RESEARCH PAPER

Sustainable energy solution: Evidence from Bangladesh

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Abstract

Energy consumption is a foundation for sustainable growth and renewable energy is a practical, affordable and environmentally sound energy solution to meet its increasing demand. This study investigates the relationship between energy uses and CO_2 emission for the sake of a sustainable energy solution in Bangladesh. The study uses CO_2 emissions, fossil fuel energy consumption, renewable energy consumption and GDP data obtained from the World Development Indicators of the World Bank database for the period 1990 to 2014. To compile this secondary data this study use SPSS software. The Pearson correlation coefficient was used in this study to probe into the relationship between fossil fuel consumption, CO_2 emission, renewable energy consumption and GDP in a linear form. The Result of this study through the data analysis revealed there was a significant positive correlation between fuel consumptions and CO_2 emissions and also CO_2 emissions and GDP growth in the Bangladesh. However, there was a significant but negative relationship between renewable energy consumption and CO_2 emission and also renewable energy consumption and GDP growth rate. So from the result of this study it was proved that the energy consumption pattern in Bangladesh is highly unsustainable because there was a negative relationship between economic growth and renewable energy consumption, hence, economic growth is increasing but the use of renewable energy is decreasing day by day. Therefore, there is a strong need for the government of Bangladesh to develop specific national and local energy policies to promote renewable energy consumption.

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Introduction

Sustainable energy solution is a fundamental factor for poverty alleviation and sustainable development for any country's economy. To ensure sustainable economic growth; energy resources should be used in such a way that meet the need of the present generation as well as the future generation and for keeping the resource limited stock sustain it is also essential to ensure the use of renewable energy resources more than non-renewable energy resources. The most well-known impact of using non-renewable energy sources is the emission of greenhouse gases, in particular CO_2 and methane, which contribute to climate change. Anthropogenic activities are the main reasons for the rapid increase of CO_2 emission over the last decades. Worldwide there is an increasing trend of greenhouse gas (GHG) emission due to anthropogenic activities which indicates a substantial increase in atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) (EPA,2014). Carbon dioxide is the most dominant greenhouse gases; which accounted 77% of the total global GHG emission where CH_4, NO_2 and other gases contributed 14%, 8% and 1% respectively (IPCC, 2007). So the additional CO_2 accumulation in the atmosphere means more greenhouse gases in the atmosphere, which generates more environmental pollution and also responsible for climate change and global warming. The Asia, Europe and United State these three regions are mainly responsible for the 82 percent of the total global emissions (EPA, 2014). Bangladesh is a densely populated and growing South Asian economy. According to the IMF, Bangladesh's economy is the second fastest growing major economy of 2016, with a rate of 7.1 percent (Devanth, 2016). Bangladesh averaged a GDP growth of 6.5 percent from 2004 and it is the world's eighth-most populous country, the fifth-most populous in Asia and the third-most populous Muslim-majority country.

With the impressive economic growth and large population size, the use of energy is increasing over the year for the expansion of the economy and population demand (sarkar *et al.,* 2015).

Although Bangladesh produces only 19 percent of global greenhouse gas emissions (IEA, 2014) but recently due to increasing demand for energy, CO_2 emission is also increasing alarmingly. So this is high time to think about backstop for the renewable energy consumption, which can be one sustainable solution for energy resources. Now-a-days lots of developing countries are starting to use renewable energy as an alternative to non-renewable energy. Moreover, with the growing prominence of sustainable development, the roles of energy consumption on economic growth have appeared to be perceived as an important contribution to sustainable growth and energy security (Azlina *et al.,* 2015).

