sciendo

DOI 10.2478/sbe-2019-0006
SBE no. 14(1) 2019

DECOMPOSING THE ROLE OF DIFFERENT FACTORS IN CO_2 EMISSIONS INCREASE IN SOUTH ASIA

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Abstract:

The purpose of this paper is to determine the role of different important factors responsible for CO_2 emissions increase in South Asia. Decomposition analysis has been done to see the factors which are primarily responsible for changes in CO_2 emissions. Logarithmic Mean Divisia Index is used to quantify the role of different important factors in CO_2 emissions increase during 1980 to 2014 in seven major South Asian countries - Bhutan, Bangladesh, India, Maldives, Nepal, Pakistan and Sri Lanka. The analysis shows that income effect and population effect are the major determinants in the increase in per capita emissions whereas fuel intensity and in few cases, emissions intensity has a negative effect in emissions increase in most of these countries. Due to high growth potential, emerging trend and rich resource endowments, it is suggested that South Asian countries should accelerate their efforts and cooperate to reduce CO_2 emissions and energy consumption. This will help to attain sustainable economic growth in future.

Key words: *CO_2 Emissions, Decomposition Analysis, Economic Growth, LMDI, SAARC, South Asia*

1. Introduction

The emissions of Greenhouse Gases (GHGs) are the major cause of global warming throughout the world. Among GHGs, emissions of CO_2 are the highest. CO_2 emissions are responsible for 58.8 percent of the GHG emissions (World Bank, 2016). With increasing concern for sustainable economic growth, developing countries are now considerate about environment-related problems due to global warming and extreme climate change conditions. Many organisations worldwide are trying to regulate and reduce the adverse impact of global warming through different agreements and mutual cooperation. Emerging South Asian countries are also committed and trying to reduce their emissions. For example, India decided its ambitious target to reduce the carbon intensity of GDP by 35 percent in Paris climate meet, and Bhutan's initiative of carbon neutrality are among the few active efforts which show these countries' commitment towards emissions reduction (Rahut, Behera, & Ali, 2016).

South Asian countries also known as South Asian Association for Regional Cooperation (SAARC) comprises of the eight countries Afghanistan, Bhutan, Bangladesh, India, Nepal, Maldives, Pakistan and Sri Lanka. Few of these countries are emerging economies and growing rapidly. The emerging trend has led to rapid depletion of environmental resources because of their growing economy, strong consumer power and large market. As well as due to the important role of trade in the economy, sometimes they are termed as pollution haven (Cole, 2004; Eskeland & Harrison, 2003) which is further responsible for their environmental degradation. This region is the home of 1.7 billion population which is increasing by 1.8 percent annually (World Bank, 2016). As the population is increasing rapidly, there is a lot of pressure to exploit the natural resources inefficiently and unsustainably. According to IPCC by the year 2030 in the Southern Asian region, the temperature is expected to increase by 2ºC throughout the year. Since most of these economies depend on the traditional agriculture sector, where they have to face problem-related to Monsoon. Monsoon is also depended on environmental conditions and ecosystem. Extreme climate conditions and problems related to global warming sometimes resultant into drought or flood. These problems have wide impact on agriculture sector and food security in these economies. Besides this, some of the countries are most vulnerable due to GHG effect. All SAARC countries have large and growing population, with low per-capita income. Their energy and land demand are also increasing rapidly this may have a direct impact on climate change. With low per capita income, they would not be able to support green and clean technology. Primarily most of them are at the initial level of Environmental Kuznets Curve (EKC) (Stern, Common, & Barbier, 1996). GDP is closely related to polluting activities as well as to carbon emissions. All nations of the SAARC region observe that emissions of CO_2 is the major reason for air pollution and global warming. The issue of climate change and global warming has become more severe especially for these poor and developing countries because they are at higher risks. The global warming causes sea level rise which is a threat to many South Asian countries surrounded by the sea, especially for the Maldives. The geographical situations of these countries act as boon and bane for their economy; due to the large costal region they are prone to be a victim of climate change; on the other hand, huge water resources and continuous sunlight gives them huge potential to explore renewable energy resources. At the same time, it is the fastest growing region. The emerging trend and high growth led to raising a question that how this rapid growth is affecting the environment. A recent study (Im, Pal, & Eltahir, 2017) shows that climate change will affect South Asian region intensely specifically the agriculture area. Over the period it will become a threat to human life and reason of suicide for farmers due to increased temperature. Ensuring sustainable development with growth is very difficult for these individual countries especially when they are stressed with the problems such as poverty, huge population, food and clean water scarcity, literacy, etc. Therefore, collective efforts by these countries and initiative for sustainable development by leader countries would be helpful in maintaining the balance between the environment and economic growth. Cooperation will help various countries to share clean technology and optimise carbon emissions level through the sale of carbon credit without having any hindrance in their growth process. For effective policy formulation, identification of the factors responsible for CO_2 emissions is of crucial importance (Gupta & Singh, 2016). Therefore, it is important to study the relationship between economic growth and environmental pollution and the major factors attributed to increase in CO_2 emissions in these countries.

