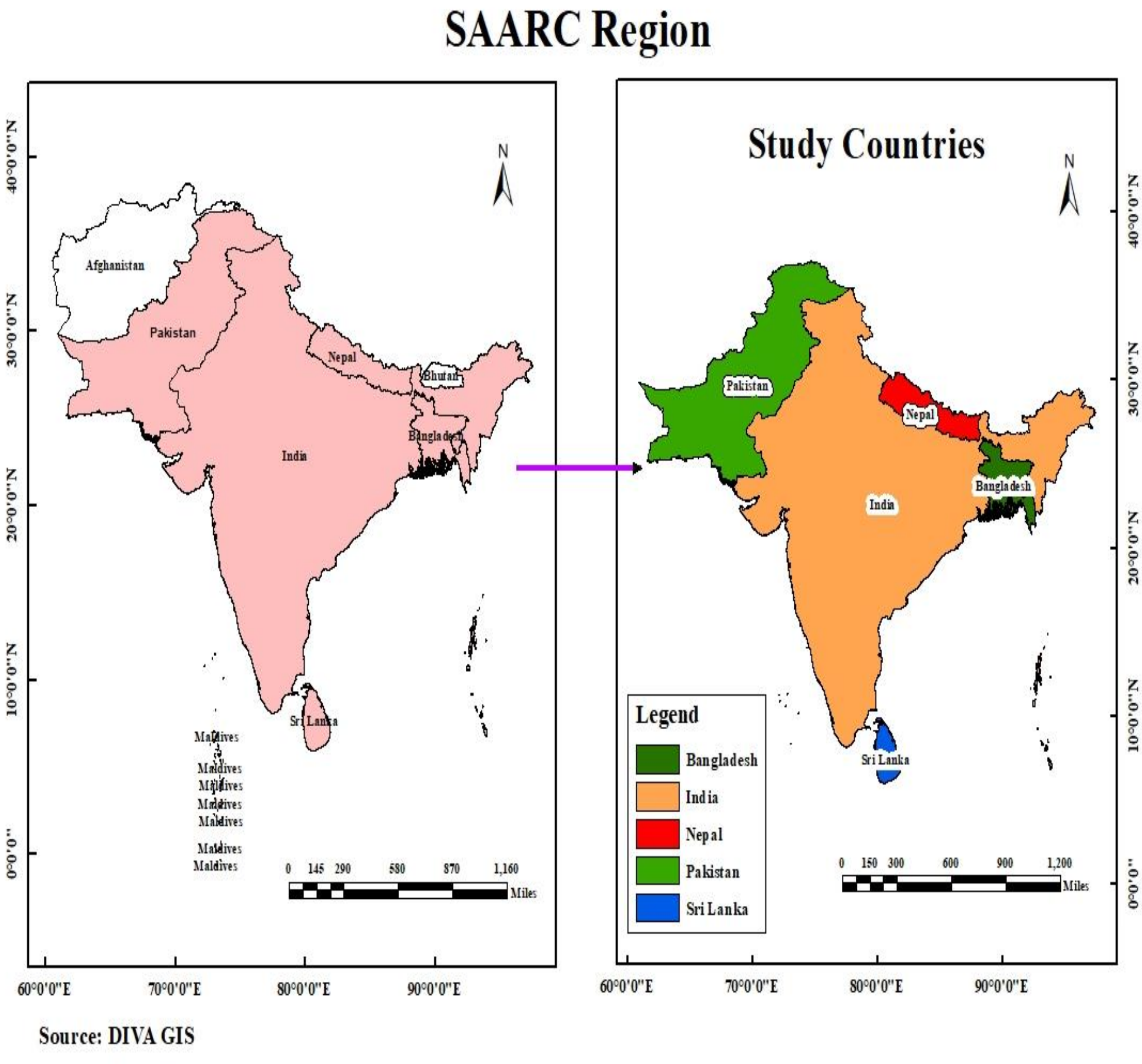

Figure 3.1: Map of the Study Area

3.4 Source of data

This research will compare the relationship between urbanization and energy consumption in five selected SRRAC countries (namely, Bangladesh, India, Nepal, Pakistan and Sri Lanka) by using national-level secondary data. These countries are selected because of not only availability of data but also their vital importance to an emerging region like SAARC. Using secondary data is a less costly and time-consuming way to get a large amount of data (Spiegel and Stephens, 1998). Another important advantage of secondary data is that it is recorded by time, so any comparative analysis against time is possible by using only secondary data. However, there are problems with secondary data, such as how the data has been collected and how accurate the data is, generally which type of collected data to use (Hox and Boeije, 2005). If secondary data will be used in the study, we need to make sure that the source is reliable and that it can provide exactly the information the researcher is looking for the study (Hox and Boeije, 2005). In addition, panel data refer to data for multiple entities such as individuals, firms, countries, in which outcomes and characteristics of each entity are observed at multiple points in time (Gujrati, 2004). Such data can be used to examine the causal relationships among different times and places; and the dependence of one on another.

The secondary data will be collected from the World Development Indicators database (WDI) from the selected regions and from various departments of the governments of the selected countries. The World Development Indicators is the most extensive database (WDI, 2016) that includes all aspects of development, by periods, and national levels in the world. This data will be complemented with government sources of data, which is also reliable data at the aggregate level in any country, for the reliability and accuracy of data. Besides, the rationale for selecting the time period from 1985 to 2014 is that the SAARC association was established in 1985.

Though the major research method is quantitative in this study, there are some qualitative data used in the study in order to explain some previous research findings that are relevant to the research issue. After data collection, analyzing data is a continuous process. The objective of this study is to explore the relationship between energy consumption and urbanization by step by step examining the research questions.

3.5 Methods for the trend of urbanization and energy consumption

The first research question, the trend of urbanization and energy consumption is examined by some descriptive statistics such as mean, standard deviation and coefficient of variation (Lin and Ouyang, 2014). However, a simple graphical method, a line chart, will be used in the study to explore the trend of different variables.

3.5.1 Mean

Mean is computed by dividing the sum of a set of values by the number of values. The formula for calculating (Spiegel and Stephens, 1998) the mean is:

$$\bar{X} = \frac{\sum_{i=1}^{n} x_i}{n}$$

where $\sum_{i=1}^{n} x_i$ is the sum values of the observations and n is the number of observations.

3.5.2 Standard deviation

One of the simplest ways of measuring variability is to use the standard deviation estimator in measuring dispersion. The formula for standard deviation (Spiegel and Stephens, 1998) is as follows:

$$S_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}}$$

where S_x is the estimator of the standard deviation of x variable and x_i is ith observation of x variable. The value of the standard deviation is closer to zero, the smaller is the dispersion for a set of data. This implies that the data values are closer to the mean value and that the data is more reliable for analytical purposes.

3.5.3 Coefficient of variation

The standard deviation as a measure of dispersion is not easy to interpret on its own. Generally, a small value for the standard deviation shows that the dispersion of the data is low and vice-versa. However, the magnitude of these values depends on what is being analyzed. A method to overcome the difficulty of interpreting the standard deviation is to take into account the value of the mean of the dataset and employ the coefficient of variation. The coefficient of variation, V_x, is a relative measure of variability and defined as follows (Spiegel and Stephens, 1998):

$$V_x = \frac{S_x}{\bar{x}}$$

3.5.4 Simple graphical method

A line graph is a graph which uses lines to connect individual data points that display quantitative values over a specified time interval. Graphical methods are typically used with quantitative statistical evaluations. Graphical methods provide information that may not be otherwise apparent from quantitative statistical evaluations, so it is a good practice to evaluate data using these methods prior to performing statistical evaluations (Spiegel and Stephens, 1998). In the chart, time is measured as years and different variables are measured as different units. They are denoted on the horizontal and the vertical axis, respectively.

3.6 Methods for impacts of urbanization factors on energy consumption at the country level

The second research question in the study area is examined by regression analysis of time-series data at the aggregate level. The influence of one or more independent variables on a dependent variable is examined by regression analysis (Spiegel and Stephens, 1980). An independent variable is defined as a variable that is not changed by the other variables, that is also called the cause of events. On the contrary, a dependent variable is a variable that is changed by other variables and it defined as the effect or result for an experiment (Spiegel and Stephens, 1998). So, regression analysis is a reliable method to identify which variables have impact on others, and anyone can easily use it to examine the relationship between different variables. The application of any regression model requires the time series of the concerned variables to be stationary which means that the mean and variance of each variable do not vary systematically over time (Shahbaz, Hye, Tiwari and Leitão, 2013; Hocaoglu and Karanfil, 2013; Ozturk and Acaravci, 2013). So, there are three steps to examine the second research question as follows.

3.6.1 Unit root

It is necessary to examine whether the time series of the variables are stationary before performing the regression analysis. (Gujrati 2004; Ozturk and Acaravci, 2013). A time series variable is said to be non-stationary (or stationary) if it has non-constant (or constant) mean, variance and autocovariance (at various lags) over time. If a non-stationary series has to be differenced d times to become stationary, then it is said to be integrated of order d, i.e. I(d). The Augmented Dickey–Fuller (Dickey and Fuller, 1979) (ADF) test is employed to examine unit roots for stationarity, and used to a larger and more complicated time series data (Munir and Khan, 2014). However, the ADF test is used to test for the existence of unit roots and determine the order integration of the variables in country by country basis. For this, the ADF test requires the equation as follows:

$$\Delta X_t = \alpha_o + \beta X_{t-1} + \delta_{1t} + \sum_{i=1}^{m} \mu_i \, \Delta X_{t-i} + \epsilon_t \qquad (1)$$

Where t is the trend variable, ϵ_t is a pure white noise error term and $\Delta X_{t-1} = (X_{t-1} - X_{t-2})$, $\Delta X_{t-2} = (X_{t-2} - X_{t-3})$ and so on. The test for a unit root has the null hypothesis that $\beta = 0$. If the coefficient is statistically different from 0, the hypothesis that $X_t$contains a unit root is rejected.

However, the power of individual unit root tests can be distorted when the span of the data is short (Christopoulos and Tsionas, 2004; Nasir and Rehman, 2011; Ozturk and Acaravci, 2013; Pierse and Shell, 1995).

3.6.2 Cointegration test

The next step is cointegration test that is testing hypotheses concerning the relationship between variables when they are nonstationary (Ahmad and Majeed, 2019; Chary and Bohara, 2010; Munir and Khan, 2014; Wang, Kang,Wang and Xu, 2017; Zeb et al., 2014). For instance, if two or more series are themselves non-stationary, but a linear combination of them is stationary, then the series are said to be cointegrated (Chary and Bohara, 2010; Munir and Khan, 2014). More importantly, regression analysis is said to be done best, by linear and by ordinary least squares method, with the help of a cointegration test (Munir and Khan, 2014). Cointegration tests are very sensitive to the choice of lag length and to the methods employed in dealing with any non-stationarity of the time series. There are two main approaches used to test the existence of cointegration relationships: the Engle-Granger and the Johansen procedures. We employ Johansen's procedure to test for cointegration between the two series. The Johansen (1988) approach relies on the relationship between rank of a matrix and its characteristic roots and it estimates long-run relationships between non-stationary variables using a maximum likelihood procedure. The Johansen tests are on the rank of the coefficient matrix Π of the equation Johansen and Juselius (1990) and have the following form:

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \cdots + \Gamma_{k-1} \Delta x_{t-k+1} + \Pi X_{t-k} + \mu + \epsilon_t$$

The null hypothesis for r cointegrating vector is

$$H_0 : \Pi \text{ has a reduced rank, } r<k$$

Where X_t is a k*1 vector of I (1) variables of $\Gamma_1 \ldots\ldots \Gamma_{k-1}$. Π is k*k matrices of unknown parameters, and the coefficient matrix contains information about the long-run relationship. The reduced rank condition implies that the process Δx_t is stationary and x_t is non-stationary. Three cases are possible for Π. Firstly, if Π is of full rank, all elements of X are stationary, and none of the series has a unit root. Secondly, if a rank of $\Pi = 0$ it implies an absence of stationary combinations and no cointegrating vectors. Finally, if the rank of Π is between r and k, the X variables are cointegrated and there exists r cointegrating vectors.

The presence of distinct cointegrating vectors can be obtained by determining the significance of the characteristics roots of Π. We use both the trace test and the maximum eigenvalue test to determine the significance of the number of characteristic roots that are not different from unity. Both tests are expressed as follows:

$$\lambda_{trace}(r) = -T\sum \ln(1 - \lambda_1)$$

and

$$\lambda_{max}(r, r + 1) = -T\sum \ln(1 - \lambda_{1+1})$$

Where λ_i are the estimated values of the characteristic roots obtained from the estimated Π matrix, r is the number of cointegrating vectors, and T is the number of observations. The critical values for these tests are tabulated in Johansen and Juselius (1990).

3.6.3 Ordinary least squares (OLS) method

If cointegration tests are satisfied and all the variables are cointegrated, the next step to find the parameters of all the selected variables such as gross domestic product, industrial share in GDP, service share of GDP, urban population and urban population growth rate. Regression analysis estimates are found using either ordinary least squares (OLS) or quantile regression (QR) depending on the distribution of the dependent variable (Spiegel & Stephens, 1998; Gujarati, 2004). The study employed the OLS method to find the regression estimation because of its simplicity and popularity (Ozturk and Acaravci, 2013). The relationship between a dependent variable (Y) and an independent variable (X) can be postulated as a linear regression (Gujrati, 2004, p. 58-62):

$$Y = \beta_0 + \beta_1 X + u \qquad (2)$$

where β_0 and β_1 are regression coefficients and parameters while u is an error term. For each observation of a dataset, this equation becomes:

$$y_i = \beta_0 + \beta_1 x_i + u_i \qquad i = 1,2,\ldots\ldots,n \qquad (3)$$

where y_i is the i^{th} value of the dependent variable Y, x_i is the i^{th} value of the independent variable X, and u_i is the error in the approximation of y_i. Based on the available data, the coefficients β_0 and β_1 are estimated with the use of the least squares method which provides the regression line that minimizes the sum of squares of the vertical distances from each point to the line. The vertical distances are the errors in the dependent variable. These errors are obtained by rewriting equation (3) as

$$u_i = y_i - \beta_0 - \beta_1 x_i \qquad i = 1,2,\ldots\ldots,n \qquad (4)$$

The sum of squares of these distances is then expressed as

$$\sum_{i=1}^{n} u_i^2 = \sum_{i=1}^{n} (y_i - \beta_0 - \beta_1 x_i)^2 \qquad (5)$$

The values of coefficients $\hat{\beta}_0$ and $\hat{\beta}_1$ that minimize the sum of squares of the error term are given by the solution of

$$\hat{\beta}_1 = \frac{\sum (y_i - \bar{y})(x_i - \bar{x})}{\sum (x_i - \bar{x})^2} \qquad (6)$$

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x} \qquad (7)$$

The estimates of $\hat{\beta}_0$ and $\hat{\beta}_1$ are the least squares estimates of β_0 and β_1 because they are the solution of the least squares method. The least squares regression line is given by

$$\bar{Y} = \hat{\beta}_0 + \hat{\beta}_1 \bar{X} \qquad (8)$$

This is known as simple linear regression which is used to estimate research question 2. For multiple linear regression with n explanatory variables (X_1…….. X_n), the estimated least squares regression is written as follows:

$$\bar{Y} = \hat{\beta}_0 + \hat{\beta}_1 \bar{X}_1 + \cdots + \hat{\beta}_n \bar{X}_n \quad (9)$$

This is also known as the mean regression which is used to estimate coefficients for research questions two in the study. It is note that the detailed model specification provided in Section 3.7 for research questions two and three.