Sustainable Development and Energy

After the industrial revolution the complex relationship between energy and sustainable development is increasing very alarmingly. In 1992 at the United Nations Conference on Environment and Development were discussed about the difficult challenges of energy and sustainable development. The issue of energy was highlighted in the Agenda 21 and according to Agenda 21 current level of energy consumption and production is not sustainable in the world. Moreover, the area of energy was not properly included in the Millennium Development Goals. After that in 2001 at the 9th session of the Commission on Sustainable Development (CSD-9), highlighted the factor about the role of alternative energy sources and in 2002 The Johannesburg Plan of Implementation (JPOI), organized at the World Summit on Sustainable Development and considered energy context as subject matter for sustainable development. Energy for Sustainable Development was focused on a cluster of thematic issues, on the Commission on Sustainable Development (CSD)-14 and 15, held in 2006 and 2007. In 2012, the "International Year of Sustainable Energy for All" was declared by the UN General Assembly and also highlighted the problems and possible solutions for sustainable energy solution. In 2014, the resolution by the UN General Assembly declaring 2014–2024 the "United Nations Decades of Sustainable Energy for All" (UN).

Finally, in 2015 the Agenda for Sustainable Development and its Sustainable Development Goals was adopted by the UN General Assembly SDG #7 is calling to "ensure access to affordable, reliable, sustainable and modern energy for all".

Therefore, this study attempts to investigate the relationship between energy uses and CO_2 emission for the sake of a sustainable energy solution in Bangladesh. In particular, the goal is to analyze the relationship between fossil fuel energy consumption, CO_2 emission and economic growth and also examine the relationship among economic growth, CO_2 emission and renewable energy consumption in the Bangladesh. To improve access of reliable, affordable, socially acceptable, economically viable and environmentally sound energy service it is expected that a positive relationship between renewable energy consumption and economic growth will be exist. Hence, it is anticipated that to meet the sustainable development goal-7, as the higher the economic growth, the renewable energy uses also will be increased.

Literature Review
Numerous studies have been conducted in this area to realize the connection and the causal relationship between energy consumption and economic growth. Different studies which have been conducted in this field can be divided into two broad sectors.

The first line of research emphasis on the relationship between economic and environmental degradation; using the Environmental Kuznet Curve (EKC) hypothesis; to test the appropriateness of the inverted U- shaped relationship between economic growth and environmental pollution. Ang (2007) undertook a study by using EKC hypothesis in France. This study found a stable long run relationship between economic growth and environmental pollution. This study explained that in the long run causally runs from economic growth to energy consumption and CO_2 emissions but in the short run energy consumption causes economic growth. Again Ang (2008) founds that causality runs from output to energy consumption not only in the short but also in the long run in Malaysia.

Wagner (2008) also gives his consent of an inverted U- shaped relationship between economic growth and energy pollutants. Song *et al.* (2008) found a long run relationship between economic growth and indicator of CO_2 emissions; which also presents an inverted U shaped relationship. Selden and Song (1994) ensure EKC hypothesis after examining the relationship between economic growth and a set of energy pollutants. On the other hand, Friedl and Gentner (2003) found an N-shaped curve and Richmond and Kaufman (2006) and Agran and Chapman (1999) concluded that there is no significant relations between economic growth and Environmental degradation.

The second line of research investigates the relationships among environmental degradation, economic growth and energy consumption using different statistical modeling and frameworks.

Alam *et. al.* (2004), analyze the causal relations among energy consumption, carbon dioxide emissions and income in India by using a dynamic modeling approach. This study identified that there was no causality relationship between energy consumption and income in any direction in the long run. Aronuri *et. al.* (2012) conducted a study on 12 Middle East and North African Countries over the period 1981-2005 to ascertain the relationship among CO_2 emission energy consumption and real GDP and found energy consumption has a positive significant impact on CO_2 emission and real GDP has a quadratic relationship with CO_2 emission in the long run. Alkhathlan and Javid (2013) investigated the short run and the long run causal relationship among economic growth, carbon emissions and energy level in Saudi Arabia over the 1980-2011 periods. Jahangir Alam *et al.* (2012) examined the dynamic causality between energy consumption, economic growth and CO_2 emission in BD using co-integration test granger causality test. This study reported an unidirectional causality from economic growth to energy consumption and CO_2 emission to energy consumption. Twumasi (2017) conducted a study in the United States to find out the relationship between carbon dioxide emissions, and renewable energy production using Pearson correlation coefficient.

