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The Decomposition Analysis of CO_2 Emission and Economic Growth in Pakistan India and China

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Abstract

The conflict between economic growth and keeping greenhouse gases (GHG) at controllable levels is one of the ultimate challenges of this century. The aim of Kyoto Protocol is to keep the level of carbon dioxide (CO_2) below a certain threshold level. The purpose of this paper is to study the effect of CO_2 emission on economic growth by conducting the regional analysis of PIC nations i.e. Pakistan, India and China. The study also provides the detail information regarding the atmospheric emission by applying decomposition analysis. It is suggested that environmental policies need more attention in the region by keeping the differences aside. So, the emission trading is considered to be the new concept. The approach should be introduced to tackle down the global warming in the region. Now it is time to respond because the low Carbon Economy is the reality.

Keywords: Decomposition analysis, CO_2 emission, economic growth.

1. Introduction

Due to the beginning of the industrial revolution, atmospheric concentration of carbon dioxide (CO_2) has risen to 35% from 1870 to 2005. Within the Kyoto Protocol summit in 1997, the governments around the world made an agreement regarding emission of CO_2 and other greenhouse gases (GHG). According to Kyoto Protocol, the Annex1 (industrialized) nations have to reduce the national emissions to 5 percent over the period of 2008-2012 below the 1990 levels. The GHG that are included in the protocol are: carbon dioxide (CO_2); methane (CH_4), nitrous oxide (N_2O); and three fluorinated gasses like: sulfur hexafluoride (SF_6), per fluorocarbons (PFCs) and hydro fluorocarbons (HFCs). These GHG have led to a 0.6^o C (1.1^o F) increase in the global average surface temperature since 1900 (WRI, 2005).

The trend of carbon dioxide emission in the world reported by International Energy Agency (IEA) is shown Table 1 below:

Table 1: Trend of CO_2 Emission: World 1971 to 2020

Year	1971	2000	2010	2020
CO_2 total emission amount, Mt	13,654	22,639	27,453	32,728
Coal, %	38	39	37	37
Petroleum,%	47	40	40	39
Natural Gas, %	15	21	23	24

Note: Trend of CO_2 emission of World from 1971 to 2020.
Source: International Energy Agency (IEA).

According to Intergovernmental Panel for Climate Change (IPCC) (2007b), if current GHG emissions trend is not restricted then the global temperature will rise from 1.4 to 5.8^{o}C (2.5 to 10.4^o F) by 2100. Out of these total global GHG estimated emission: carbon dioxide (CO_2) contributes 77%; followed by methane (CH_4) 14%and nitrous oxide (N_2O) 8%. Other three fluorinated gasses like: sulfur hexafluoride (SF_6), per fluorocarbons (PFCs), and hydro fluorocarbons (HFCs) contributes only 1 percent (IPCC, 2007a).

The climate change is considered to be the serious threat for the developing nations especially for the Asian. The most of Asian region is considered to be warm above the global mean. These developing nations are often helpless to control or minimize the climate change. Unlike industrialized nations, the developing nations do not have financial and infrastructure resources to adopt and mitigate the climate change (IPCC, 2007c). “It should be a global priority to promote and support the climate change mitigation and adaptation strategies in developing countries. Especially, the industrialized northern countries, which are historical considered responsible for the bulk of global change, should have the responsibility to assist their poorer neighbors in the South (Urban, 2009).”

The UN Millennium Project anticipated the close linkage between energy and eight Millennium Development Goals (MDGs). The modern energy services help in reducing the poverty in developing nations (MDG 1). It also plays an important role in providing educational opportunities for children, empowering women and promoting the gender equality(MDG 2& MDG 3). The availability of energy sources is important in reducing child mortality(MDG 4). By the reduction of the heavy loads of fuel wood will improve maternal health(MDG 5). The inefficient fuel consumption is the major cause of respiratory illness and other diseases (MDG 6). The fuel substitution will help to lessen environmental damage of biomass use(MDG 7). In the end, the substitution of modern energy for traditional biomass can be conventional point for the global partnership (MDG 8) (Malyshev, 2009).