3.7 Methods for casual relationships between energy consumption and urbanization factors

In this section the methods for answering the third research question are analyzed in detail. A framework based upon the theory of energy-urbanization nexus which is employed in the multivariate context to study the relationship between energy consumption and urbanization factors in selected SAARC countries (Mudakkar et al., 2013; Shahbez et al., 2013). The standard energy usage function with final energy consumption 'EC' as a function of urbanization 'U' reads

$$EC_t = F[U_t] \quad (10)$$

where "F" is a linear homogenous function and 't' the time index. The process of urbanization mainly consists of two aspects, namely population urbanization (PU), and economic urbanization (EU) (Wang et al., 2018b). Therefore, equation (10) takes the following form:

$$EC_t = F[EU_t, PU_t] \quad (11)$$

Per capita GDP (GDP), the industrial share of the GDP (SIG), and the service share of the GDP (SSG) are variables used to measure the economic urbanization. However, the urban population (UP) and urban population growth rate (UPG) are indicators of population urbanization (Wang et al., 2018b). Based on equation (11), this study attempted to include urban population, urban population growth rate, per capita GDP, industrial and service sector's share of GDP as indicators in the energy function, in order to manage robust data analysis. Therefore, the final energy consumption function, after this extension, can be expressed as:

$$EC_t = f(GDP_t, SIG_t, SSG_t, UP_t, UPG_t) \qquad (12)$$

Again, to analyze the effect of urbanization on energy consumption in the SAARC countries, the model is as follows:

$$EC_{it} = B_0 GDP_{it}^{\beta_{1i}} SIG_{it}^{\beta_{2i}} SSG_{it}^{\beta_{3i}} UP_{it}^{\beta_{4i}} UPG_{it}^{\beta_{5i}} \qquad (13)$$

In this study, we transform all the series into logarithms to attain direct elasticities. The empirical equation is modeled as follows:

$$lnEC_{it} = \beta_0 + +\beta_{1i} lnGDP_{it} + \beta_{2i} lnSIG_{it} + \beta_{3i} lnSSG_{it} + \beta_{4i} lnUP_{it} + \beta_{5i} lnUPG_{it} + \epsilon_{it} \qquad (14)$$

where β_0 and ϵ_{it} represent $\ln(B_0)$ and error term respectively of the ith country at t time respectively. Most importantly, $\beta_{1,} \dots \dots \dots \dots \dots \dots, \beta_{5,}$ represent the long-run elasticities of the dependent variable with respect to the independent variables. The description of the variables is provided in Table 3.3.

The 3rd objective of our empirical analysis is to test whether there exist causal relationships between urbanization factors and energy consumption in the SAARC countries. The testing procedure consists of four steps, namely panel unit root tests, panel cointegration tests and its estimates, and Granger causality analysis (Abbasi et al., 2020; Ahmad and Majeed, 2019; Ahmad et al., 2016; Ahmed 2017; Apergis and Payne, 2012; Kasman and Duman, 2015; Wang, Zhou, Zhou and Wang, 2011; Wang et al., 2014). At the first step, we use panel unit root tests to examine the stationary properties of the underlying variables. If the variables contain a unit root or as nonstationary, second step is to test whether there is a long run relationship between the variables using the panel cointegration test (Abbasi et al., 2020; Ahmad and Majeed, 2019; Ahmad et al., 2016; Ahmed 2017; Apergis and Payne, 2012; Hossain, 2011; Kasman and Duman, 2015; Wang et al, 2016; Westerlund and Edgerton, 2008).

Table 3.3: Description of the Variables

Variable	Label	Definition	Unit of Measurement
Energy consumption	EC	Per capita electric power consumption	Per capita Kwh
GDP per capita	GDP	GDP divided by population by the end of year	$ per capita (2010 prices)
Share of Industry sector	SIG	The ratio of Industry sector value added in GDP	Percent
Share of Service sector	SSG	The ratio of Service sector value added in GDP	Percent
Urban population	UP	The percentage of the urban population in the total population	Percent
Urban population growth	UPG	Population density at the end of year	Persons/Skm

Source: Author’s own design

Note: Kwh= Per hour Kilo watt; Skm=Square Kilometer; $= US dollar

If any existence of cointegrating relationship between variables is found based on the outcomes of cointegration tests, the next task is to estimate the parameters of the long run relationship (Abbasi et al., 2020; Ahmad and Majeed, 2019; Ahmed, et al., 2016; Canning and Pedroni, 2008; Hossain, 2011; Wang et al, 2016). And, in the final step we employ the panel-based vector error correction model (VECM) to examine the direction of causality both in the short-run and the long-run among the variables of the model (Abbasi et al., 2020; Ahmad and Majeed, 2019; Ahmed, et al., 2016; Ahmed 2017; Apergis and Payne, 2012; Kasman and Duman, 2015; Mulali et al., 2015; Rehman and Rashid, 2017; Zeb et al., 2014).

3.7.1 Panel unit root test

In the first step of the estimation process, the study examines the stationary properties of the data series to provide valid empirical evidence on long-run relationships among variables (Lee, 2005;

Salim and Shafiei, 2014). Because some non-stationary time series often exhibit the same change tendency, that means there is no direct relationship between variables (Lee, 2005; Wang et al., 2017). The unit root test is used to check the stationary or non-stationary of the variables (Bai and Carrion-I-Silvestre, 2009; Gujarati 2004; Salim and Shafiei, 2014; Wang et al., 2014). In addition, panel unit root test is used to determine the stationarity of the data due to panel data used to examine the effects of urbanization on energy consumption in this region. The advantage of a panel unit root test is that it has higher significance than the individual unit root test for maintaining persistence of individual time series regression errors across its cross section (Ahmed, 2017; Christopoulos and Tsionas, 2004; Wang et al., 2014). There exist a number of tests to be employed for testing panel unit roots (Wang et al., 2011). In this study, three panel unit root tests: the Levin-Lin-Chu (LLC) test (Levin, Lin and Chu, 2002), the Im-Pesaran-Shin (IPS) test (Im, Pesaran and Shin, 2003), and the MW test (Maddala and Wu, 1999) are applied to enhance the robustness of the results (Ahmad and Majeed, 2019; Ahmed et al., 2016; Christopoulos and Tsionas, 2004; Hossain, 2011; Wang et al., 2011; Wang et al., 2017). Both the LLC and IPS are based on the Augmented Dickey- Fuller principle, whereas the MW test is based on the Fisher test (Omri, Daly, Rault and Chaibi, 2015).

(a) LLC panel unit root test

The test is designed by Levin et al. (2002) and allows detection of individual regression errors, trend and intercept coefficient to move freely across the cross sections. Levin et al. (2002) consider the following basic Augmented Dicky-Fuller equation:

$$\Delta X_{i,t} = \alpha_i + \beta_i X_{i,t-1} + \delta_i t + \sum_{j=1}^{k} \mu_{i,j} \, \Delta X_{i,t-j} + \epsilon_{i,t} \qquad (15)$$

Where Δ is the first difference operator, and $X_{i,t}$ is the dependent variable i over period t, and $\epsilon_{i,t}$ a white-noise disturbance with a variance of σ_i^2. Both β_i and lag order μ in equation (15) are permitted to vary across sections (countries). The test proposes the following hypotheses:

$$\mathrm{H}_0\text{: } \beta_\mathrm{i} = 0\text{; each series contains a unit root (Null hypothesis)}$$

$$\mathrm{H}_1\text{: } \beta_\mathrm{i} < 0\text{; each series does not contain a unit root (Alternative hypothesis)}$$

Ahmed, et al. (2016), Ahmed (2017), Hossain (2011), Lee, 2005 and Omri et al. (2015) argued that the test is better than the common unit root test, and used it for detecting unit roots problems in their studies and also provide a brief of the test procedure**.**

(b) IPS panel unit root test

Im et al. (2003) proposed a testing procedure based on the Augmented Dicky-Fuller regression presented by equation (1). Im et al. (2003) proposed a standardized t- bar test to detect unit roots in dynamic heterogenous panels. This test was used to test stationarity properties of variables by several studies such as Ahmed et al., 2016; Ahmed, 2017; Hossian, 2011; Lee, 2005; and Kasman and Duman, 2015. By contrast, the null and alternative hypotheses are not similar to the LLC test, where the rejection of the null hypothesis indicates that all the series are stationary. So, the hypotheses of the test are given as:

$$\mathrm{H}_\mathrm{o}\text{: } \beta_1 = \beta_2 = \cdots = \beta_\mathrm{N} = 0$$

$$\mathrm{H}_1\text{: Some but not necessarily all } \beta_\mathrm{i} < 0$$

The IPS test is calculated as the average of the t statistic with and without trend. Alternative t-bar statistic for testing the null hypothesis of unit root for all individuals ($\beta_i = 0$)is as follows

$$\bar{t} = \frac{\sum_{i=1}^{N} t\beta_i}{N}$$

Where t is the estimated Augmented Dicky- Fuller statistics from individual panel members; N is the number of individuals.

(c) **MW panel unit root test**

The MW test is a Fisher-type test which combines the ρ-values from individual unit root tests, developed by Maddala and Wu (1999). The test is non-parametric and has a chi-square distribution with 2nd degrees of freedom, where n is the number of countries in the panel. The test statistic can be expressed as follows:

$$\mathrm{P} = -2\sum_{\mathrm{i}=1}^{\mathrm{N}} \ln\rho_{\mathrm{i}} \quad \rightarrow \mathrm{x}_{2\mathrm{N}}^{2}$$

$$\mathrm{H}_0\text{: } \mathrm{x}_{\mathrm{i}} = 0\text{; for all i (Null hypothesis)}$$

$$\mathrm{H}_1\text{: } \mathrm{x}_{\mathrm{i}} < 0\text{; for i= N+1, N+2, ….. N (Alternative hypothesis)}$$

The advantage of the MW test is that its value does not depend on different lag length in the individual ADF regression (Christopoulos and Tsionas, 2004; Hossain, 2011).

The LLC test takes into account the heterogeneity of various sections, but it has low power in small samples because of the serial correlation, which cannot be completely eliminated. The IPS test considers the heterogeneity among the sections and also eliminates the serial correlation, thus has a strong ability of testing in small samples, while the MW test allows different lags during the individual ADF test (Christopoulos and Tsionas, 2004; Hossain, 2011; Wang et al., 2011).

3.7.2 Panel cointegration test

Once the panel unit root tests confirm that the panel data is non-stationary, this meets the requirements of the panel cointegration test. The cointegration test in time series examine whether there is any long-run relationship between variables when they are non-stationary (Ahmed, et al., 2016; Liddle and Lung, 2014; Westerlund and Edgerton, 2008; Wang et al., 2016). There are various testing procedures available for use, such as Maddala and Wu (1999), Kao (1999) and Pedroni (1999, 2004). This study conducts cointegration tests by Pedroni (1999, 2004) and Kao (1999) because of their popularity (Wang et al., 2011).

(a) Pedroni cointegration test

Pedroni's test proposes seven different statistics to test for cointegration relationship in heterogeneous panel (Pedroni, 1999; 2004). These tests are corrected for bias introduced by potentially endogenous regressors. The seven test statistics of Pedroni are classified into within-dimension and between-dimension groups. The first group of statistics or within-dimension statistics, also referred as panel cointegration statistics, they are mainly: panel ν- statistic (Zν), panel ρ -statistic (Zρ), panel PP-statistic (ZPP), and panel ADF- statistic (ZADF). The second group of statistics or between-dimension statistics are known as group mean panel cointegration statistics. These statistics are mainly; group ρ -statistic ($Z\rho^{\sim}$), group PP-statistic ($ZPP^{\sim}$), and group ADF-statistic ($ZADF^{\sim}$). These cointegration test statistics are based on the residual of the

Engle and Granger (1987). The procedure involves the estimation of seven test statistics required in the step to estimate the following panel cointegration regression equation based on the fixed effects:

$$Y_{i,t} = \alpha_i + \beta_i t + \sum_{j=1}^{k} \mu_{i,j} \Delta X_{i,t-j} + \epsilon_{i,t} \qquad (16)$$

where I = 1,2,...,N and represents each country of SAARC in the panel, and t = 1,2,...,T refers to the time period. α_i and β_i are the cross section fixed effect and the period fixed effect, respectively. All statistics are used to test the following hypothesis:

H_o: $\rho_i = 0$ i.e. No cointegration (Null hypothesis)

H_1: $\rho_i = \rho < 0$ 0 i.e. Cointegration (Alternative hypothesis)

Hossian (2011); Lee (2005); Kasman and Duman (2015), Wang et al. (2017); and Wang et al. (2018b) used the Pedroni statistics to test cointegration of variables.

(b) Kao test

Kao (1999) developed a residual-based test to examine if any cointegration relationship is available in heterogeneous panels. The basic construction of the test procedure is similar to the Pedroni test and also the hypothesis of this test is same as in the Pedroni test (Ahmed, 2017; Ahmed et al., 2016; Kasman and Duman, 2015).