The analysis of energy data projected that share of solid and liquid fuel consumption in total CO_2 emissions is highest whereas gaseous fuel consumption emits lowest CO_2. The electricity and heat production generates the highest CO_2 emissions in all of these countries except Nepal, where transport has the highest share in CO_2 emissions. Manufacturing industries (cement and chemicals, etc.) and construction also have around one-fourth share in total CO_2 emissions from fuel combustion. In all countries, the major change in sector-wise emissions in 20 years is that CO_2 emissions from residential building and commercial and public services has increased and the prime reason behind this is growing population and thereby increase in infrastructure and residential demand. Another reason can be the economic growth. These are nothing but the indicators of economic growth.

The objective of the present study is to see the various trends and analyse different factors responsible for changes in CO_2 emissions with the help of decomposition analysis which could help in future policy formulations. This change in CO_2 emissions is broken into five major effects - emissions coefficient effect, fuel intensity effect, energy intensity effect, GDP per capita effect and population effect. Plan of the paper is as follows: Section 2 reviews the literature. Section 3 deals with the methodological framework. Section 4 presents the details of data. Section 5 empirically analyses the role of economic growth and other factors in CO_2 emissions increase and finally, section 6 concludes the paper.

2. Literature Review

Literature shows a plethora of studies which have tried to find out the determinants of CO_2 Emissions in different countries. Most studies (such as Ahmad, 2013; Hettige, Huq, Pargal, & Wheeler, 1996; Uddin & others, 2014) find that economic growth and population growth are the two biggest determinants of CO_2 emissions. Uddin & others (2014) consider CO_2 emissions as a function of GDP growth. Population growth does not receive much attention as an important determinant of CO_2 emissions until Ahmad (2013) who follows co-integration approach, finds that in Bangladesh, India, Nepal and Pakistan, the population is one of the major causes of CO_2 emissions and environmental degradation. Apart from GDP growth and population, there are many potential determinants of CO_2 emissions.

Increasing energy prices, macroeconomic stabilisation programmes, industrial restructuring and growing industrial investments force countries in transition to change their environmental habits. Chary & Bohara (2010) evaluate the causal relationships between income, energy consumption and carbon emissions in the four major SAARC countries and conclude that emissions are caused by income and energy consumption together. Nag & Parikh (2000), while analysing the emissions intensity and commercial energy use in India, find that income effect has become prominent in CO_2 emissions increase in last three decades, earlier it was energy intensity. It is due to technological improvements and economic growth. We argue on the lines of Dinda & Coondoo (2006) that these developing countries might not need to forego economic growth due to the reduction in carbon emissions. One reason behind this is that there are other measures to reduce emissions such as energy consumption patterns, energy production and distribution efficiencies which could help in reducing carbon emissions. Identification of these factors might have important policy implications around the nature of optimal energy consumption and in emissions reduction. Agreements like Kyoto protocol enhance energy efficiency without harming economic growth; they help to motivate technology transfer and sale to their carbon credits. Their analysis suggests that these countries should consider reducing energy consumption and focus on clean energy sources in order to reduce CO_2 emissions without having a negative impact on their income growth. The projection exercises of Murthy, Panda, & Parikh (2007) show energy efficiency programmes could reduce the average annual growth rate of CO_2 emissions. In case of India, they suggest various emissions reduction strategies to promote growth. Moreover, they highlight the cost of a CO_2 reduction in terms of lower GDP and higher poverty. They also emphasize on the role and effectiveness of the market instruments to combat CO_2 emissions. Not only India but other developing countries should open up their doors to sell the carbon credits and cooperate for green technology to reduce CO_2 emissions. Table 1 lists the studies which specifically investigates the role of different variables in CO_2 emissions increase in South Asian economies.