In UN climate conference in Copenhagen 2009, three fundamental elements: scientific evidence, political will, and economic interest; and four practical elements: target setting for emissions reductions, adaptation, technology, and financing were addressed. The

conference fundamentally focused on the understanding economic impacts. But the developed nations are concerned with negative economic effect that's why the developing nations are much worried about their future if they sign up to a legally binding targets. The ratio of emissions between the Annex I (industrialized) nations and the rest of the world is 50:50. If Annex I nations, which includes thirteen industrialized nations, will cut off their emission by 80%, the developing nations will have to cut off only by 20% (Pan, 2009).

2. Literature Review

The major issue for the 21st century business world faced is the awareness and strict enforcement of limits on CO_2 emission for the social and environmental welfare. The intensity factors of CO_2 for the production of electricity from different sources of energy are shown in Table 2.

Table 2: The CO_2 Emission: Intensity Factor

Fuel	CO_2 Intensity Factor
Coal	0.92 kg CO_2/k Wh
Gas	0.52 kg CO_2/k Wh
Nuclear	0.00 kg CO_2/k Wh
Renewable Energy	0.00 kg CO_2/k Wh

Note: The CO_2 Intensity Factor for electricity depends on the fuel used for the generation and the efficiency of conversion.
Source: British Petrleum (2007), Xie (2009).

The amount of the GHG emissions is increasing which has adversely affected the climate, raised the sea level and threatened the natural environment. From 1870 to 2000, the emission of CO_2concentration has been increased to 30%. If the emission continues with the same rate, the sea levels will be expected to rise between 15to 95 cm between 1995 and 2100. This rise of sea levels will cause many costal damages like floods, soil erosion, loss of wet lands and reduce fresh water resources (Sathiendrakumar, 2003).

According to Alcock (2008) in coming future the investors will demand the reliable information about the company's carbon foot print and also want to know the efforts put together by the company to reduce the CO_2 emission. It is expected that the company's carbon statement will be considered to be as a prominent as the financial statement. The carbon management will be considered to be DNA of corporate world. Almost of 94% of major energy users have supported the government's plan for the reduction of CO_2 emission.

According to Urban (2009), those nations who are in the race of economic development will never think to mitigate the climate change at the expense of its economic growth. However, the agreement for reducing CO_2 emission by specifying the sectors would be more feasible for their economy. But if the climate policies are combined with

development policies, that combination will create soft bindings targets to reduce the emission without jeopardizing the economic growth.

The relationship between energy use and economic growth is logically understandable. In many poor nations, underinvestment in public utilities, inefficient management, under pricing and unattractive climate for private investment are the main reasons of energy shortage and hold back economic growth and development (Malyshev, 2009).It is the responsibility of government that it should set the internal emission targets and devise strategies to meet the mitigation goals. The carbon tax and trade permits would be used to fund the research in energy efficiency, renewable energy, carbon sequestration and prudent urban design. Such type of effort would protect the energy security and create the carriers for the masses of young and educated citizen of the nation (Sathiendrakumar, 2003 & Zeng, Ding, Pan, Wang & Gregg, 2008).

The carbon trading market grows to the extent widely anticipated. The European Union (EU) has been considered to be the main driver of international market currently valued up to $ 70 billion. It will be expected to once the United States (US) and other major economies climb up the board, the market will cross over the limit of $ 1 trillion land mark. In 2005, EU has introduced the world first “cap-and-trade” scheme to allow companies to exceed their carbon emissions limit by purchasing extra credits released by companies that emit less. According to Kyoto Protocol, the companies from wealthier nations have to fulfill the ecological obligations by investing in different sustainable development programs to cut CO_2emissions in poorer nations (Hu, 2002).

The carbon credit is one of the economic tools to control the CO_2 emission. Globally the carbon market is working which includes the trading of these carbon credits among the nations or companies, who are trying to meet mandatory GHG emission reduction targets. That carbon market is growing rapidly and reached to USD 21.5 billion. More than 22 funds carbon funds have been created globally to trade credits (Berger & Mallory, 2007).Tang (2008) proposed the four cycle framework, PAIN: Preparation cycle; Assessment cycle; Implementation cycle; and Notify, which are based on nine key steps are of major strategic benefit if applied methodically and suitably supported by appropriate resources within and outside the company.