3.7.3 Panel cointegration estimates

If cointegration tests are satisfied and all the variables are cointegrated, the next step is to estimate the long run coefficients of all the selected variables. There are a number of methods, such as the ordinary least squares (OLS), fixed effect (FE), random effect (RE), generalized method of moments (GMM), feasible generalised least squares (FGLS), fully modified least squares (FMOLS), the linear regression with panel-corrected standard errors (PCSE), the linear regression with Newey-West standard errors (N-W) and the linear regression with Driscoll–Kraay standard errors (DK) which are used to estimate the parameters. In addition, the OLS, fixed effect, random effect, GMM methods are not always efficiently estimating parameters and resulting estimators are biased and inconsistent because of the problem of serial correlations in the panel data (Ahmad and Majeed, 2019; Ahmed, et al., 2016; Apergis and Payne, 2012; Kasman and Duman, 2015). Rather they used the FMOLS method of Pedroni (2000) in their studies for estimating the parameters. For this purpose, the impact of urbanization on energy consumption in the SAARC countries is estimated the long-run coefficients by using the FMOLS method. The FMOLS estimation technique's most reliable approach is compared to other approaches (Ahmad and Majeed, 2019). The main benefit of the FMOLS method is that this technique resolves the problem of serial correlation, endogeneity, simultaneity bias and heterogeneous dynamics (Abbasi et al., 2020; Ahmad and Majeed, 2019; Ahmed, et al., 2016; Apergis and Payne, 2012; Jebli et al., 2016; Kahia et al., 2016; Kasman and Duman, 2015; Rehman and Rashid, 2017; Zeb et al., 2014). The panel FMOLS estimator is specified below:

$$\hat{\beta}_{FMOLS} = \frac{1}{N}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}(X_{it} - \bar{X}_i)^2\right)^{-1}\left(\sum_{t=1}^{T}(X_{it} - \bar{X}_i)Y_{it}^{*} - T\hat{\gamma}_i\right)$$

Where $Y_{it}^{*} = Y_{it} - \bar{Y}_i - \left(\hat{\Omega}_{2,1,i} / \hat{\Omega}_{2,2,i} \right) \Delta X_{it},\ \hat{\gamma}_i = \hat{\Gamma}_{2,1,i} + \hat{\Omega}_{2,1,i}{}^{0} - \left(\hat{\Omega}_{2,1,i} / \hat{\Omega}_{2,2,i} \right) \left(\hat{\Gamma}_{2,1,i} / \hat{\Omega}_{2,2,i} \right)$

and Ω_{it} is the long-run covariance matrix which can be further decomposed as; $\Omega_i = \Omega_i^0 + \Gamma_i + \acute{\Gamma}_i$

The associated t-statistics is specified as:

$$t_{\hat{\beta}_{FMOLS}} = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} t_{\hat{\beta}_{FMOLS}}, i; \text{ where } t_{\hat{\beta}_{FMOLS}}, i = \left(\hat{\beta}_i - \beta_0 \right) \left[\hat{\Omega}_{1,1,i}{}^{-1} (Y_{it} - \bar{Y})^2 \right]^{1/2}$$

3.7.4 Panel Granger causality test

The cointegrating relationship is confirmed among the variables, that indicates not only the existence of a long-run relationship but also the presence of a causal relationship between these variables, at least in one direction. But it does not give information on the direction of the causal relationship. If cointegration exists, then we employ the Granger causality based on the panel vector error correction method (VECM) to investigate the direction of causality among the variables of the model. The VECM Granger causality can capture the short-run causality based on the F-statistic and the long-run causality based on the lagged error correction term (Abbasi et al., 2020; Ahmad and Majeed, 2019; Ahmed, et al., 2016; Ahmed 2017; Apergis and Payne, 2012; Farhani and Ozturk, 2015; Kasman and Duman, 2015; Mulali et al., 2015; Munir and Khan, 2014; Rehman and Rashid, 2017; Zeb et al., 2014). This method essentially integrates the lagged of residual from the specified long-run regression model as a right-hand side variable. Thus, to test the causal relationship between the variables of the model, a panel-based error correction model is defined as follows:

$$\begin{pmatrix} \Delta lnEC_{it} \\ \Delta lnGDP_{it} \\ \Delta lnSIG_{it} \\ \Delta lnSSG_{it} \\ \Delta lnUP_{it} \\ \Delta lnUPG_{it} \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \end{pmatrix} + \sum_{k=1}^{P} \begin{pmatrix} \beta_{11k}\beta_{12k}\beta_{13k}\beta_{14k}\beta_{15k}\beta_{16k} \\ \beta_{21k}\beta_{22k}\beta_{23k}\beta_{24k}\beta_{25k}\beta_{26k} \\ \beta_{31k}\beta_{32k}\beta_{33k}\beta_{34k}\beta_{35k}\beta_{36k} \\ \beta_{41k}\beta_{42k}\beta_{43k}\beta_{44k}\beta_{45k}\beta_{46k} \\ \beta_{51k}\beta_{52k}\beta_{53k}\beta_{54k}\beta_{55k}\beta_{56k} \\ \beta_{61k}\beta_{62k}\beta_{63k}\beta_{64k}\beta_{65k}\beta_{66k} \end{pmatrix} \begin{pmatrix} \Delta lnEC_{it-k} \\ \Delta lnGDP_{it-k} \\ \Delta lnSIG_{it-k} \\ \Delta lnSSG_{it-k} \\ \Delta lnUP_{it-k} \\ \Delta lnUPG_{it-k} \end{pmatrix} + \begin{pmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \end{pmatrix} ECM_{it-1} + \begin{pmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \\ \varepsilon_{4it} \\ \varepsilon_{5it} \\ \varepsilon_{6it} \end{pmatrix}$$

Where i= 1, 2, … … …, n; t= P+1, P+2, P+3, … … …, T; Δ and ECM symbolize the first difference of the variable and the error-correction term respectively. K denotes the optimal lag length which is determined by the Schwarz Information Criterion (SIC). α's and β’s are parameters of the model, and ε’s are adjustment coefficients. These parameters are to be estimated.

3.8 Conclusion

The implication of research design and methodology is useful in this research to have the outline and research plan by which the researcher can conduct and execute the research successfully. The selection of research design and appropriate methods is very important to collect and assess data relating to the major variables of the research. The research study is conducted by quantitative research method with the adaptation of exploratory research investigation. Secondary data collection method is necessarily used in this research. Thematic method of data analysis is applied for effective interpretation of the data and efficient findings of the research.

Chapter Four

Discussion of Results

4.1 Introduction

In this chapter, the results of the empirical estimations based on secondary data (Appendix 5) on the issue of effects of urbanization on energy consumption in five selected SAARC countries (due to availability of data) are analyzed. The organization of this chapter is as follows. Section 4.2 focuses on the first research question that refers to the trend of urbanization and energy consumption. The second research question, analyzing the impact of specific urbanization factors on energy consumption at the country level is discussed in section 4.3. The results based on the OLS (ordinary least squares) method are explained in this section. Additionally, the results derived from the panel model, which shows the expected causal relationship between energy consumption and urbanization factors, according to the third research question, are reported and discussed in Section 4.4. Section 4.5 concludes this chapter.

4.2 The trend of urbanization and energy consumption

Two simple statistical methods are employed to examine the trend of urbanization factors and energy consumption by country. First, some descriptive statistics such as the mean, standard deviation and the coefficient of variation (CV) are calculated. Second, a simple graphical method is used to examine the time trend of different variables. The share of urban land, the GDP per capita, the share of the industry sector in GDP, the share of the service sector in GDP, urban population growth rate and urban population density are the explanatory variables, as urbanization factors, and total energy use is the dependent variable in this study.

4.2.1 Descriptive statistics of variables by country and the SAARC

Various simple statistical methods are used to assess the impact of urbanization factors on energy consumption. Table 4.1 shows the variability in the per capita electric power usage and four commonly used urbanization factors in Bangladesh by using those simple tools. Four time periods are considered to observe the variability over time. Table 4.1 indicates significant variability of all components. First, the mean for both the per capita power consumption and all urbanization factors (except urban population growth) have increased steadily over the four periods.

Table 4.1: Descriptive Statistics of the Variables for Bangladesh

Variables	Statistical tools	1975-1984	1985-1994	1995-2004	2005-2014
Per capita electric power consumption	Mean	22.64	50.28	106.73	243.12
	Standard deviation	5.13	12.62	27.19	48.43
	Coefficient of variation	0.23	0.25	0.25	0.20
Per capita GDP	Mean	361.92	411.96	518.96	775.11
	Standard deviation	17.21	20.13	43.24	111.01
	Coefficient of variation	0.05	0.05	0.08	0.14
Sectoral share of industry in GDP	Mean	17.51	20.94	22.51	24.98
	Standard deviation	3.39	1.35	0.53	0.92
	Coefficient of variation	0.19	0.06	0.02	0.04
Sectoral share of services in GDP	Mean	38.16	45.63	50.31	53.15
	Standard deviation	7.37	1.04	2.10	0.30
	Coefficient of variation	0.19	0.02	0.04	0.01
Urban population (% of total population)	Mean	13.91	19.50	23.62	30.12
	Standard deviation	2.60	1.31	1.47	2.27
	Coefficient of variation	0.19	0.07	0.06	0.08
Urban population growth rate (%)	Mean	8.87	4.66	3.97	3.71
	Standard deviation	2.63	0.56	0.32	0.20
	Coefficient of variation	0.30	0.12	0.08	0.05

Source: The World Development Indicators (May 28, 2020)

Absolute variability, measured by the standard deviation, has shown different patterns but the relative variability, measured by the coefficient of variation, also increased for almost all variables over the same period. All these provide evidence of an increasing demand of energy consumption in Bangladesh over the last 40 years.

Table 4.2: Descriptive Statistics of the Variables for India

Variables	Statistical tools	1975-1984	1985-1994	1995-2004	2005-2014
Per capita electric power consumption	Mean	143.73	264.80	395.22	630.79
	Standard deviation	21.06	49.69	29.32	113.56
	Coefficient of variation	0.15	0.19	0.07	0.18
Per capita GDP	Mean	431.70	559.29	813.06	1320.38
	Standard deviation	23.56	51.46	96.72	196.84
	Coefficient of variation	0.05	0.09	0.12	0.15
Sectoral share of industry in GDP	Mean	25.40	26.94	27.63	30.00
	Standard deviation	1.09	0.43	0.84	1.22
	Coefficient of variation	0.04	0.02	0.03	0.04
Sectoral share of services in GDP	Mean	34.86	37.33	41.68	45.57
	Standard deviation	0.66	0.66	2.78	1.22
	Coefficient of variation	0.02	0.02	0.07	0.03
Urban population (% of total population)	Mean	22.83	25.40	27.64	30.78
	Standard deviation	0.96	0.70	0.76	1.05
	Coefficient of variation	0.04	0.03	0.03	0.03
Urban population growth rate (%)	Mean	3.69	3.00	2.68	2.51
	Standard deviation	0.29	0.18	0.10	0.15
	Coefficient of variation	0.08	0.06	0.04	0.06

Source: The World Development Indicators (May 28, 2020)

A presentation of these variables is illustrated in Table 4.2 which shows the basic characteristics of the data in India over time. From the table it is found that the mean value of per capita power consumption has increased more than four times over 1975-2014, and the mean value of most urbanization factors has risen gradually, whereas the urban population growth rate decreased by almost 32%. There seems to be a time trend in both absolute and relative measures of variability.

Though absolute variability increased in all factors, the relative variability has shown some fluctuations.

Table 4.3: Descriptive Statistics of the Variables for Nepal

Variables	Statistical tools	1975-1984	1985-1994	1995-2004	2005-2014
Per capita electric power consumption	Mean	13.01	32.78	57.64	105.13
	Standard deviation	4.43	6.14	11.15	23.93
	Coefficient of variation	0.34	0.19	0.19	0.23
Per capita GDP	Mean	291.39	351.87	444.68	587.73
	Standard deviation	8.76	25.90	29.71	71.29
	Coefficient of variation	0.03	0.07	0.07	0.12
Sectoral share of industry in GDP	Mean	10.78	16.62	19.37	14.99
	Standard deviation	1.46	2.26	2.22	1.03
	Coefficient of variation	0.14	0.14	0.11	0.07
Sectoral share of services in GDP	Mean	23.32	32.12	38.18	47.51
	Standard deviation	1.98	1.49	5.34	1.36
	Coefficient of variation	0.08	0.05	0.14	0.03
Urban population (% of total population)	Mean	5.96	8.78	13.02	16.63
	Standard deviation	0.78	1.02	1.39	1.02
	Coefficient of variation	0.13	0.12	0.11	0.06
Urban population growth rate (%)	Mean	6.62	6.26	5.41	2.60
	Standard deviation	0.42	0.50	1.35	0.64
	Coefficient of variation	0.06	0.08	0.25	0.24

Source: The World Development Indicators (May 28, 2020)

Table 4.3 shows the basic characteristics of these variables in Nepal over the four periods. From the table it is found that the mean value of per capita electric power consumption has increased eight times from the first period (1975-1984) to the fourth period (2005-2014) with both absolute variability and relative variability risen also. In addition, the mean value of the per capita GDP has risen, and both absolute variability and relative variability in per capita GDP have increased over the four periods. However, other urbanization factors such as industrial share in GDP, services share in GDP, urban population and urban population growth rate have significantly positive changed over the periods.

Table 4.4 presents the variability in the per capita electric power usage under the impact of five commonly used urbanization factors in Pakistan. The mean value for both the per capita power consumption and all urbanization factors (excepting urban population growth) has increased steadily over the four periods. Absolute variability, measured by the standard deviation, has shown different patterns but the relative variability, measured by the coefficient of variation, has also increased for almost all factors over the same period. All these provide evidence of an increasing demand on energy resources in Pakistan over the last 40 years.

Table 4.4: Descriptive Statistics of the Variables for Pakistan

Variables	Statistical tools	1975-1984	1985-1994	1995-2004	2005-2014
Per capita electric power consumption	Mean	138.87	274.74	366.36	443.70
	Standard deviation	26.63	51.89	22.49	14.41
	Coefficient of variation	0.19	0.19	0.06	0.03
Per capita GDP	Mean	548.24	732.18	826.30	994.78
	Standard deviation	54.68	50.87	24.83	31.94
	Coefficient of variation	0.10	0.07	0.03	0.03
Sectoral share of industry in GDP	Mean	20.99	21.70	22.27	20.79
	Standard deviation	0.96	0.71	1.05	1.83
	Coefficient of variation	0.05	0.03	0.05	0.09
Sectoral share of services in GDP	Mean	41.71	44.11	46.86	51.91
	Standard deviation	1.07	0.68	1.58	1.42
	Coefficient of variation	0.03	0.02	0.03	0.03
Urban population (% of total population)	Mean	27.82	30.46	32.85	34.90
	Standard deviation	0.95	0.75	0.64	0.62
	Coefficient of variation	0.03	0.02	0.02	0.02
Urban population growth rate (%)	Mean	4.31	3.81	3.31	2.79
	Standard deviation	0.12	0.21	0.30	0.09
	Coefficient of variation	0.03	0.05	0.09	0.03

Source: The World Development Indicators (May 28, 2020)

The change of these factors is illustrated in Table 4.5 which shows the descriptive statistics of Sri Lanka over the analysis time frame. The mean value for all factors has risen over the four periods. Though absolute variability has increased for some factors and has decreased for others, this trend is also true for the relative measures of variability. All these provide evidence of a positive changing effect of urbanization factors on energy consumption in Sri Lanka over the last 40 years.

Table 4.5: Descriptive Statistics of the Variables for Sri Lanka

Variables	Statistical tools	1975-1984	1985-1994	1995-2004	2005-2014
Per capita electric power consumption	Mean	92.68	153.91	273.17	461.80
	Standard deviation	17.87	22.91	49.05	53.75
	Coefficient of variation	0.193	0.149	0.180	0.116
Per capita GDP	Mean	893.23	1198.27	1739.36	2794.35
	Standard deviation	95.63	110.74	177.43	481.23
	Coefficient of variation	0.107	0.092	0.102	0.172
Sectoral share of industry in GDP	Mean	27.68	26.58	27.44	29.20
	Standard deviation	1.19	0.64	0.72	1.22
	Coefficient of variation	0.043	0.024	0.026	0.042
Sectoral share of services in GDP	Mean	43.45	47.00	53.60	56.80
	Standard deviation	1.91	1.58	3.36	1.31
	Coefficient of variation	0.044	0.034	0.063	0.023
Urban population (% of total population)	Mean	18.47	18.54	18.39	18.24
	Standard deviation	0.21	0.047	0.047	0.038
	Coefficient of variation	0.011	0.003	0.003	0.002
Urban population growth rate (%)	Mean	2.01	1.18	0.61	0.64
	Standard deviation	0.47	0.17	0.13	0.25
	Coefficient of variation	0.235	0.146	0.219	0.388

Source: The World Development Indicators (May 28, 2020)

The evolution of these factors is illustrated in Table 4.6 which shows the descriptive statistics of these for all SAARC countries, over four time periods. These are considered to observe the variability over the same time frame as for the individual countries descriptive statistics. First, the mean value for both the per capita power consumption and all urbanization factors (except urban population growth) has increased steadily over the four periods. It provides evidence of an increasing demand of energy consumption in the SAARC countries over the last 40 years.