Table 1. Different studies which show role of different variables in environmental degradation in SAARC countries

Study	Time period	Variables	Major findings
Hettige, Huq, Pargal, & Wheeler (1996)	1992-94	Pollution (measured in Biological Oxygen Demand emission), pollution intensity, local input prices, firm characteristic. Post-primary education, per-capita household expenditure and population density as proxy for living standard	The results show that pollution intensity is negatively related to scale of production, production efficiency and new technology.
Alauddin & others (2002)	1980-1998	GDP, net domestic savings, education expenditure and CO_2 emissions per capita	The study finds that South Asian development process is environmental intensive and at the same time environmental problems will put a limitation on sustaining the economic growth. Further, the study shows that environmental degradation has an adverse impact on domestic savings.
Noor & Siddiqi (2010)	1971-2006	GDP, energy use, gross fixed capital formation and labour force	The study finds unidirectional causality from per capita GDP to per capita energy use in short run whereas in long run energy use dampens GDP.
Chary & Bohara (2010)	-	GDP, energy use and carbon emissions	Emissions are caused (in the Granger sense) by income and energy consumption together in this study and it shows causal relationships between income, energy consumption and carbon emissions four major SAARC countries.

Pradhan (2010)	1970-2006	Economic growth, per capita oil and electricity consumption	The unidirectional relationship between energy consumption to economic growth in few countries whereas countries like Bangladesh and Pakistan exerts bi-directional relationship between the two.
Ahmad (2013)	1980-2008	CO_2 emissions, population density and industrialisation	Finding suggests that industrialisation and population have a major role in CO_2 emissions.
Rabab Mudakkar *et al*. (2013)	1975-2011	GDP, relative energy prices, FDI and other financial indicators	Results of Granger causality show that energy consumption, GDP, relative energy prices and financial developments are the important determinants of FDI in short and long run.
Uddin & others (2014)	1972-2012	Per capita GDP and CO_2 emissions	The causal relationship between economic growth and CO_2 emissions, emissions coefficient and significant positive effect on GDP in the long run.
Zeb, Salar, Awan, Zaman, & Shahbaz (2014)	1975-2010	GDP, CO_2 emissions, electricity production from renewable sources, natural resource depletion and poverty	A significant relationship between CO_2 emissions, natural resource depletion, poverty and energy production.
Akhmat, Zaman, Shukui, Irfan, & Khan (2014)	1975-2011	Average precipitation, CO_2 emissions, total fuel consumption, energy consumption, nitrous oxide emissions, methane emissions from different sectors and other climate variables	They find that energy consumption has an important role in environmental pollution and this relationship is unidirectional in most of these countries. Interestingly, CO_2 emissions have a major role in electric power consumption.
Mallick & Tandi (2015)	1972-2010	GDP, energy consumption, openness of trade and CO_2 emission	Long run relationship between these variables. No evidence of EKC in these countries. The positive relationship between economic growth and CO_2 emissions.
Rezitis & Ahammad (2016)	1990-2012	GDP, energy use, gross fixed capital formation and labour force	The significant positive relationship between GDP, energy use, gross fixed capital formation and labour force. Unidirectional causality from energy consumption to economic growth.

Many authors examine the dynamic relationship between carbon emissions, energy consumption and economic growth in a single framework for single country, for example, Ghosh (2002), Ang (2004) and Soytas, Sari, & Ewing (2007). Along similar lines, Hatzigeorgiou, Polatidis, & Haralambopoulos (2008) use mean divisia index to find the contribution of different factors contributing to energy-related CO_2 emissions and conclude that energy decomposition analysis is intricate. The relative contributions of different fossil fuels to total energy-related CO_2 emissions have changed over time. They help to motivate technology transfer and sale to their carbon credits. This paper evaluates the relationship between income, energy consumption and carbon emissions in seven major SAARC countries. Such studies lead to our motivation to further understand the causal relationships among carbon emissions, energy consumption and income so that effective emissions reduction policies can be adopted faster by the SAARC countries.