2.1 Emission in Pakistan

The Pakistan government had accepted the importance of Kyoto Protocol in 2001, but ratifies internationally in Argentine in 2004 due some international circumstances and signed on January 11, 2005. In 2005, the government also created the policy framework for proper implementation. In Pakistan, the electricity production is the oil-based and gas-based generation experienced an increase of 68% and 51% respectively. While the hydro-based generation faces a decrease of 27% due to water shortage in dams. The availability of electricity supply totally depends on oil imports. The environment is now going to expose to the additional 167 million tons of CO_2. In order to bring CO_2 emissions to 1995 level, new policy incentives must have to be introduced. The model results presented by researchers that the high CO_2reduction targets for the electricity sector of Pakistan are not only achievable but also with significant economic effects based on policy interventions, such as 5 percentCO_2 tax proposal. The researchers suggested that there is the need for policy interventions encompassing long-term investment guarantees from the Government of Pakistan (Qudrut-Ullah & Karakul, 2007).

In June 2009, the Ministry of Environment of Pakistan (MEP) had approved 7 Clean Development Mechanism (CDM) projects costing US $ 300.44 million (Rs. 2.41 billion) with CDM Review Committee. The sanctioned amount will be spent on energy and waste to heat recovery sectors for reduction of heavy fuel oil usage for power generation. These CDM projects will cover up the power and steam demand by reducing the carbon emission of 0.355 million tons of CO_2 per year by reducing the local air pollutants. By implementation of these projects, Pakistan will earn substantial foreign exchange revenue amounting to US $ 7.110 million per year along with other socio economic, technological and environmental benefits for sustainable development of Pakistan. So far, Pakistan has granted host country approval of 21 CDM Projects out of which three have already been registered with the CDM Executive Board in Bonn, Germany. The remaining projects are under validation process with the Designated Operational Entity (DOEs) appointed by the CDM Executive Board (MEP, 2009).

2.2 Emission in India

India ratified and signed the Kyoto Protocol in August, 2002. It accounts almost one third of the world's population. But the people of India have no access to clean, reliable and efficient energy sources due to low income. More than 400 million people have no access to electricity. The most of the people are relying on biomass energy. The dominant role of coal in the electricity complex would become understandable, in the year 2020, is still expected to be increased by 61% for India. Clearly, fossil-fuel-based electricity generally and coal-based electricity particularly, would continue to make significant contributions to the overallCO_2emissions. It is expected to account for nearly 57 % of total CO_2emissions.The provision of carbon capture and storage (CSS) in fossil-fuel power plants could significantly increase the overall cost of electricity generation in all nations. Such increase could be rather high in the case of Pakistan (up to 98 %), India (approximately 70%), and relatively modest in the case of China (up to 42 %) (Ronger, Sharma, & Jalal, 2008).

***2.3** Emission in China*

China, the booming economy of world, is the higher emitter of GHG. But the energy per capita is too much lower than that of developed nations; it was almost six times lower than US in 2005. The major source of energy on which China relay is coal andCO_2emission per capita is five times lower than US in 2004. In 2002, China actually ratified the Kyoto Protocol and made commitments to international world to mitigate the climate change. It also introduced the renewable energy law, renewable energy target and developed large scale energy efficiency program. In 2008, China advocate industrialized nations to show leadership in reducing CO_2emission and openly recognized the need of long term action to mitigate the emission (Urban, 2009).

China's GDP has grown by 9.5% per year for the last 27 years, but its CO_2emissions have increased only by 5.4% per year. The reason behind this success is that the government emphases on energy efficiency. Out of the China's total CO_2emission, 23% is the result of producing goods for export to other nations. It has also the largest coal reserves in the world and 67% of its primary energy utilization depends upon the coal. Instead of this, the government has also set the goal to reduce the energy intensity by 20% (Zeng, et. al. 2008).