Table 4.6: Descriptive Statistics of the Variables for the SAARC Countries

Variables	Statistical tools	1975-1984	1985-1994	1995-2004	2005-2014
Per capita electric power consumption	Mean	82.19	155.30	239.82	376.91
	Standard deviation	15.02	28.65	27.84	50.82
	Coefficient of variation	0.22	0.19	0.15	0.15
Per capita GDP	Mean	505.30	650.71	868.47	1294.47
	Standard deviation	39.97	51.82	74.39	178.46
	Coefficient of variation	0.07	0.07	0.08	0.12
Sectoral share of industry in GDP	Mean	20.47	22.56	23.84	23.99
	Standard deviation	1.62	1.08	1.07	1.24
	Coefficient of variation	0.09	0.05	0.05	0.06
Sectoral share of services in GDP	Mean	36.30	41.24	46.13	50.99
	Standard deviation	2.60	1.09	3.03	1.12
	Coefficient of variation	0.07	0.03	0.07	0.02
Urban population (% of total population)	Mean	17.80	20.54	23.10	26.13
	Standard deviation	1.10	0.77	0.86	1.00
	Coefficient of variation	0.08	0.05	0.04	0.04
Urban population growth rate (%)	Mean	5.10	3.78	3.20	2.45
	Standard deviation	0.79	0.32	0.44	0.27
	Coefficient of variation	0.14	0.09	0.14	0.15

Source: The World Development Indicators (May 28, 2020)

4.2.2 Graphical analysis of variables

The trends in the per capita electric power consumption for all five countries – Bangladesh, India, Nepal, Pakistan and Sri Lanka - over the last four decades are depicted in Figure 4.1. It is evident that the per capita power consumption in all countries rose overtime. The rate of growth of the per capita electric power consumption in India was much higher compared to other countries. However, increased economic activities is the main cause of the upward trend of per capita electric power consumption, as both the industrial and the services sectors are significantly correlated in the process of urbanization. However, the rate of increase in Nepal was higher in 2014 compared to 1975 followed by Bangladesh, Sri Lanka, India and Pakistan, respectively.

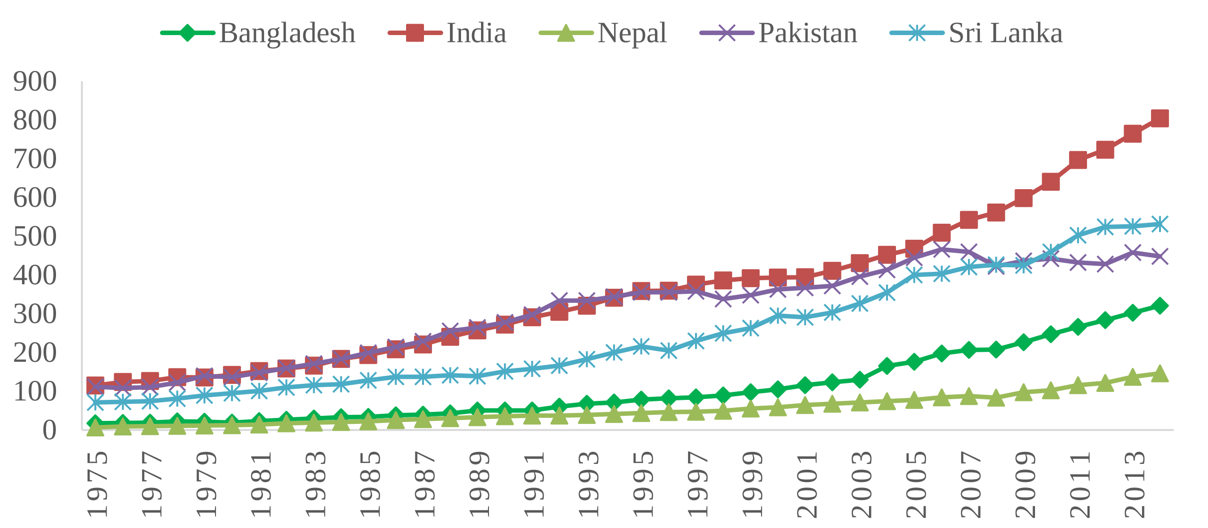

Figure 4.1: Trend of Electric Power Consumption Per Capita(Kwh)

Source: The World Development Indicators **(**May 28, 2020**)**

Per capita gross domestic product (GDP) is the measure of the economy's performance in any country and it is calculated by dividing the GDP of a country by its population. The data for per capita GDP have been presented in Figure 4.2. It can be observed from the figure that per capita GDP has increased to $3506 in 2014 from $769 in 1975 for Sri Lanka, and it was much higher compared to the other countries. However, the overall rate of change trend is upward, and India is in the second position followed by Pakistan, and Bangladesh. Figure 4.2 also shows that the per capita GDP in Nepal which increased to $711 in 2014 from $280 in 1975, has registered a lower growth rate compared to the other countries in the same period. The significant increase of the per capita gross domestic product might be due to the increased economic activities and to the overall quantity of production.

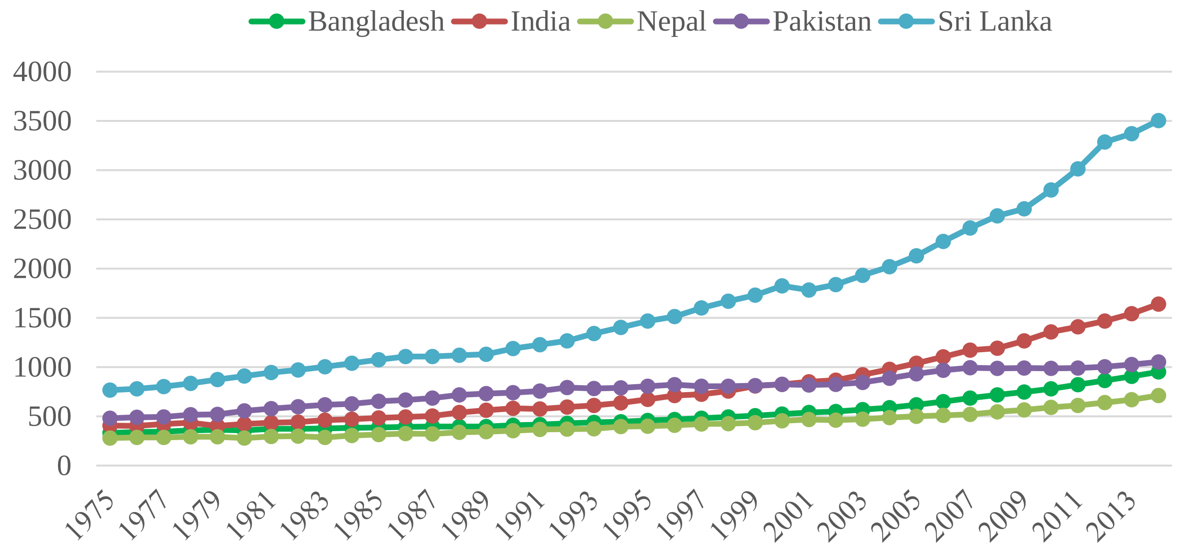

Figure 4.2: Per Capita GDP ($ in 2010)

Source: The World Development Indicators **(**May 28, 2020**)**

The sectoral share of industry in the GDP is presented in Figure 4.3. It can be observed from the figure that the sectoral share of industry in GDP has increased in India, Sri Lanka and Bangladesh whereas in Nepal had slightly decreased and has been almost the same in Pakistan with some variations over the period. The contribution of the industrial sector's share in GDP is not more enough increased over the four decades. Among the five countries, the sectoral share of industry in the GDP in Nepal experienced significantly more fluctuations, especially with a continuous rise and some fluctuations until 1997, and then an overall decline with some modest fluctuations, whereas this contribution slightly increased in Sri Lanka over the four decades.

In Figure 4.4, the share of the service sectors in GDP over the analyzed period can be located visually. The sectoral share of the services in the GDP tends to increase on average in all countries with some variations over the period. However, the rate of increase in Nepal was 55% in 2014 with respect to 1985 whereas in India, Sri Lanka, Bangladesh, and Pakistan the rates of increase were 32%, 25%, 21% and 17% respectively.

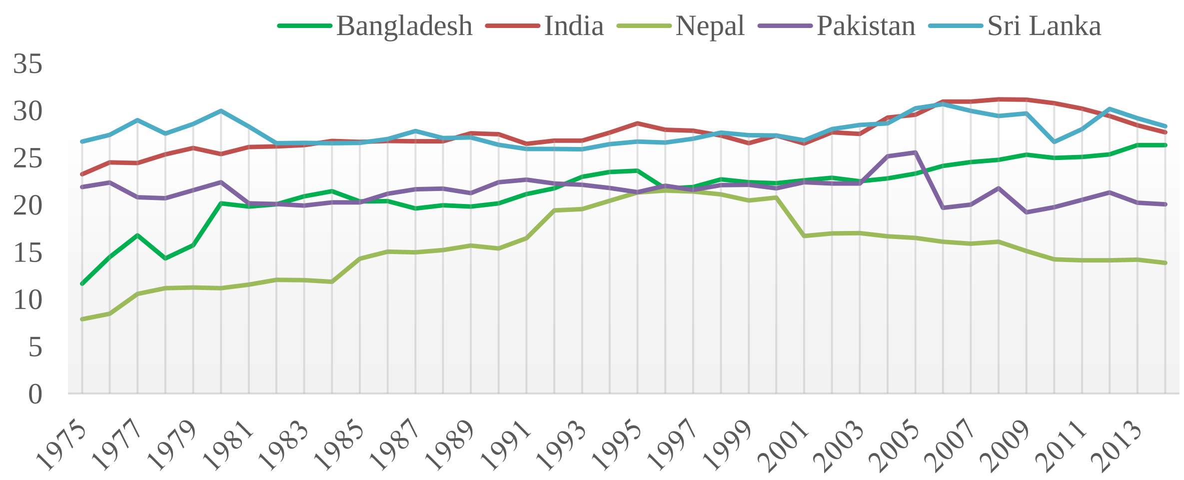

Figure 4.3: Sectoral Share of Industry in GDP (%)

Source: The World Development Indicators **(**May 28, 2020**)**

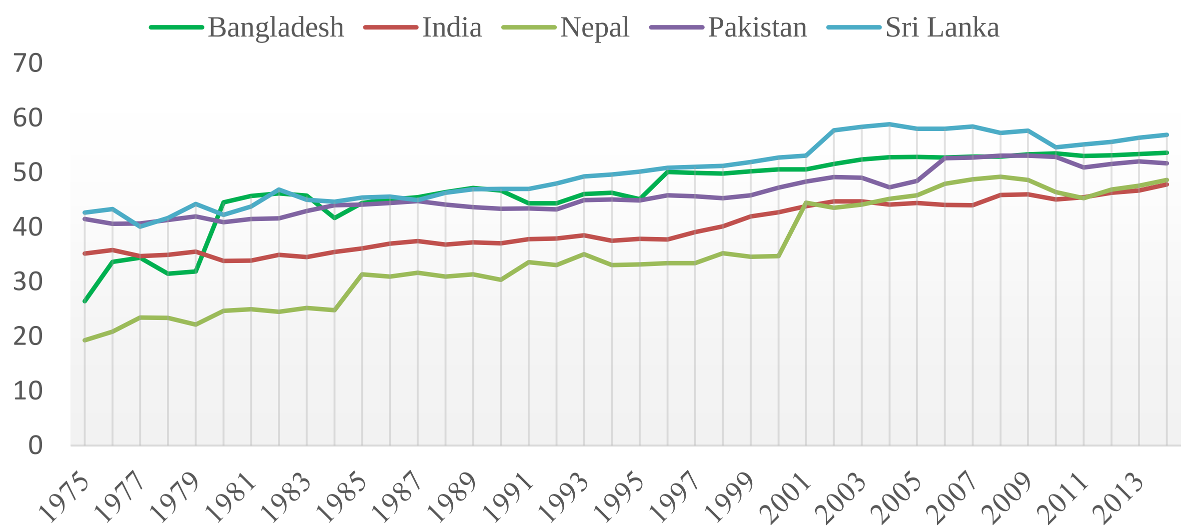

Figure 4.4: Sectoral Share of Service in GDP (%)

Source: The World Development Indicators **(**May 28, 2020**)**

Figure 4.5 provides a graphical presentation of the urban population as a percentage of total population in the SAARC countries. Its increasing trend is observed in all countries excepting Sri Lanka. The rate of increase was higher for Nepal at 277% followed by Bangladesh, India and

Pakistan with growth rate of 66%, 51% and 64% respectively. Significant increases of the urban population might be due to earning opportunities as well as to increases in overall quality of life.

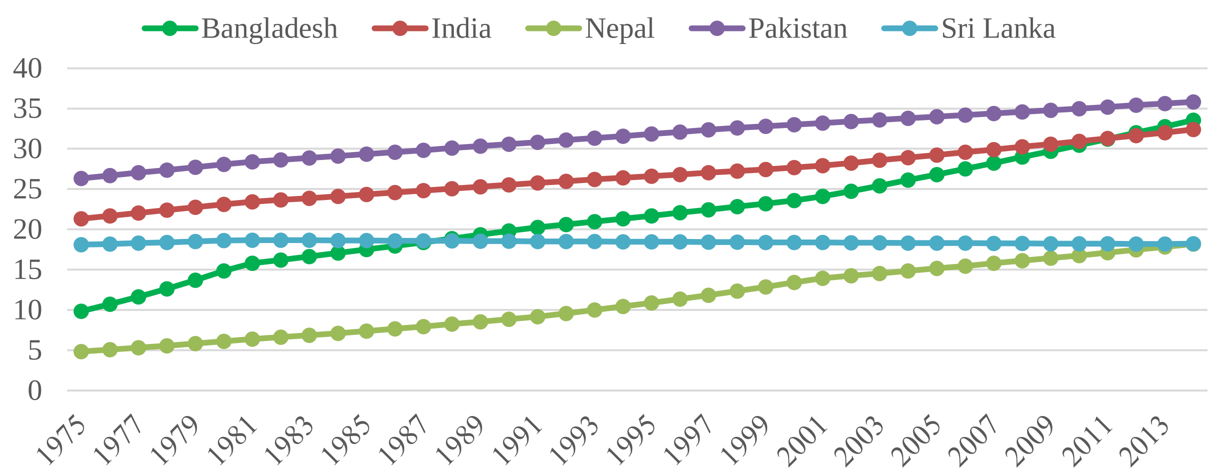

Figure 4.5: Urban Population (% of total population)

Source: The World Development Indicators **(**May 28, 2020**)**

Urban population growth differs across countries in this region. Country-wise, urban population growth is shown in Figure 4.6. It is obvious that the overall rate of change trend is downward, although the decreasing urban population growth rate is not similar in all countries. This is due to the fact that the urban areas, urban population densities and other socioeconomic characteristics of urban households in all SAARC countries are not similar. Among the five countries, the urban population growth rate in Bangladesh has sharply decreased to 3.50% in 2014 from 10.50% in 1975, and there was a huge difference between these periods. This decreasing trend was higher in Bangladesh followed by Nepal, Pakistan, India and Sri Lanka. Development of education, quality of life and rising living expenses in urban areas may be potential causes of the downward trend of urban population growth. Because educated people realize to control family size as a way of enhancing their income and economic condition of their households.