The above discussion shows that the literature mentions the determinants of CO_2 emissions increase and proves the positive relationship between economic growth and environmental degradation. But no study quantifies the role of different factors and economic growth in environmental degradation in these countries. To effectively implement any emissions reduction policy, it is important to know the significant factors and their contribution to CO_2 emissions increase. In addition, to analyze the relationship between economic growth and environmental degradation, the current study will try to find out the important factors responsible for the change in CO_2 emissions in South Asia with the help of decomposition method. The findings would help to formulate and guide the future policy actions accordingly.

3. Model and Methodology

To see the important factors responsible for CO_2 emissions increase in the South Asian region, decomposition analysis has been used. Decomposition analysis was first used in the 1970s, and since then it is widely adopted in energy & environmental issues. Ang, Zhang, & Choi (1998) and Ang (2004; 2005) have provided a detailed technical analysis of this method. Choi & Ang (2012) further extend the methodology for index decomposition analysis (IDA) of multiplicative – Log Mean Divisia Index (LMDI) and show that this method can be efficiently used in industrial energy efficiency and other sectors. There are various methods used for decomposition analysis; most prevalent methods are LMDI, Arithmetic Mean Divisia Index (AMDI), Fisher Ideal and Laspeyre Decomposition Index (Ang *et al*., 1998; Ang, 2004; Ang, 2005; Boyd *et al*., 1987). Various other decomposition methods and application can be found in Ang & Zhang (2000), Ang (2004), Lise (2006), Choi & Ang (2012). Liu, Ang, & Ong (1992) discuss the application of the Divisia index to the decomposition of changes in industrial energy consumption. Decomposition helps to quantify the contributions of the factors which significantly impact the change of CO_2 emissions. Ang *et al.* (1998) propose and demonstrate that LMDI is a perfect decomposition that does not leave any residuals and has the time-reversal and the factor reversal properties and therefore advantageous to use as compare to another method. Boyd, McDonald, Ross, & Hanson (1987) make some comparisons between energy intensity decomposition and the formulation of economic indices.

A recent development in decomposition studies is cross-section approach which is included in this study through analysis of different South Asian countries. Lee & Oh (2006) decompose the changes in CO_2 emissions in Asia-Pacific Economic Cooperation (APEC) countries over time with logarithmic mean Divisia decomposition approach. They find that growth in income and population are the two dominant contributors to the increase in CO_2 emissions. For these countries, they suggest that energy efficiency and fuel switching are the other two important factors for possible cooperation. Ang & Zhang (2000) present a detailed survey related to Index decomposition method and review more than a hundred studies to show the application of the method. The study uses a parametric method based on divisia Index.

For the present analysis, LMDI is used. Ang *et al.* (1998) introduced this methodology and modified the earlier decomposition methods by logarithmic function instead of the arithmetic mean weight function. LMDI index helps to estimate the value of these parameters which, in the present case, responsible for CO_2 emissions. It is a weighted sum of the relative change in CO_2 emissions from energy consumption and related to several factors. It is perfect decomposition index and an ideal index number where multiplicative and additive results can be linked easily with simple equations. In case of large variation in variable values, LMDI performs well (Lee and Oh, 2006). Further, it provides a robust assessment of changes of the activities. Ang *et al.* (1998) have explained the decomposition methodology in detail in energy demand area and compare LMDI method of decomposition with other methods. They also present application of this method in different studies to demonstrate its advantages. They explain that how LMDI turns out to be perfect decomposition with zero residual and deals with the zero value in data points. Ang (2005) presents a practical approach to use LMDI approach with the help of illustration of different cases. Ang (2004) shows that as compare to LMDI other indices such as Laspeyres and Paasche do not have factor reversal and time reversal properties whereas Arithmetic Mean Divisia index (AMDI) does not have factor reversal and aggregation properties. Further, these can give large residual term. Ang (2004) itself mentions that among the various indices LMDI is primarily recommended. If there were a residual term, decomposition would not be perfect; it means all the components are not able to explain the change in the CO_2 emissions in the present case. But LMDI ensures no residual, and this is why it is a perfect decomposition index which means the factors are completely able to explain the total change in CO_2 emissions. In additive form, these changes can be negative and positive, sum of both will show the aggregate change.