The source of primary energy consumption, the emission of GHG and percentage of CO_2emissions are reported by International Energy Agency (IEA) are shown in the Table 3.

Table 3: The Energy Sources and GHG Emissions: Pakistan, India and China

Country	Year	Primary Energy					GHG	CO2	Emission Share of CO2 as % of GHG
		C	O/G	H	N	Oth	(Mtons)	(Mtons)	
Pakistan	1990	5	48	3	0	43	224	85	38
	2003	5	54	3	1	37	302	122	41
	2020								
India	1990	34	13	2	1	50	1593	733	46
	2003	37	14	1	1	47	2175	1166	53
	2020	34	32	2	3	29		1714	57
China	1990	62	14	1	0	23	3881	2525	65
	2003	57	22	2	0	19	4939	3393	69
	2020	54	29	3	3	11		5708	56

Note: The Energy Sources and GHG Emissions: Pakistan, India, & China from 1990 to 2020.
*C-coal, O-oil, G-gas, H-hydro, N-nuclear, and Oth-other
Source: International Energy Agency (IEA).

3. Model and Data

The different economic tools are used to control the GHG. The decomposition analysis is one of those tools, which include four different factors like: activity level; structure; energy intensity; and fuel mix. By changing any one of the factors, alone or in combination, can influence the CO_2emission. The equation derived from above factors is:

Total CO2 production

= (Population) (GDP/Population) (Energy Consumption/GDP) (CO_2/Energy Consumption) …… (3.1)

= (Activity level) (Energy Intensity) (Fuel Mix) …… (3.2)

Where:

Activity level	=	(Population) (GDP/Population)
Energy Intensity	=	Energy Consumption /GDP
Fuel Mix	=	CO_2/Energy Consumption

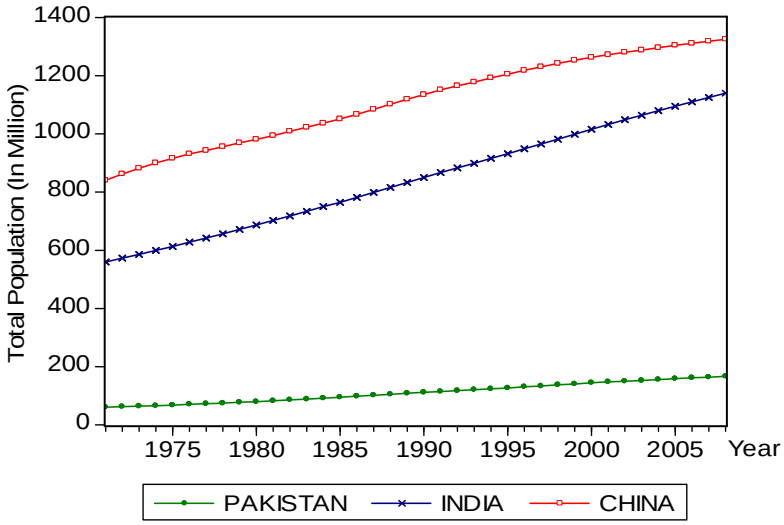
To reduce the total production of carbon dioxide by lowering these factors like: population size; energy intensity; and fuel mix, instead of lowering the GDP per population because it shows the quality of life. But the reduction in population is impossible because the poor countries are over populated. The new technology induction will improve the energy efficiency. The policies are highly aimed to reduce carbon dioxide per unit of energy utilized (Ang & Liu, 2001 & Sathiendrakumar, 2003).

The data of all these factors: like population; GDP; energy consumption; and total CO_2emission, from 1971 to 2008, has been taken from Carbon Dioxide Information Analysis Centre (CDIAS) Data: CDIAS Mercury Metadata Summary and World Bank's (WB) World Development Indicators (2011).