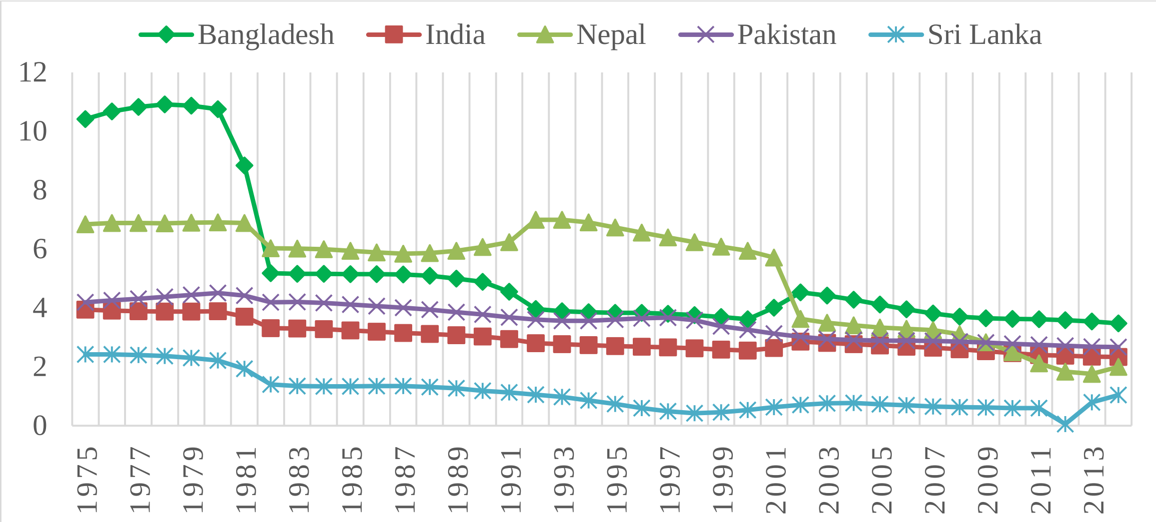

Figure 4.6: Trend of Urban Population Growth (%)

Source: The World Development Indicators **(**May 28, 2020**)**

4.3 Analysis of influencing urbanization factors on energy consumption at the country level

The second research question refers to urbanization factors that are influencing the energy consumption at the country level. Three methods are employed to examine which urbanization factors are influencing the energy consumption at the country level. First, the ADF unit root test is used for checking the stationarity of all variables. Second, the Johansen cointegration (Johansen, 1988) test is used to examine the cointegration among these variables. Then, the OLS method is employed to estimate the coefficients of the variables.

4.3.1 Unit root test results

The objective of the study is to conduct the ADF unit root test (for time series data) for checking the stationarity of all variables. If the variable possesses non-stationary properties, the regression analysis would produce spurious results that is important to examine our research hypothesis. For the unit root test, two cases have been considered in this study. In case one both constant and trend terms are included (at the level form) and in case two, only the constant term (at the level form and first difference) is included in the equation. The researcher has chosen this option because macroeconomic variables tend to exhibit a trend over time. As a result, it is more appropriate to consider the regression equation with constant and trend terms at level form.

Table 4.7: Results of ADF Unit Root Test for the Countries

Variables	Bangladesh	India	Nepal	Pakistan	Sri Lanka
Case 1a: Model with constant and trend terms [level form]					
LNEC	0.055	-0.141	3.865	-0.332	2.493
LNGDP	1.316	-1.723	-1.254	-2.012	-0.300
LNSIG	-5.14	-2.714	-1.565	-3.467	-2.672
LNSSG	-4.437	-2.582	-1.676	-2.747	-2.549
LNUP	-4.624	-3.071	-0.795	-2.569	-5.214
LNUPG	-2.224	-2.161	-1.083	-3.679	-5.309
Case 1 b: Model with only constant term [level form]					
LNEC	-4.014	-4.104	-2.960	-2.757	-0.821
LNGDP	5.965	2.912**	2.189**	-1.886	2.703
LNSIG	-4.114**	-2.165	-3.119**	-3.518**	-2.498
LNSSG	-3.899**	0.228	-3.268	-0.614	-0.980
LNUP	-0.731	0.885	-1.701	-2.274	-1.927
LNUPG	-2.205	-1.338	0.824	-0.318	-3.212**
Case 2: Model with only constant term [first difference]					
ΔLNEC	-6.813*	-5.157*	-7.212*	-4.757*	-6.308*
ΔLNGDP	-3.815**	5.902*	-6.673*	-4.412**	-4.509*
ΔLNSIG	-6.623*	-2.497**	-4.860*	-7.963*	-6.460*
ΔLNSSG	-6.936*	-6.077*	-7.629*	-5.589*	-7.273*
ΔLNUP	-3.049**	-2.567	-1.033	-2.365	-2.917**
ΔLNUPG	-4.391**	-4.357**	-4.556*	-3.385**	-7.015*

Source: Author's own calculations, November 2020

Note: * and ** indicate statistical significance at 1% and 5% level of significance, respectively.

Since first differencing is likely to remove any deterministic trend in the variables, regression should include only the constant term. The results of the ADF unit root test for the country level are shown in Table 4.7. The unit root test results support that most of all variables for all countries are integrated of order one in case 2, but the results are different in case 1. The results indicate that the majority of the time series for the five different countries are non-stationary, when the variables are defined at the first differences with constant term. While in the case of SIG and SSG for Bangladesh, GDP for India, GDP and SIG for Nepal, SIG for Pakistan, and UPG for Sri Lanka, the null hypothesis of unit root defined at levels can be rejected at 5 % level of significance indicating the stationary time series, i.e., I (0), the EC for all five countries becomes stationary when the series are differenced once; the null hypothesis of unit root can be rejected after first differencing at 5% level of significance. This indicates that the variables are integrated of order 1, i.e., I (1). It indicates that most of all variables at the country level are found as non-stationary at level but stationary at the first difference from Table 4.7. The I (1) variables may have utility in further econometric analysis, if these variables are cointegrated with each other.

4.3.2 Johansen cointegration test results

In the next step, we take energy consumption (EC) as the dependent variable, and GDP, the industrial share in GDP, the service sector share in GDP, urban population and urban population growth rate together as the independent variables, and then the Johansen cointegration among them is tested. Table 4.8 shows the Johansen cointegration relationship between the variables. The results of Table 4.8 indicate that, in the case of Bangladesh, starting with the null hypothesis of no cointegration ($r = 0$) among the variables, the trace statistic is 226.90 and exceeds the 95% critical value of the λ_{trace} statistic (critical value is 95.75). Hence it allows us to reject the null hypothesis ($r = 0$) of no cointegration vector, in favor of the general alternative $r \geq 1$ concluding that at least one cointegration relationship exists among energy consumption from gross domestic product (GDP), the industrial share in GDP, the service share in GDP, urban population and urban population growth. While the null hypothesis of $r \leq 1, \ldots\ldots, r \leq 5$ cannot be rejected at 5 percent level of confidence.

Table 4.8: Results of the Johansen Cointegration Test

H_0	H_1	Test statistics	5% Critical values	H_0	H_1	Test statistics	5% Critical values
Bangladesh							
		λ_{trace}				λ_{max}	
r=0	r>0	226.90*	95.75	r=0	r>0	91.71*	40.07
r≤1	r>1	135.18*	69.818	r≤1	r>1	59.45*	33.87
r≤2	r>2	75.738*	47.85	r≤2	r>2	48.00*	27.58
r≤3	r>3	27.73	29.79	r≤3	r>3	16.69	21.13
r≤4	r>4	11.04	15.49	r≤4	r>4	11.02	14.26
r≤5	r>5	0.016	3.84	r≤5	r>5	0.016	3.84
India							
		λ_{trace}				λ_{max}	
r=0	r>0	171.19*	95.75	r=0	r>0	67.37*	40.07
r≤1	r>1	103.82*	69.81	r≤1	r>1	37.73*	33.87
r≤2	r>2	66.08*	47.85	r≤2	r>2	25.70	27.58
r≤3	r>3	40.38*	29.79	r≤3	r>3	20.80	21.13
r≤4	r>4	19.57*	15.49	r≤4	r>4	14.75*	14.26
r≤5	r>5	4.82*	3.84	r≤5	r>5	4.82*	3.84
Nepal							
		λ_{trace}				λ_{max}	
r=0	r>0	118.38*	95.75	r=0	r>0	42.67	40.07
r≤1	r>1	75.70*	69.81	r≤1	r>1	26.61	33.87
r≤2	r>2	49.09*	47.85	r≤2	r>2	23.21	27.58
r≤3	r>3	25.87	29.79	r≤3	r>3	18.17	21.13
r≤4	r>4	7.69	15.49	r≤4	r>4	6.85	14.26
r≤5	r>5	0.83	3.84	r≤5	r>5	0.83	3.84
Pakistan							
		λ_{trace}				λ_{max}	
r=0	r>0	131.94*	95.75	r=0	r>0	64.11*	40.07
r≤1	r>1	67.82	69.81	r≤1	r>1	28.5	33.87
r≤2	r>2	39.25	47.85	r≤2	r>2	19.84	27.58
r≤3	r>3	19.41	29.79	r≤3	r>3	11.45	21.13
r≤4	r>4	7.95	15.49	r≤4	r>4	5.81	14.26
r≤5	r>5	2.13	3.84	r≤5	r>5	2.13	3.84
Sri Lanka							
		λ_{trace}				λ_{max}	
r=0	r>0	130.66*	95.75	r=0	r>0	40.89*	40.07
r≤1	r>1	89.76*	69.81	r≤1	r>1	35.00*	33.87
r≤2	r>2	54.76*	47.85	r≤2	r>2	25.22	27.58
r≤3	r>3	29.53*	29.79	r≤3	r>3	15.59	21.13
r≤4	r>4	13.94	15.49	r≤4	r>4	13.82	14.26
r≤5	r>5	0.11	3.84	r≤5	r>5	0.11	3.84

Source: Author's own calculations, November 2020

On the other hand, λ_{max} statistic rejects the null hypothesis of no cointegration vector (r =0) against the alternative (r= 1) as the calculated value λ_{max} (0, 1) = 91.71. This exceeds the 95% critical value (40.07). Thus, on the basis of λ_{max} statistic it is found that one long run cointegration exists among energy consumption from gross domestic product, the industrial share of GDP, the service sectors share of GDP, urban population and urban population growth. In the case of the remaining SAARC countries (India, Nepal, Pakistan and Sri Lanka), the results are similar to those obtained in the case of Bangladesh. The λ_{trace} and λ_{max} statistics predict the presence of one cointegrating relationship among these in the selected SAARC countries.

4.3.3 Regression results of the country

The results of the linear regression model are presented in Table 4.9. Generally, the results are logical because the explanatory power of R^2 and adj. R^2 are fairly high for all the five countries, there is no serious autocorrelation problem as shown by Durban Watson Statistics and F-statistics which further reveal that all regressors jointly influence the response variables during the period under the study. Overall the results are logical and extensively satisfactory. The R^2 values are 0.98, 0.99, 0.98, 0.97 and 0.99. They indicate that almost 98%, 99%, 98%, 97% and 99% of the variation in energy consumption is due to GDP, the industrial share in GDP, the service sectors share in GDP, urban population and urban population growth rate in the case of Bangladesh, India, Nepal, Pakistan and Sri Lanka, respectively, while the remaining 1% variation in energy consumption is due to the other variables which are not included in the model. The Durban Watson values in all the models are close to two (2) and indicate that the value is lying in no autocorrelation zone. The F statistics values are reasonably high, indicating that all the independent variables have a joint significance effect on the response variable that is urbanization factors influencing energy consumption in the study.

It is evident from Table 4.9, that the estimates of linear regression indicate that energy consumption is positively related to the GDP and negatively related to the service sector share in GDP in all the five countries. The coefficient of GDP is statistically significant at 1% level of significance for Bangladesh, Pakistan and Sri Lanka, while at 5% and 10% levels for India and Nepal, respectively.

Table 4.9: Results of OLS Method at the Countries

	Bangladesh		**India**		**Nepal**	
Variables	**Coeff**	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**
Constant	-5.24*	-3.78	-3.08**	-2.27	-2.23	-1.06
LNGDP	1.39*	5.67	0.26**	2.13	0.22***	0.61
LNSIG	1.26*	3.19	0.10	0.41	0.82*	4.50
LNSSG	-0.15***	-0.39	0.08	0.32	-0.34**	1.40
LNUP	1.94*	4.28	2.32*	3.60	0.85**	2.56
LNUPG	0.37	2.65	1.11	6.25	0.56	3.95
R^2	0.985		0.993		0.988	
Adjusted R^2	0.983		0.992		0.987	
D-W stat	1.59		1.54		1.91	
F-stat	463.29		1125.73		592.91	
	Pakistan				**Sri Lanka**	
Variables	**Coeff**	**t-stat**			**Coeff**	**t-stat**
Constant	-14.81*	-4.35			-19.38*	-5.00
LNGDP	1.92*	5.70			1.04*	19.51
LNSIG	0.82*	3.26			0.16	-0.85
LNSSG	-0.097	-0.16			-1.61*	8.92
LNUP	1.40	1.30			3.87*	3.17
LNUPG	0.57	1.81			0.02	1.57
R^2	0.979				0.994	
Adjusted R^2	0.978				0.993	
D-W stat	1.25				1.42	
F-stat	328.22				1254.61	

Source: Author's own calculations, November 2020

Note: *, ** and *** indicate statistical significance at 1%, 5% and 10% level of significance, respectively.

The coefficient of the industrial sector share in GDP is statistically significant at 1% level of significance for Bangladesh, Nepal and Pakistan. The coefficient of the industrial sector share in GDP is statistically significant at 1% level of significance for Bangladesh, Nepal and Pakistan.