We use additive LMDI index which shows that total emissions are the additive function of different factors over the period of time. In the present case, negative value shows the decrease in CO_2 emissions change whereas positive value shows the increase in CO_2 emissions. The detailed model is given below.

$$\Delta E_{i(tot)} = E_{i(T)} - E_{i(0)} = \Delta E_{tx1} + \Delta E_{tx2} + \Delta E_{tx3} + \Delta E_{tx4} + \cdots + \Delta E_{txn} \quad (1)$$

Where *tot* subscripts show emissions over the period. *t* symbolises the final period, and *0* shows the initial period. In the equation, *n* shows the different factors responsible for the change in the emissions, and *i* represents a different country.

LMDI is also helpful to see the relative contribution of these factors in CO_2 emissions through the ratio of the change by converting additive LMDI to Multiplicative LMDI through a simple formula. It is a ratio analysis –

$$\Delta R_{i(tot)} = E_{i(T)} / E_{i(0)} = R_{tx1} R_{tx2} R_{tx3} R_{tx4} \ldots R_{txn} \quad (2)$$

Where *R* denotes the ratio change in the factors over the period of time. Multiplicative LMDI decomposes these effects through an index. In the index, values less than one shows the decreasing role of the particular factor in CO_2 emissions increase and values above one shows the increasing role of the factor in CO_2 emissions increase. The results are consistent with additive LMDI. The multiplicative decomposition shows the relative growth or ratio change of an indicator between two periods whereas additive decomposition shows the difference change in an indicator. Further, LMDI qualifies a zero value robust and negative value robust test which means that they can handle the zero and negative values in the data.

Since more than two decades one of the prominent application of decomposition analysis is done for energy economics and policy analysis. A simple understanding for decomposition is that CO_2 emissions from consumption of the energy related to several factors. By decomposition, we will get the factors impacting significantly in increment of CO_2 emissions. The simple additive decomposition method shows that change in CO_2 emissions increase is due to change in following effects (Vinuya *et al.,* 2010) –

CO_2 emissions from energy = CO_2 emissions per unit of fossil fuel consumed
× Fossil fuel consumed per unit of energy consumed
× Energy consumed per unit of GDP
× GDP per capita
×Population
(3)

To breakdown the effect of in equation (1) into variables, Lee and Oh (2006) define following variables for a country –

E = the amount of CO_2 emissions
FEC = the fossil fuel energy consumption
TEC = the total primary energy consumption
GDP = the Gross Domestic Product
POP = the population

Here we decompose this change effect in five factors. Therefore, change in CO_2 emissions in a country i can be expressed as the products of the five factors as follows:

$$E_t = \left(\frac{E_t}{FEC_t}\right)\left(\frac{FEC_t}{TEC_t}\right)\left(\frac{TEC_t}{GDP_t}\right)\left(\frac{GDP_t}{POP_t}\right)(POP_t) \quad (4)$$

$$E_t = C_t F_t I_t G_t P_t \quad (5)$$

In this way, change in CO_2 emissions in a country (ΔE_t) between a particular time period (here base year 1980 to end year 2010) can be decomposed into the emissions coefficient effect, fuel intensity effect (share of fossil fuels in total energy consumption), energy intensity effect, GDP and population effect.

This identity has been used widely in the literature, for example, Ang *et al.* (1998). But they use it to segregate the sectoral effect or at industry level effect. The present analysis is a cross section decomposition because we decompose the effects of different factors over different period in different countries (Lee and Oh, 2006).

$$\Delta E_i = [E_i(T) - E_i(0)] = C_{eff} + F_{eff} + I_{eff} + G_{eff} + P_{eff} \quad (6)$$

The effect mentioned above can be calculated by using following formula of LMDI

$$C_{eff} = [E_i(T) - E_i(0)] \times \left\{\frac{\ln[C_i(T)/C_i(0)]}{\ln[E_i(T)/E(0)]}\right\} \quad (7)$$