This study identified there was no specific pattern between renewable energy and CO2 emissions; meaning that producing more renewable energy does not necessarily decreased CO2 emissions.

From the literature review it can be observed that there are a lot of studies has been conducted in this important topic, but in case of relationship between CO2 emission, economic growth and renewable energy consumption there has been no systematic investigation in Bangladesh. To ensure environmentally sound and sustainable energy services now this is essential for Bangladesh to explore the benefits of using more renewable energy. The proposed study is an attempt to fill these entire gaps.

Materials and methods
Data source
This study has based on the secondary data sources where all of the data have been collected from the World Development Indicators of the World Bank database (World Bank, 2017).

Variables
The key variables of this study are CO2 emission, fossil fuel energy consumption and renewable energy. Fossil fuel energy consumption, renewable energy consumption, gross domestic product considered as independent variables; while CO2 emission is considered as the dependent variable. To find the relationship among the variable this study was used Pearson Correlation Coefficient.

Statistical analysis
The Statistical method Pearson Correlation is widely used for investigating the relationship between two quantitative and continuous variables (Ravisankar *et al.*, 2005).

Pearson Correlation helps to test the strength and direction of a relationship between two quantitative or numerical variables range from negative (-1) to positive (+1) coefficient values. It counts the degree to which two variables are linearly related or correlated (Meyers LS and *et al.,* 2017). A sophisticated statistical software SPSS version 16.0 was used in the study and following abbreviations were used to add data input and analysis in the SPSS software.

CO2 = CO2 emission (metric ton per capita)
Renewable = Renewable energy consumption
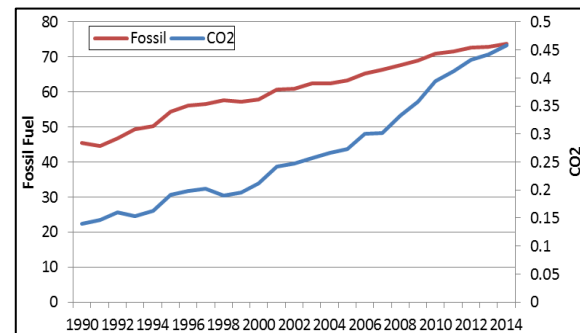Fossil = Fossil fuel energy consumption
GDP = Gross domestic product

Result and discussion
The main objective of this study is to analyze the relationship between fossil fuel energy consumption, CO2 emission and economic growth and also examine the relationship between economic growth, CO2 emission and renewable energy consumption in the Bangladesh. So this study used Pearson Correlations to analyze this relationship between each variable.

Table 1. Correlation between CO2 emission and fossil fuel energy consumption.

CO2	Correlations	CO2	Fossil
	Pearson Correlation	1	.955
	Sog/(2-taoed)		.000
	N	25	25
Fpssil	Pearson Correlation	.955	1
	Sog/(2-taoed)	.000	
	N	25	25

**Correlation is significant at the 0.01 level (2-tailed).

Fig. 1. Correlation between CO2 emission and fossil fuel energy consumption from 1990-2014.
Source: Compiled by author.

Here, Table 1 shows correlations between CO2 emission and fossil fuel consumption Pearson correlation result between CO2 emission and fossil fuel consumption in economics was found to be statistically significant and strong positive relationship (r=.95, N= 25, p=.00). The correlations were strong in strength.

Table 2. Correlation between gross domestic product and fossil fuel energy consumption.

CO2	Correlations	CO2	Fossil
	Pearson Correlation	1	.605"
	Sog/(2-taoed)		.001
	N	25	25
Fpssil	Pearson Correlation	. 605"	1
	Sog/(2-taoed)	.001	
	N	25	25

**.Correlation is significant at the 0.01 level (2-tailed).

Pearson Correlations results in *Table 2* examined the correlation between gross domestic product and fossil fuel emission. The result also shows a significant and positive relationship (r= .61, N= 26, p= .00). From *Table 1* we can find that increasing use of fossil fuel also responsible for increasing CO2 emission in Bangladesh and from Table 2 we find that economic growth also have a positive relationship with fossil fuel consumption that also represents economic growth is on an increasing trend in Bangladesh but fossil fuel consumption also increased day by day; which is not sustainable energy consumption because for ensuring sustainable energy solution we need to concern about using fossil fuel energy use because it is harmful for our environment as well as global climate.