The result shows that a 1% increase in the industrial sector's share in GDP leads to an increase in energy consumption of 1.26% and .82%, respectively, in Bangladesh, and in both Nepal and Pakistan. The result further indicates that a 1% increase in the service sector's share in GDP leads to a reduction in energy consumption of 0.15%, 0.34% and 1.61%, respectively, in Bangladesh, Nepal and Sri Lanka. The result for urban population indicates that a 1% increase in urban population leads to an increase in energy consumption by 1.94%, 2.32%, 0.85% and 3.87%, respectively, for Bangladesh. India, Nepal and Sri Lanka.

4.4 Analysis of casual relationships between energy consumption and urbanization factors

The 3rd research question is whether any causal relationship exists between urbanization factors and energy consumption at the aggregate (regional) level. Four methods are employed to examine the causal relationship between energy consumption and urbanization factors at the SAARC level. First, panel unit root tests are used for checking for the stationarity of all variables. Second, the panel cointegration tests are used to examine the cointegration among these variables. Then, the fully modified ordinary least squares (FMOLS) method is employed to estimate the coefficients of the variables. Finally, the panel vector error correction model (VECM) is used to examine the causality direction between variables.

4.4.1 Panel unit root tests results

To avoid any spurious results and to investigate the possibility of panel cointegration, a panel unit root test is conducted with regard to all the regression variables to detect the existence of unit roots (Zheng and Walsh, 2019). To examine the stationary properties of the variables using a panel model, three tests, the LLC test (Levin et al., 2002), the IPS test (Im et al., 2003) and the MW test (Maddala and Wu, 1999), are used. The three tests have the null hypothesis that all the panels contain a unit root. A cointegration test is applied to determine the long-term equilibrium relationship if the variables are stationary at the first difference. The results from these tests are given in Table 4.10 which indicates that not all the variables are stationary with and without time trend specifications (Case 1) at level form using the LLC, the IPS and the MW tests. Case 2 in Table 4.10 presents the results of the tests at first difference for the LLC, IPS and MW tests in the intercept.

Table 4.10: Results of the LLC, IPS and MW Panel Unit Root Tests

Variables	LLC test	Prob.	IPS test	Prob.	MW test	Prob.
Case 1a: Model with constant and trend terms [level form]						
LNEC	-2.214**	0.013	-2.194**	0.014	17.970***	0.055
LNGDP	1.523	0.936	3.777	0.999	1.485	0.999
LNSIG	-1.769	0.038	-2.598*	0.004	26.611*	0.003
LNSSG	-3.066*	0.001	-2.601*	0.004	37.151*	0.000
LNUP	-1.201	0.114	-2.949*	0.001	63.350*	0.000
LNUPG	-1.250	0.105	-1.942**	0.026	21.080	0.020
Case 1 b: Model with only constant term [level form]						
LNEC	-2.162**	0.015	0.629	0.735	12.389	0.259
LNGDP	6.734	1.000	9.317	1.00	2.731	0.987
LNSIG	-2.615*	0.004	-2.714*	0.003	36.530*	0.000
LNSSG	-0.484	0.313	1.127	0.870	19.091	0.039
LNUP	0.275	0.608	1.400	0.919	60.699*	0.000
LNUPG	-0.561	0.287	0.663	0.746	9.438	0.491
Case 2 : Model with only constant term [first difference]						
ΔLNEC	-4.625*	0.000	-7.111*	0.000	126.312*	0.000
ΔLNGDP	-3.982*	0.000	-4.670*	0.000	89.114*	0.000
ΔLNSIG	-8.936*	0.000	-10.973*	0.000	134.396*	0.000
ΔLNSSG	-7.235*	0.000	-10.257*	0.000	144.238*	0.000
ΔLNUP	-3.314*	0.000	-2.182**	0.014	16.708***	0.081
ΔLNUPG	-5.859*	0.000	-7.316*	0.000	77.509*	0.000

Source: Author’s own calculations, November 2020

Note: *, ** and *** indicate rejection of the null hypothesis of no unit root at 1%, 5% and 10% level of significance, respectively.

The LLC and the IPS and the MW test statistics imply that energy consumption and urbanization variables reveal almost similar results at the first difference without time trends, indicating they are stationary at the first difference. This implies the null hypothesis of unit roots (i.e. non-stationary) is rejected at the 1% level of significance for the five variables, and the UP variable is significant at the 5% level and 10% level of significance for the IPS test and the MW test respectively, which indicates that variables under the model are stationary, that is, I (1). The panel unit root tests results support that all the panel variables are stationary of order one using the LLC, IPS and MW tests. Therefore, the panel cointegration method is applied to test the existence of cointegration relationship among the variables. Therefore, the panel cointegration method is applied to test the existence of cointegration relationship between energy consumption and the other variables.

4.4.2 Panel cointegration tests results

In this part, we are going to test if there is any long-run relationship among the dependent variable and the independent variables using the Pedroni (Pedroni, 1999; 2004) and Kao Residual Cointegration Test (Kao, 1999). The results of these two tests are presented in Table 4.11. As for the Pedroni residual cointegration test, most of the statistics such as panel rho-stat, panel PP-stat, group rho-stat and group PP-stat are found statistically significant at the 1% level for panels.

In the Pedroni cointegration test (Table 4.11), the results demonstrate that 4 out of 7 statistics reject the null hypothesis of non-cointegration at the 1% level of significance. It is shown from the Pedroni cointegration test that there is a long-run stable relationship among variables in the panel data sets based on the *p* values. The result is also verified by another test, the Kao residual cointegration test. The findings of the test confirm that there is a long-run relationship between the I (1) variables. Since there is a long-run relationship, intensify of the long-run relationship should be estimated properly.

Table 4.11: Results of Pedroni and Kao Panel Cointegration Tests

Pedroni Residual Cointegration Test		
	Statistics	*p* values
Panel v-stat	0.426	0.33
Panel rho-stat	0.764	0.00
Panel PP-stat	-0.735	0.00
Panel ADF-stat	0.033	0.005
Group rho-stat	1.747	0.00
Group PP-stat	-0.307	0.00
Group ADF-stat	0.923	0.82
Kao Residual Cointegration Test		
ADF	-2.430	0.00

Source: Author’s own calculations, November 2020

4.4.3 Fully modified ordinary least square estimation results

Since the Pedroni panel co-integration and the Kao estimation techniques confirm that the cointegration exists among the selected variables in the study, the next step is to examine the long run relationship between variables. The model of this study (Equation 14 in Chapter 3) is estimated using the FMOLS estimation technique. Since all data are converted into natural logarithmic form, the parameters of the equation express long-run elasticities of the per capita energy consumption with respect to the other five independent variables. The long-run coefficients are estimated by using the fully modified ordinary least square technique. The results are reported in Table 4.12. According to the FMOLS estimation, the results demonstrate that all the variables are statistically significant at 1% level of significance except urban population growth.

Table 4.12 shows that there is a direct relationship between energy consumption and GDP, and the panel estimate results reveal that the long run elasticity of EC with respect to GDP is approximately equal to 1.083. The result explains that a 1% increase in GDP rises the energy consumption by approximately 1.083%. The main reason is that increases in GDP require more energy to produce goods and services and also the increased use of transportation shows a positive impact on energy consumption. The finding is statistically significant, and consistent with studies by Apergis and Payne (2012), Azam and Khan (2016), Anser et al. (2020), Tang and Shahbaz (2013), Wang et al. (2018b), Zhang and Lin (2012). As for the industrial sector's share of GDP, a significant and direct relationship with energy consumption is found from this study. An increase in the industrial sector's share of GDP of 1% consumes an additional per capita energy of 0.586% in the study area. Energy consumption increases because the portion of traditional technology based industry is higher than the modern or energy efficient technology based industry in the industrial share of GDP in this region, and energy use in tertiary industry (traditional- technology based industry) is high. Our result is consistent with results obtained by Ahmed et al. (2016), Ahmad and Majeed (2019), Hossain (2011), Tang and Shahbaz (2013), Wang et al. (2018b) research.

Table 4.12 shows that an inverse relationship exists between energy consumption and the service sector's share in GDP. The long-run elasticity of energy consumption for the service sector's share in GDP is -0.566; that implies that an increase in the service sector's share in GDP of 1% reduces per capita energy consumption by 0.56%. In addition, urban infrastructure development, energy efficiency and automobile technology efficiency are components of the service sector in GDP, they all have a less energy will be consumed. The finding is consistent with findings by Ahmad and Majeed (2019). As for the urban population, a significant positive relationship with energy consumption is found for the SAARC countries.

For this panel, the long-run elasticity of energy consumption for urban population is 1.359; this indicates that an increase in urban population of 1% rises per capita energy consumption by 1.35%. The finding is consistent with Poumanyvong et al. (2012), Salim and Shafiei (2014), Wang et al. (2017), and Zhang and Lin (2012) whose research shows that more population increases energy consumption. In conclusion, energy consumption has a long-run positive relationship with GDP, the industrial sector's share in GDP, and urban population, and a long-run inverse relationship with the service sector's share in GDP in the SAARC region.

Table 4.12: Panel FMOLS Results for the SAARC (LNEC is the dependent variable)

Independent variables	Coefficient	t-Statistic	Prob.
LNGDP	1.083	11.806	0.000
LNSIG	0.586	3.039	0.002
LNSSG	-0.566	-1.834	0.006
LNUP	1.359	7.405	0.000
LNUPG	0.296	4.450	0.096
R^2			0.987
Adj. R^2			0.986
D-W test			1.54
Source: Author's own calculations, November 2020			
Notes: Panel method= Grouped estimation; Country dummy= Yes; Period dummy=Yes			

4.4.4 Causality analysis

The estimation of the long-run relationship between variables does not provide information about the causal relationships between variables. So, the important steps that follow the establishment of a long-run relationship include estimating the panel vector error correction model (VECM), and examining the causality direction between variables. The econometric theory states that at least one causal relationship must exists between energy consumption, GDP, the industrial sector's share in GDP, the service sector's share in GDP, urban population and urban population growth rate variables, as the cointegration hypothesis has not been rejected. We know from the methodology section that the coefficients of the variables are statistically significant and the coefficients of error correction terms in the equation present evidence of the existence of a short-run as well as a long-run causal relationship, respectively. For the long-run causality, we calculate the coefficient of Error Correction Term (ECT), if the coefficient is significant and has a negative sign then a long-run relationship exists between variables; otherwise not. The results of testing for causality direction are reported in Table 4.13.

In the long-run, there is evidence of three causal relationships: (1) from GDP, industrial sector share in GDP, service sector share in GDP, urban population and urban population growth rate to energy consumption, because the value coefficient of Error Correction Term (ECT) is -0.02 and at 1% level of significance; (2) from energy consumption, the industrial sector share in GDP, the service sector share in GDP, urban population and urban population growth rate to GDP (ECT is -0.016 with 1% level of significance); and (3) from energy consumption, GDP, the service sector share of GDP, urban population and urban population growth rate to the industrial sector share of GDP (ECT is -0.005 with 5% level of significance). In the short-run, there is evidence of four short-run unidirectional causal relationships: (1) from GDP, the service sector share in GDP, urban population to energy consumption; (2) from energy consumption, industrial sector share in GDP and service sector share in GDP to GDP; (3) from energy consumption, GDP, urban population to industrial sector share in GDP; and (4) from industrial sector share in GDP, service sector share in GDP and urban population growth rate to urban population. Table 4.13 indicates that there are some short-run bidirectional causal relationship between GDP and energy consumption; between GDP and the industrial sector share in GDP; between energy consumption and service sector share in GDP; and between energy consumption and population. The findings of the study is explained in terms of major research questions to elaborate how urbanization factors are influencing to energy consumption. The findings also suggest that there is a positive relationship between urbanization factors and energy consumption that proofs to the research hypothesis of the study.

Table 4.13: Panel Causality Test Results for the SAARC

Dependent variables	Source of causation (Independent variables) Short-run						Long-run
	ΔLNEC	ΔLNGDP	ΔLNSIG	ΔLNSSG	ΔLNUP	ΔLNUPG	ECT
ΔLNEC	---	0.49* (2.81)	0.13 (1.96)	0.16** (2.13)	2.79** (2.39)	0.016 (0.98)	-0.02* (-3.06)
ΔLNGDP	0.042** (1.09)	---	0.028* (0.89)	0.026** (0.68)	0.548 (0.98)	0.013 (0.16)	-0.016* (-4.47)
ΔLNSIG	0.083* (0.98)	0.317** (0.72)	---	0.076 (0.92)	0.28** (0.23)	0.017 (1.01)	-0.005** (-0.06)
ΔLNSSG	-0.161 (2.22)	0.472 (3.00)	0.006 (0.11)	---	-0.158 (-0.511)	0.016 (1.13)	0.009 (1.43)
ΔLNUP	0.004 (0.93)	0.023 (2.33)	0.006** (1.73)	0.027* (5.98)	---	0.010** (0.11)	-8.98 (-0.198)
ΔLNUPG	0.358 (0.84)	1.71 (1.85)	0.007 (0.02)	0.40 (0.98)	22.40 (0.66)	----	0.025 (0.630)

Source: Author’s own calculations, November 2020

The p-values are presented in parentheses while t-statistics are in brackets; ECT = the estimated coefficient on the error correction term; * and ** denote statistical significance at 1% and 5% level, respectively.

4.5 Concluding comments

The first objective of this chapter was to examine the trend of the correlation between urbanization factors and energy consumption by countries of the study area. Different descriptive statistics were used: the mean, standard deviation, coefficient of variation, and graphical methods. The descriptive statistics have revealed that there are significant variations in the correlation between the urbanization variables and energy consumption across the countries during the 1975–2014 period. The second research objective of this chapter was to evaluate the effects of urbanization factors on the energy consumption and the variability of results for the five different selected countries by using the OLS method with time series data. The results have revealed that the impacts of urbanization variables vary among the five countries. GDP is positively related to energy consumption in the linear model of all countries, while some urbanization variables are positively and some are negatively related to the dependent variable for the selected countries. The third and main objective of this chapter was to examine the causality direction between variables for the panel data, and whether there is an improvement over time series and cross-sectional data. The results have revealed that the error correction term is statistically significant with the required negative sign, reflecting that there is a long-run relationship between the variables. However, it has been also found that there is a short-run bidirectional or unidirectional causal relationship between energy consumption and the selected urbanization variables in this region.

Chapter Five

Summary and Conclusion

5.1 Introduction

This study has investigated the impacts of urbanization on energy consumption in the SAARC region at two levels – country-wise and aggregate or group-wise. Based on time series data and cross-sectional time series data in the study area, the analytical part of this thesis covered three major aspects:

- An overview of energy consumption in this region and urbanization factors responses to it using country-wise time series data;
- Impacts of urbanization on energy consumption using country-wise time series data; and
- Casual relationships among energy consumption and urbanization factors using panel data.

The organization of this chapter is as follows. Section 5.2 summarizes the main findings to answer the three research questions. Section 5.3 provides policy recommendations based on the findings. Section 5.4 presents the limitations of the study and identifies some aspects for further research.

5.2 Summary of findings

This section briefly sets out the major findings as answers to the three research questions of this study.