$[E_i(T) - E_i(0)] / \{\ln[E_i(T)/E(0)]\}$ is a log mean of CO_2 emissions in the base year (0) and end year (T). Similarly other effects ($F_{eff}, I_{eff}, G_{eff}, P_{eff}$) is also decomposed for all seven SAARC countries

$$F_{eff} = [E_i(T) - E_i(0)] \times \left\{\frac{\ln[F_i(T)/F_i(0)]}{\ln[E_i(T)/E(0)]}\right\} \quad (8)$$

$$I_{eff} = [E_i(T) - E_i(0)] \times \left\{\frac{\ln[I_i(T)/I_i(0)]}{\ln[E_i(T)/E(0)]}\right\} \quad (9)$$

$$G_{eff} = [E_i(T) - E_i(0)] \times \left\{\frac{\ln[G(T)/G_i(0)]}{\ln[E_i(T)/E(0)]}\right\} \quad (10)$$

$$P_{eff} = [E_i(T) - E_i(0)] \times \left\{\frac{\ln[P_i(T)/P_i(0)]}{\ln[E_i(T)/E(0)]}\right\} \quad (11)$$

4. Data

For Decomposition analysis, the major secondary data source is World Development Indicators (WDI) database of World Bank, International Energy Statistics, U.S. Energy Information System. Decomposition of CO_2 change is done for the time periods 1980 to 2014 for all countries. For decomposition analysis, the model is based on (Lee & Oh, 2006) formulations and defined variables are population, GDP (constant 2010 US$), amount of fossil fuel consumption (million metric ton of oil equivalent), total CO_2 emissions from the consumption of energy-fossil fuel (million metric tons), total primary energy consumption (million metric ton of oil equivalent). Due to unavailability of the data Afghanistan is not the part of the current study.

5. Empirical Results and Discussion

To quantify the role of different factors in environmental degradation including the economic growth, we try to answer the following main questions - What are the magnitudes of different factors in the increase of CO_2 emissions in different sectors of the SAARC economies in 1980 – 2014. How do these magnitudes change over 34 years?

Table 2 presents the country wise decomposition analysis of CO_2 emissions in SAARC. As the table shows that total emissions in these SAARC countries have been broken down into five major effects emissions intensity effect, fuel intensity effect (the share of fossil fuel in total fuel consumption), energy intensity effect, income effect and population effect over the three decades 1980 to 2010 as well as over the 34 years from 1980 to 2014. The analysis has been done for seven SAARC countries except Afghanistan due to unavailability of the data.

The decomposition of the change in emissions between 1980 and 2014 are reported in the table. It reflects that GDP per capita has strongest and positive effect on change in CO_2 emissions for all countries. The quantification of their contribution shows that overall GDP per capita and the population has a positive place and emissions intensity, fuel intensity and energy intensity has negative effects in most of the case in a CO_2 emissions increase.

Table 2. Decomposition Analysis of CO_2 emissions in SAARC Countries

Country	Time Period	Changes in Emission	Emissions Intensity (C_{eff})	Fuel Intensity (S_{eff})	Energy Intensity (I_{eff})	GDP Per Capita (G_{eff})	Population (P_{eff})
Bangladesh	**1980-2014**	57.31	23.872	-24.530	15.625	17.352	24.991
	1980-1990	6.44	5.218	-5.465	2.791	2.617	1.276
	1990-2000	15.31	0.950	-0.684	5.825	4.315	4.903
	2000-2010	25.93	15.098	-14.946	3.888	5.813	16.082
Bhutan	**1980-2014**	0.60	0.225	-0.290	0.389	0.068	0.205
	1980-1990	0.07	0.037	-0.060	0.077	0.006	0.015
	1990-2000	0.02	-0.063	0.058	-0.016	0.005	0.038
	2000-2010	0.40	0.258	-0.171	0.106	0.061	0.147
India	**1980-2014**	1632.80	202.095	-146.505	-113.926	511.628	1179.502
	1980-1990	266.80	32.255	-22.154	50.976	84.498	121.221
	1990-2000	344.62	-36.769	15.214	-6.852	131.055	241.977
	2000-2010	740.16	114.637	-67.017	-168.341	187.864	673.018
Maldives	**1980-2014**	1.69	0.015	0.003	0.312	0.327	1.030
	1980-1990	0.08	0.014	0.000	-0.001	0.014	0.056
	1990-2000	0.40	-0.080	0.000	0.220	0.067	0.196
	2000-2010	0.60	0.023	0.000	-0.151	0.190	0.539
Nepal	**1980-2014**	4.22	0.706	-0.396	1.614	0.968	1.328
	1980-1990	0.32	0.109	-0.147	0.165	0.096	0.097
	1990-2000	2.10	0.129	0.437	0.854	0.330	0.350
	2000-2010	0.80	-0.160	-0.397	0.174	0.382	0.801
Pakistan	**1980-2014**	115.04	4.502	0.046	-8.088	65.701	52.884
	1980-1990	34.82	-4.145	8.168	1.618	15.368	13.816
	1990-2000	41.19	4.805	-1.605	4.619	21.641	11.733
	2000-2010	32.87	9.671	-19.899	-8.057	25.730	25.426
Sri Lanka	**1980-2014**	12.73	0.980	0.024	-4.847	3.394	13.176
	1980-1990	0.43	0.430	-0.913	-1.177	0.746	1.341
	1990-2000	5.70	-0.277	1.402	0.606	0.689	3.280
	2000-2010	2.20	-0.041	-0.835	-3.004	0.912	5.169