Table 3. Correlation between CO2 emission and renewable energy consumption.

CO2	Correlations	CO2	Fossil
	Pearson Correlation	1	-.969"
	Sog/(2-taoed)		.000
	N	25	25
Fpssil	Pearson Correlation	-.969"	1
	Sog/(2-taoed)	.000	
	N	25	25

**.Correlation is significant at the 0.01 level (2-tailed).

A similar calculation was done in Table 3 showing correlations between CO2 emissions and renewable energy consumption in the case of Bangladesh. The results revealed a significant but highly negative relationship (r= -.97, N= 25, p= .00). The Table 4 presents correlations between GDP and renewable energy consumption in Bangladesh.
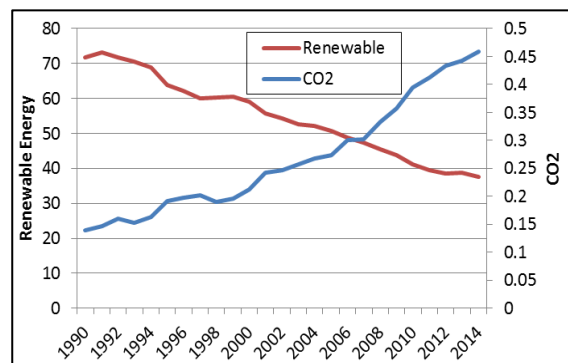
Pearson Correlations result between renewable energy consumption and gross domestic product was found statistically significant and negatively relationship (r = -.62, N= 25, p= .00).

From the Fig. 2 we can observed that CO2 emission has been increasing, but the consumption of renewable energy is decreasing day by day, which can be interpreted like as although the renewable energy consumption decreased so to meet the high demand of energy this country consumes more nonrenewable energy (Fig. 1) which is the main reasons behind the increasing trend of CO2 emission in Bangladesh. From *Table 4* also found a negative relationship between GDP and renewable energy consumption, which is a highly unsustainable pattern of energy consumption.

Table 4. Correlation between gross domestic product and renewable energy consumption.

CO2	Correlations	GDP	Renewable
GDP	Pearson Correlation	1	-.621"
	Sog/(2-taoed)		.001
	N	25	25
Fpssil	Pearson Correlation	-.9621"	1
	Sog/(2-taoed)	.001	
	N	25	25

**. Correlation is significant at the 0.01 level (2-tailed).

Fig. 2. Correlation between CO2 emission and Renewable energy consumption from 1990-2014.
Source: Compiled by author.

Therefore, from all of the results of the Pearson correlations it is found that fossil fuel consumption has a positive relationship with CO2 emission and economic growth whereas renewable energy consumption has a negative relationship with CO2 emission and economic growth.

Use of more renewable energy rather than non-renewable energy is essential for environmentally sound energy use.

Conclusion

Energy is an important factor for economic growth as well as for achieving sustainable development it is also essential to ensure sustainable energy solutions. From the findings of this study it is found the renewable energy use is decreasing in Bangladesh also to meet the high demand of the energy the use of fossil fuel is increasing day by day. Fossil fuel consumption is responsible for high CO_2 emission as well as greenhouse gas emissions. So this study also found a positive relationship with fossil fuel consumption and CO_2 emissions. Again, for sustainable energy solution, it is demanded to increase the use of renewable energy use, but the findings from this study shows that in Bangladesh use of renewable energy is decreasing which is a matter of concern. There is no alternative solution except for reducing the fossil fuel consumption and also to increase the use of renewable energy for the sake of sustainable energy solution in Bangladesh. If Bangladesh is looking forward to fulfill SDG#7, calling to "ensure access to affordable, reliable, sustainable and modern energy for all" than this is high time to think about energy consumption pattern of this country because only renewable energy consumption can bridge the gap between economic growth and environmental protection.

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