The objective of research question one has been to identify trends in the evolution of energy consumption and urbanization factors. The findings of research question one show that increasing amounts of per capita energy were consumed and the impacts of urbanization factors vary over time across all five selected countries in the SAARC region. However, country-wise different levels of energy consumption and urbanization processes were based on a country’s economic conditions, population, and geographical areas.

The second research question has explored the impacts of urbanization factors on energy consumption using country-wise data for the 1975-2014 period. The overall findings confirm that urbanization variables (GDP, industrial sector share in the GDP, services sector share in the GDP, urban population) have had significant effects on energy consumption by using the linear regression method, although the effects vary among the countries. The findings indicate that energy consumption is positively related to a country’s GDP (gross domestic product) and is negatively related to the service sector share in the GDP in all five countries. The industrial sector share in the GDP is statistically significant for Bangladesh, Nepal, and Pakistan. Moreover, the urban population share is statistically significant for most countries’ energy consumption.

The 3rd research question's objective has been to examine the causal relationship between energy consumption and urbanization variables in this region by using panel data. The answer to this research question indicates that urbanization variables and energy consumption are causally related by using the fully modified ordinary least squares (FMOLS) method to estimate the coefficients of the variables and the vector error correction model (VECM) method to examine the direction of causality between variables. The findings show that all the variables are statistically significant at 1% level of significance except urban population growth, although the effects vary among variables. The findings from the VECM, according to the value of error correction term (ECT) show that, there are three casual relationships in the long-run: there is a positive causal relationship between the SAARC's GDP and its energy consumption, showing that as a country's GDP is higher, the amount of energy consumed is higher; between the energy consumption and GDP indicating that more energy consumption leads to more economic growth; and between the energy consumption and industrial sector's share in the GDP, which means that increasing energy consumption leads to more industrial contribution to the GDP. Besides, in the short-run, there are four unidirectional causal relationships: from GDP to energy consumption; from energy consumption to GDP; from energy consumption to industrial sector's share in the GDP; and from industrial sector's share in the GDP to urban population, while bidirectional causal relationships are between GDP and energy consumption; between GDP and industrial sector's share in the GDP; between energy consumption and services sector's share in the GDP; and between energy consumption and urban population. Therefore, findings of the research question two and three confirm the research hypothesis that means more (less) urbanization leads to more (less) energy consumption in the study area.

5.3 Policy implications and recommendations

This study has assessed the impact of urbanization on energy consumption at two different but interlinked levels, at country level and at an association of countries level, the SAARC being the analysis unit. In doing so, various standard statistics and econometric techniques were used, and the results were reported in Chapter Four and summarized in section 5.2. Overall, it is found that there are causal relationships between urbanization factors and energy consumption in the SAARC region from this study. Based on these findings, the following specific recommendations are made for reducing energy consumption or for efficiently using the energy in the SAARC region countries challenged by rapid urbanization:

The level of GDP (gross domestic product) positively affects energy consumption (Wang et al., 2018b). Most of the SAARC countries are developing economies where energy consumption is higher due to the higher growth rate of these economies. Higher GDP growth rates increase the demand for expert labor force, for capital and equipment, and for more raw materials and finally increasing pressure on energy consumption (Liang and Yang, 2019). In addition, most of the countries' economies in this region are experiencing structural transformation, as they transition from agriculture to industrial development in the economy. Industrialization of the production processes increases production, which increases per capita income, and finally, GDP growth leads to increase in energy consumption. These countries' governments should take the initiative to invest in energy efficient technologies to lead the country toward an economic growth for sustainable development.

An increase in the size of the industrial sector share in GDP is likely to increase energy consumption (Wang et al., 2018b). Energy is one of the main resources of the productive and industrial activities in the economy. As industrial sector's share in the GDP expands, production increases and that leads to increase in energy consumption. In addition, SAARC countries are, developing economies which export different types of manufactured products to developed countries, due to the availability of these products at a much cheaper rate. This is another reason for the increase in the industrial sector's share in GDP, as well as the increase in energy consumption. The governments of these countries should change their industrial policies by providing incentives to these industries to adopt new technologies such as green technology and energy efficiency, which could reduce their energy consumption.

The service sector's share in the GDP can play another important role in energy consumption, as a result of this sectoral contribution to the GDP. An increase in this contribution can lead to rising energy consumption. Infrastructure and transportation are two significant subsectors of this sector (Ali, Bakhsh and Yasin, 2019; Bilgili, Koçak, Bulut and Kuloglu, 2017). The increased transportation in urban areas increases energy consumption. This is specifically true for private transportation, mostly dependent on fossil fuels (Ali et al., 2019). Adding more infrastructure also raises energy demand in urban areas. These two components of the urbanization process are increasing the demand for energy in urban areas. So, sustainable urbanization policies are important to secure efficient energy use or to reduce energy consumption. The governments and policymakers of these countries should develop policies supporting investments to develop an energy-efficient public transportation system and discourage private transportation and energy intensity in the infrastructure with the aim to reduce energy consumption in urban areas.

The urban population and its growth rate are other factors of energy consumption. The study has shown that an increase in urban population results in increased demand for economic output as well as the production of economic output and leads to more energy consumption (Wang et al., 2017; Wang et al., 2018b, Zhang and Lin, 2012). In this study, from the answers to research questions two and three, it is found that the urban population has a significant impact on energy consumption. This finding likely indicates that a rise in the existing economic growth in urban areas leads to increase in urban population, which eventually leads to higher energy consumption. Governments of these countries should take immediate policy responses to the population growth. For example, the governments should take initiatives to educate people to realize the consequences of fast population increase and take initiatives to control it. However, governments can also develop policies for discouraging energy use at the household level such as by rising gasoline prices, and encouraging public transportation use.

Another important policy that the governments of these countries should initiate is to educate the people concerning the environmental consequences of energy use, so that educated people are aware of energy overuse and its consequences for the environment.

Therefore, the present study has sought to provide a comprehensive and systematic analysis of urbanization's impacts on energy consumption in the SAARC member countries and at the aggregate level of SAARC. The study results have important policy implications that provide a useful framework for decision-making in the field of energy policy.

5.4 Limitations of the study and scope for further research

The data sets used in this study used the time series cross-sectional data found in the World Development Indicators database, which provides a general view of the selected countries, but data of all countries of the SAARC region are not available from this source or from other sources. As a result, this thesis cannot present an overall scenario of this region. So, the lack of availability of data from all SAARC countries is a limitation of the study. Another limitation of this study is that it does not provide details about energy production in the selected countries at the urban and rural levels, nor about renewable and non-renewable energy consumption. In the future, the research should be extended to many other aspects of this topic. For instance, the identified relationships need to be investigated to include all countries of the SAARC and the rest of the world to allow for valid comparisons with different categories (urban and rural; renewable and non-renewable) of energy consumption. Furthermore, land urbanization and social urbanization issues in energy consumption analysis are also worth exploring.

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Appendix

Appendix 1: Correlation Matrix of Variables

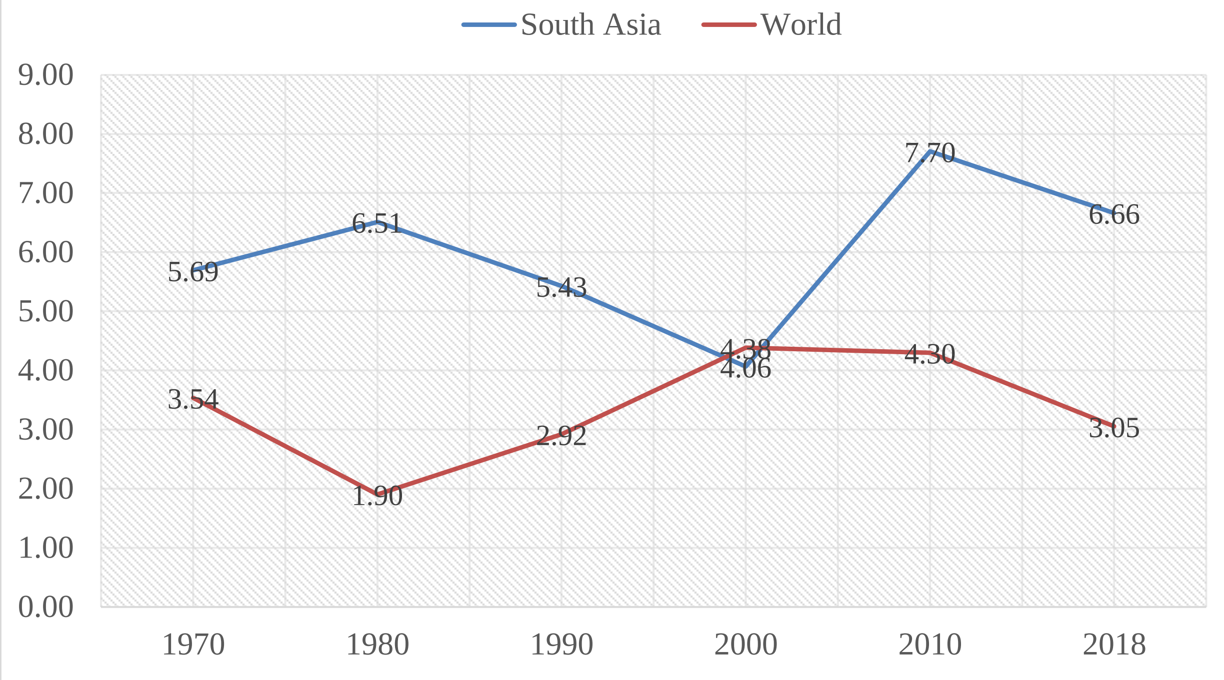
	LNEC	LNGDP	LNSIG	LNSSG	LNUP	LNUPG
LNEC	1					
LNGDP	0.782	1				
LNSIG	0.746	0.671	1			
LNSSG	0.688	0.720	0.614	1		
LNUP	0.840	0.458	0.672	0.679	1	
LNUPG	0.588	0.871	0.570	0.593	0.24	1

Source: The World Development Indicators (May 28, 2020)

Appendix 2: Descriptive Statistics of the Time Series Variables

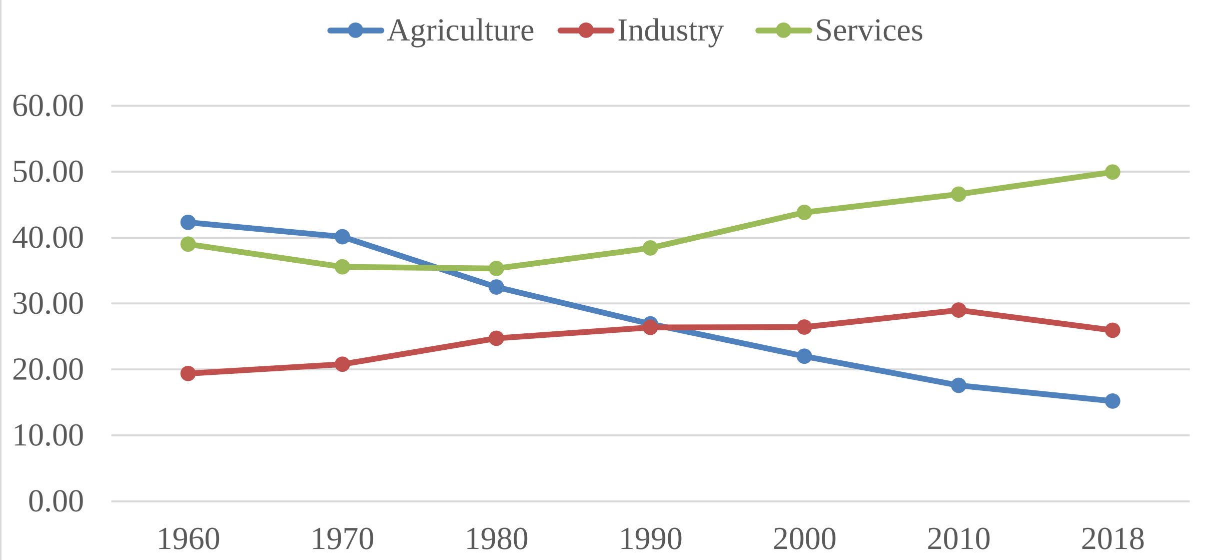
Variables	Statistical tools	Bangladesh	India	Nepal	Pakistan	Sri Lanka
Per capita electric power consumption	Mean	105.69	358.64	52.14	305.92	245.39
	Standard deviation	23.34	53.41	11.41	28.86	35.90
	Coefficient of variation	0.23	0.15	0.24	0.12	0.156
Per capita GDP	Mean	516.99	781.11	418.92	775.38	1656.30
	Standard deviation	47.90	92.15	33.92	40.58	216.26
	Coefficient of variation	0.08	0.10	0.07	0.06	0.12
Sectoral share of industry in GDP	Mean	21.49	27.49	15.44	21.44	27.725
	Standard deviation	1.55	0.90	1.74	1.14	0.94
	Coefficient of variation	0.078	0.0325	0.115	0.055	0.034
Sectoral share of service in GDP	Mean	46.813	39.86	35.28	46.15	50.21
	Standard deviation	2.70	1.33	2.54	1.19	2.04
	Coefficient of variation	0.065	0.035	0.075	0.0275	0.041
Urban population	Mean	21.79	26.66	11.10	31.51	18.41
	Standard deviation	1.91	0.87	1.05	0.74	0.086
	Coefficient of variation	0.1	0.033	0.11	0.023	0.005
Urban population growth rate	Mean	5.30	2.97	5.22	3.56	1.11
	Standard deviation	0.93	0.18	0.73	0.18	0.25
	Coefficient of variation	0.14	0.06	0.16	0.05	0.25

Source: The World Development Indicators (May 28, 2020)



Appendix 3: GDP Growth Rate (%)

Source: The World Development Indicators (May 28, 2020)



Appendix 4: Sectoral Contribution of GDP (%) in the SAARC

Source: The World Development Indicators (May 28, 2020)