The table shows over the period of time population has been a dominant factor in CO_2 emissions increase in these countries. All these countries comprise huge population; with increasing population, energy consumption also increases. Second most important factor is income growth which is again positive and dominant in CO_2 emissions increase. In all countries emission intensity is positively contributing in CO_2 emissions increase except

1990-2000 and few other periods. Overall fuel intensity and energy intensity has negative role in CO_2 emissions increase. Among these countries India, Pakistan and Bangladesh has highest CO_2 emissions.

In addition to income effect, carbon emissions intensity is also found to be significant in a CO_2 emissions increase. Emissions intensity effect is the ratio of CO_2 emissions from fossil fuels to the consumption of fossil fuels, which is negative for Bangladesh, China and India, indicating the change in technology and use of renewable resources for energy production. Emission intensity is defined here as emissions per unit of fuel consumption. If it decreases, it shows some technological improvement which is the case of the decade 1990-2000. In 1990s, there were some economic transition and reforms in these countries. Therefore, it helped to reduce CO_2 emissions. Nag and Parikh (2000) find in their study that from the 1980s onwards, income effect has been the major determinant of India’s per capita emissions increase as this is also shown in our result but before that, energy intensity used to be the most important factor. In this way, this study focuses on energy consumption evolution pattern in these countries and their implications for the overall carbon intensity of the economy.

Fuel intensity shows share of diesel and gasoline in total primary energy consumption. In most of these nations, it has negative impact on CO_2 emissions increase which shows gradually these countries are switching towards cleaner mode of energy generation. Fuel intensity has been defined as the ratio of the consumption of fossil fuels to the total consumption of energy provides the value for the share of fossil fuels in total energy. The share of fossil-fuel in total energy consumption is decreasing in most of the countries. Fuel mixed has also changed. Results show that for the past 34 years gains in the efficiency of energy use in the economy, the lowering share of fossil fuels in total energy consumption and lowering of emissions intensity of fuels all contributed to offsetting the effect of Gross Domestic Product (GDP) per capita and the population growth in carbon emissions across South Asia. Secondly, there has been a major shift towards electricity from primary energy carriers in the major energy consuming sectors, and the higher end use-efficiency of electricity has been able to compensate for the high emissions coefficient of electricity consumption. As in case of Nepal, changes in energy efficiency due to decreased use of fossil fuel leads to negative intensity and substitution effect.

Energy intensity reflects the share of primary energy consumption in total GDP. It has also decreased which reflects that as income increase, technology increase and production efficiency yield less energy consumption in order to produce more GDP. Energy intensity is either low or negative in all cases except Nepal and Bangladesh. In this way, this study focuses on the pattern of energy consumption and their implication for the overall carbon intensity of the economy.

GDP per capita and population effect has positive and significant effect in CO_2 emissions increase in all countries. Decomposition analysis shows a positive relationship between GDP and CO_2 emissions. Per capita GDP growth and population in these developing countries are the two dominant factors responsible for CO_2 emissions increase. Moreover, emissions coefficient and energy efficiency are the promising areas where the focus is required as they help to reduce CO_2 emissions. The findings would help policymakers to address these important factors while designing any emissions reduction policy. The study has implications for policymakers as it helps to understand the complexities of the nexus between energy-consumption, economic growth and CO_2 emissions by using a systems approach.

6. Conclusion

It is important to investigate the trends of CO_2 emissions in SAARC countries and to find out the prospects for optimal utilisation and alternative sources of energy to reduce the CO_2 emissions. Energy Information Administration (EIA, 2017) estimates an increase of 52 percent between 1993 and 2003 in South Asia's primary energy consumption. Such rapid increase in energy consumption has significantly increased the level of carbon emissions in the region. Also, since the SAARC countries are highly dependent on coal as a source of primary energy, significant increases in carbon emissions from these countries are expected in the future. The relationships between economic growth and environmental pollution, as well as economic growth and energy consumption, have been intensively analysed empirically over the past three decades. The results show that in all SAARC countries population effect and income growth effect is prominent in CO_2 emissions increase whereas fuel intensity and in few cases, emissions intensity and energy have a negative effect in emissions increase in most of these countries.

Results imply that emissions in the developing SAARC countries can be reduced by reducing energy consumption potentially through energy efficiencies without impacting their income. We also note that with income growth, energy consumption would grow in Pakistan and Bangladesh. However, at a given level of income, energy consumption can be minimised to reduce emissions without impacting income. We, therefore, suggest that these countries should consider improving energy efficiencies and reducing energy consumption through strict environmental policies without negatively impacting income growth. CO_2 emissions has increased in all of these countries because of rapid economic growth which is line with the increase in fossil fuel consumption. However, the potential of the development of renewable energy resources would help them to extract the role of fuel and emission intensity and reduce the income effect in the CO_2 increase.

Also, there is potential for cooperation as there are energy resource-surplus countries (Nepal, Bhutan in the region, Central Asian countries) who may get benefit from energy export-led growth and implementation of large-scale regional projects which otherwise would be infeasible; those with significant energy import needs (India, Pakistan and Sri Lanka) would enhance energy security, as would the others (Bangladesh) from improving the energy mix.

The United Nations Framework Convention on Climate Change has also emphasised on Intended Nationally Determined Contributions (INDC) during the 21st Conference of the Parties (COP21) in Paris during December 2015. To meet emissions reduction targets, many countries have announced their INDC. COP21 helped to send strong signals for de-carbonization and adoption of low carbon technologies. These low carbon emissions targets would be achieved through effective and radical policy action. When we talk about south-south cooperation, these forums of regional integration unite on many fronts, because as developing countries they are still dependent on other countries for various economic and technical resources. Similarly, they can also collaborate on many environmental protection programmes. Regional integration cannot only promote growth, but it can also account for green development (Rahman, Khatri, & Brunner, 2012). Due to rapid industrialisation and economic growth, the demand for energy in South Asia is also proliferating. Reduction in poverty and increase in economic growth in few of the countries lead to economic growth of the region as a whole. However, this does not lead to any progress in energy production. World Bank report (2009) shows that energy growth is lower (around 4 percent) than the economic growth (9 percent).

World Bank (2017) also mentions that South Asia has a good potential towards sustainable economic growth because of its rising net adjusted saving and a positive saving rate which is one of the necessary conditions for sustainable economic growth. However, due to a large population, increasing industrialisation, economic development, commercial use of traditional sources of energy in these nations has risen sharply. As a result, the amount of CO_2 emissions was also increased rapidly. The total amount of CO_2 released from petroleum products, natural gases and coal, was the highest in these countries. Only Bhutan has successfully maintained clean sources of energy consumption with low per capita CO_2 emissions. Bhutan has indigenous renewable energy resources (Rahut *et al.*, 2016). The share of renewable resources except for hydropower, such as solar, wind, nuclear is still very low. In hydropower generation, Nepal has put tremendous effort to build infrastructure for hydro energy sources. The paper is novel in the sense that it empirically analyses and quantifies the role of different factors in CO_2 emissions increase in South Asian Countries using Panel data and LMDI index.

Future research can be done to decompose the emissions by identifying different other important factors and including the sectorwise analysis over time of these countries. The comparative advantage of different sectors through cross-section decomposition analysis will further help in identifying the sector-specific factors responsible for CO_2 emissions. To analyse the pattern of other GHG emissions and decoupling of CO_2 emissions from GDP would be the other areas of potential future research.

7. References

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