Appendix 5: Country Level Time Series Data on Energy Consumption and Urbanizing Variables							
Country	Year	EC	GDP	SIG	SSG	UP	UPG
Bangladesh	1975	17.28	332.89	11.61	26.43	9.84	10.41
Bangladesh	1976	17.60	343.95	14.45	33.64	10.70	10.67
Bangladesh	1977	18.61	344.44	16.73	34.37	11.63	10.82
Bangladesh	1978	21.88	359.09	14.31	31.44	12.63	10.91
Bangladesh	1979	21.42	366.24	15.69	31.86	13.70	10.87
Bangladesh	1980	19.11	359.46	20.12	44.56	14.85	10.75
Bangladesh	1981	22.83	375.43	19.81	45.69	15.80	8.84
Bangladesh	1982	25.83	373.55	20.04	46.14	16.21	5.18
Bangladesh	1983	29.45	378.09	20.87	45.78	16.63	5.15
Bangladesh	1984	32.43	386.06	21.43	41.65	17.06	5.15
Bangladesh	1985	33.50	388.64	20.32	44.42	17.50	5.14
Bangladesh	1986	37.93	394.34	20.38	45.08	17.94	5.15
Bangladesh	1987	39.40	398.59	19.60	45.49	18.40	5.13
Bangladesh	1988	42.51	397.76	19.94	46.39	18.86	5.09
Bangladesh	1989	50.59	398.85	19.79	47.18	19.33	4.99
Bangladesh	1990	49.78	411.16	20.15	46.70	19.81	4.89
Bangladesh	1991	50.42	415.71	21.12	44.36	20.26	4.55
Bangladesh	1992	60.41	428.66	21.72	44.38	20.61	3.96
Bangladesh	1993	67.19	439.23	22.93	46.04	20.97	3.88
Bangladesh	1994	71.08	446.65	23.47	46.28	21.33	3.85
Bangladesh	1995	78.23	459.61	23.58	45.13	21.69	3.83
Bangladesh	1996	81.94	470.27	21.68	50.12	22.06	3.83
Bangladesh	1997	83.75	481.12	21.86	49.93	22.44	3.79
Bangladesh	1998	88.81	495.63	22.66	49.83	22.82	3.76
Bangladesh	1999	97.16	508.39	22.38	50.20	23.20	3.69
Bangladesh	2000	104.61	524.95	22.28	50.57	23.59	3.61
Bangladesh	2001	115.14	541.29	22.58	50.58	24.10	4.01
Bangladesh	2002	122.99	551.90	22.84	51.57	24.76	4.52
Bangladesh	2003	129.39	568.14	22.47	52.40	25.43	4.41
Bangladesh	2004	165.31	588.33	22.78	52.81	26.11	4.27
Bangladesh	2005	176.08	617.54	23.30	52.88	26.81	4.11
Bangladesh	2006	196.94	649.93	24.10	52.74	27.52	3.95
Bangladesh	2007	206.10	687.32	24.50	52.88	28.24	3.81
Bangladesh	2008	207.53	720.36	24.73	52.93	28.97	3.70
Bangladesh	2009	226.05	748.30	25.30	53.32	29.71	3.64
Bangladesh	2010	247.26	781.15	24.96	53.50	30.46	3.63
Bangladesh	2011	265.64	822.19	25.05	53.05	31.23	3.62
Bangladesh	2012	283.46	865.75	25.31	53.15	31.99	3.58
Bangladesh	2013	301.96	907.26	26.31	53.39	32.76	3.53
Bangladesh	2014	320.20	951.31	26.31	53.64	33.54	3.47

India	1975	114.56	406.89	23.20	35.14	21.33	3.93
India	1976	124.12	404.24	24.48	35.80	21.68	3.91
India	1977	126.26	423.74	24.40	34.66	22.03	3.89
India	1978	135.92	437.82	25.32	34.94	22.38	3.88
India	1979	135.74	405.47	25.99	35.52	22.74	3.88
India	1980	141.71	422.90	25.34	33.81	23.10	3.89
India	1981	151.88	438.01	26.10	33.87	23.42	3.70
India	1982	158.10	442.80	26.15	34.90	23.65	3.31
India	1983	165.69	464.18	26.30	34.52	23.88	3.30
India	1984	183.30	470.97	26.74	35.42	24.11	3.27
India	1985	193.53	484.64	26.63	36.11	24.35	3.23
India	1986	207.98	496.64	26.73	36.99	24.59	3.19
India	1987	220.22	505.18	26.70	37.45	24.82	3.15
India	1988	240.03	542.05	26.71	36.80	25.06	3.11
India	1989	257.04	562.30	27.55	37.23	25.31	3.07
India	1990	272.06	581.22	27.45	37.04	25.55	3.03
India	1991	290.90	575.50	26.44	37.79	25.78	2.94
India	1992	304.43	595.01	26.79	37.91	25.98	2.80
India	1993	320.55	611.12	26.78	38.49	26.19	2.76
India	1994	341.23	639.27	27.63	37.50	26.40	2.73
India	1995	358.76	674.62	28.60	37.85	26.61	2.70
India	1996	359.82	711.93	27.91	37.71	26.82	2.68
India	1997	375.49	727.04	27.84	39.08	27.03	2.65
India	1998	385.86	757.93	27.30	40.13	27.24	2.62
India	1999	392.04	810.22	26.52	41.97	27.45	2.58
India	2000	393.65	826.59	27.33	42.73	27.67	2.54
India	2001	393.81	851.62	26.49	43.81	27.92	2.63
India	2002	410.64	869.20	27.66	44.73	28.24	2.85
India	2003	430.48	922.17	27.47	44.70	28.57	2.81
India	2004	451.61	979.28	29.22	44.11	28.90	2.77
India	2005	468.03	1040.31	29.53	44.44	29.24	2.72
India	2006	509.21	1106.93	30.93	44.04	29.57	2.68
India	2007	541.74	1173.88	30.90	44.01	29.91	2.64
India	2008	561.25	1192.51	31.14	45.88	30.25	2.60
India	2009	598.50	1268.25	31.12	45.98	30.59	2.53
India	2010	640.39	1357.56	30.73	45.03	30.93	2.47
India	2011	696.84	1410.43	30.16	45.44	31.28	2.40
India	2012	723.24	1469.18	29.40	46.30	31.63	2.37
India	2013	764.20	1544.62	28.40	46.70	32.00	2.34
India	2014	804.51	1640.18	27.66	47.82	32.38	2.33
Nepal	1975	6.63	279.93	7.86	19.30	4.83	6.84
Nepal	1976	8.97	285.87	8.45	20.84	5.06	6.88
Nepal	1977	9.84	288.01	10.54	23.41	5.30	6.88

Nepal	1978	10.52	294.01	11.14	23.37	5.55	6.87
Nepal	1979	11.58	294.22	11.20	22.17	5.82	6.90
Nepal	1980	12.39	280.90	11.17	24.66	6.09	6.91
Nepal	1981	14.12	297.38	11.53	24.93	6.38	6.88
Nepal	1982	17.42	301.52	12.05	24.49	6.62	6.02
Nepal	1983	18.57	285.79	11.99	25.21	6.86	6.01
Nepal	1984	20.03	306.29	11.83	24.81	7.12	5.99
Nepal	1985	22.18	317.77	14.27	31.35	7.39	5.94
Nepal	1986	25.70	324.93	15.00	30.91	7.66	5.88
Nepal	1987	27.97	323.24	14.96	31.62	7.94	5.84
Nepal	1988	30.19	340.45	15.18	30.92	8.24	5.86
Nepal	1989	32.69	347.02	15.65	31.33	8.54	5.94
Nepal	1990	35.17	354.26	15.35	30.37	8.85	6.06
Nepal	1991	37.21	367.11	16.45	33.55	9.18	6.23
Nepal	1992	37.01	371.97	19.40	33.03	9.58	6.99
Nepal	1993	38.46	375.89	19.52	35.06	10.00	6.99
Nepal	1994	41.25	396.12	20.39	33.07	10.43	6.90
Nepal	1995	43.84	399.70	21.27	33.18	10.88	6.73
Nepal	1996	46.17	411.19	21.49	33.37	11.35	6.56
Nepal	1997	46.49	422.49	21.40	33.42	11.83	6.39
Nepal	1998	49.18	426.31	21.08	35.23	12.34	6.23
Nepal	1999	54.96	436.56	20.44	34.58	12.86	6.08
Nepal	2000	58.81	455.28	20.74	34.71	13.40	5.93
Nepal	2001	64.48	469.17	16.66	44.45	13.95	5.70
Nepal	2002	67.54	462.55	16.95	43.55	14.24	3.62
Nepal	2003	70.53	473.98	16.97	44.13	14.54	3.50
Nepal	2004	74.43	489.57	16.66	45.17	14.84	3.40
Nepal	2005	77.07	500.21	16.47	45.83	15.15	3.33
Nepal	2006	83.82	510.65	16.07	47.93	15.46	3.29
Nepal	2007	87.63	521.74	15.87	48.78	15.78	3.25
Nepal	2008	83.48	547.70	16.05	49.20	16.11	3.10
Nepal	2009	96.94	567.91	15.07	48.61	16.43	2.83
Nepal	2010	102.54	592.40	14.20	46.40	16.77	2.49
Nepal	2011	115.82	612.03	14.11	45.29	17.11	2.11
Nepal	2012	120.90	642.52	14.10	46.87	17.46	1.83
Nepal	2013	136.64	670.84	14.15	47.55	17.82	1.76
Nepal	2014	146.47	711.30	13.83	48.65	18.18	2.00
Pakistan	1975	111.20	480.59	21.85	41.49	26.34	4.19
Pakistan	1976	107.91	490.56	22.32	40.60	26.68	4.26
Pakistan	1977	110.21	494.67	20.77	40.68	27.02	4.31
Pakistan	1978	121.77	518.13	20.67	41.32	27.37	4.38
Pakistan	1979	139.83	520.78	21.53	41.97	27.72	4.44
Pakistan	1980	136.05	555.65	22.38	40.91	28.07	4.50

Pakistan	1981	147.73	580.15	20.13	41.49	28.38	4.42
Pakistan	1982	159.29	597.69	20.06	41.62	28.62	4.19
Pakistan	1983	171.02	617.09	19.89	42.96	28.86	4.20
Pakistan	1984	183.65	627.07	20.25	44.03	29.10	4.17
Pakistan	1985	198.89	652.89	20.23	44.11	29.34	4.11
Pakistan	1986	214.23	666.93	21.16	44.43	29.59	4.06
Pakistan	1987	228.46	687.79	21.63	44.78	29.83	4.00
Pakistan	1988	255.64	717.57	21.69	44.14	30.08	3.93
Pakistan	1989	264.58	730.65	21.20	43.63	30.33	3.85
Pakistan	1990	277.43	741.00	22.36	43.35	30.58	3.77
Pakistan	1991	297.19	756.51	22.64	43.40	30.83	3.68
Pakistan	1992	333.41	792.40	22.25	43.25	31.08	3.60
Pakistan	1993	333.93	784.46	22.09	44.95	31.33	3.56
Pakistan	1994	343.66	791.63	21.77	45.03	31.58	3.56
Pakistan	1995	355.19	807.99	21.32	44.86	31.84	3.60
Pakistan	1996	355.49	823.39	21.99	45.83	32.09	3.65
Pakistan	1997	357.54	808.21	21.56	45.65	32.35	3.66
Pakistan	1998	337.64	805.55	22.05	45.30	32.59	3.58
Pakistan	1999	347.90	812.26	22.10	45.84	32.78	3.37
Pakistan	2000	362.40	824.73	21.72	47.24	32.98	3.25
Pakistan	2001	366.85	820.14	22.38	48.35	33.18	3.12
Pakistan	2002	372.19	826.37	22.22	49.15	33.38	3.02
Pakistan	2003	395.39	846.36	22.23	49.04	33.58	2.94
Pakistan	2004	412.99	888.01	25.12	47.31	33.78	2.90
Pakistan	2005	444.59	934.39	25.53	48.45	33.98	2.89
Pakistan	2006	466.23	969.62	19.67	52.63	34.18	2.89
Pakistan	2007	459.56	993.55	19.98	52.76	34.39	2.87
Pakistan	2008	422.06	987.85	21.74	53.11	34.59	2.85
Pakistan	2009	436.68	993.38	19.19	53.11	34.79	2.82
Pakistan	2010	442.18	987.41	19.72	52.84	35.00	2.78
Pakistan	2011	432.58	992.88	20.50	50.93	35.20	2.74
Pakistan	2012	427.85	1006.07	21.30	51.57	35.41	2.71
Pakistan	2013	457.81	1028.44	20.22	52.01	35.61	2.68
Pakistan	2014	447.50	1054.23	20.03	51.70	35.82	2.67
Sri Lanka	1975	70.96	769.15	26.69	42.66	18.10	2.42
Sri Lanka	1976	72.58	780.18	27.38	43.30	18.20	2.41
Sri Lanka	1977	74.54	805.01	28.94	40.08	18.30	2.40
Sri Lanka	1978	81.05	835.30	27.53	41.68	18.40	2.36
Sri Lanka	1979	89.12	873.45	28.53	44.24	18.50	2.30
Sri Lanka	1980	94.77	909.32	29.92	42.26	18.61	2.21
Sri Lanka	1981	100.51	946.24	28.25	43.79	18.68	1.93
Sri Lanka	1982	109.86	970.91	26.52	46.88	18.66	1.40
Sri Lanka	1983	115.17	1003.19	26.54	44.98	18.64	1.35

Sri Lanka	1984	118.26	1039.54	26.50	44.65	18.63	1.33
Sri Lanka	1985	128.15	1076.14	26.55	45.39	18.61	1.33
Sri Lanka	1986	136.69	1107.10	26.96	45.59	18.60	1.34
Sri Lanka	1987	137.29	1110.29	27.78	44.92	18.58	1.34
Sri Lanka	1988	141.19	1121.96	27.03	46.28	18.57	1.31
Sri Lanka	1989	138.37	1132.42	27.10	46.94	18.55	1.26
Sri Lanka	1990	151.45	1189.66	26.33	46.99	18.54	1.19
Sri Lanka	1991	157.68	1229.49	25.90	47.02	18.52	1.12
Sri Lanka	1992	166.10	1269.03	25.89	47.99	18.50	1.05
Sri Lanka	1993	182.54	1342.37	25.85	49.27	18.49	0.97
Sri Lanka	1994	199.67	1404.25	26.40	49.62	18.47	0.86
Sri Lanka	1995	215.76	1469.43	26.68	50.18	18.46	0.74
Sri Lanka	1996	204.49	1514.94	26.57	50.89	18.44	0.59
Sri Lanka	1997	229.82	1602.94	26.99	51.06	18.43	0.48
Sri Lanka	1998	249.18	1669.78	27.62	51.22	18.41	0.42
Sri Lanka	1999	263.03	1732.38	27.36	51.91	18.40	0.45
Sri Lanka	2000	294.82	1825.14	27.32	52.75	18.38	0.52
Sri Lanka	2001	290.82	1784.19	26.82	53.11	18.37	0.63
Sri Lanka	2002	303.11	1840.26	28.01	57.71	18.35	0.71
Sri Lanka	2003	326.26	1933.19	28.42	58.34	18.33	0.76
Sri Lanka	2004	354.36	2021.31	28.62	58.84	18.32	0.76
Sri Lanka	2005	400.10	2130.13	30.19	57.99	18.30	0.72
Sri Lanka	2006	403.08	2275.89	30.64	58.02	18.29	0.69
Sri Lanka	2007	420.32	2412.69	29.92	58.40	18.27	0.65
Sri Lanka	2008	426.39	2538.09	29.37	57.25	18.26	0.63
Sri Lanka	2009	425.12	2609.69	29.67	57.64	18.24	0.61
Sri Lanka	2010	459.68	2799.65	26.64	54.64	18.23	0.60
Sri Lanka	2011	502.14	3014.58	28.00	55.14	18.21	0.59
Sri Lanka	2012	524.31	3286.01	30.13	55.63	18.20	0.05
Sri Lanka	2013	525.72	3371.18	29.16	56.36	18.20	0.79
Sri Lanka	2014	531.09	3505.55	28.30	56.90	18.22	1.04