4. Decomposition Analysis and Trend of CO_2 Emission

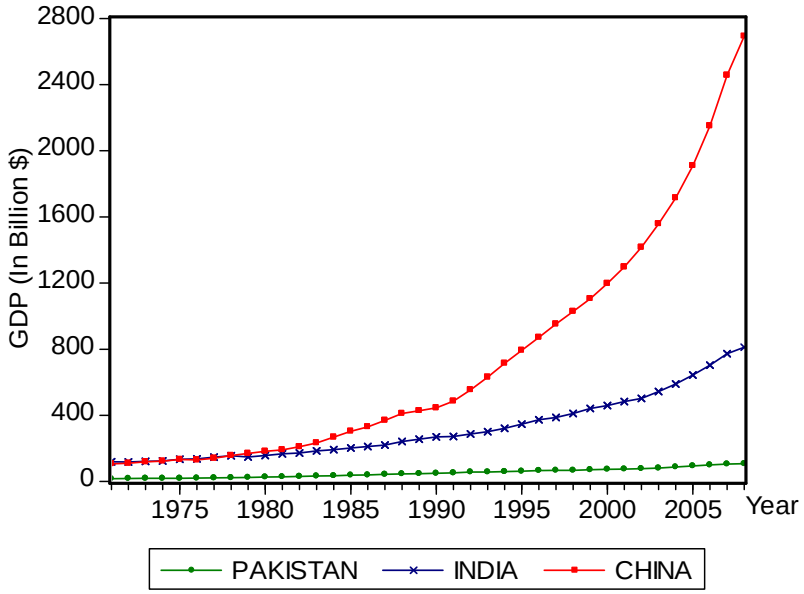
The world population in 1971 was 3.76 billion, but the population of China, Pakistan and India was 845 million, 63 million, and 560 million respectively, as shown in Figure 1. In 2008 the world population became almost double which is 6.87 billion; the population of China was 1.33 billion and India's became double, 1.13 billion. So the population of Pakistan was 167 million, which is low as compared to China and India but the growth rate is higher than its neighbors.

Figure 1: The Population: Pakistan, India and China from 1971-2008



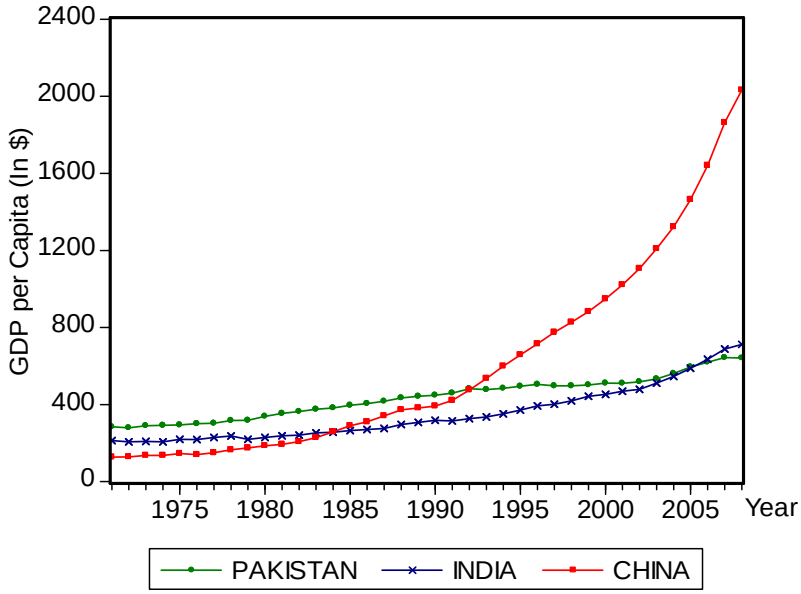
The Gross Domestic Product (GDP) of world in 1971 is $ 12.91 trillion; the contribution of China, Pakistan and India was $ 132.95 billion, $ 17.37 million and $ 119.10 million respectively. The economic boost in China in late 70's, its GDP crossed the limit $ 2.69 trillion in 2008, but the world total GDP was $ 39.49 trillion as shown in Figure 2. The GDP of Pakistan and India did not increase with the same speed as that of China; it was $ 107.57 billion and $ 811.54 billion respectively.

Figure 2: Gross Domestic Product: Pakistan, India and China from 1971-2008



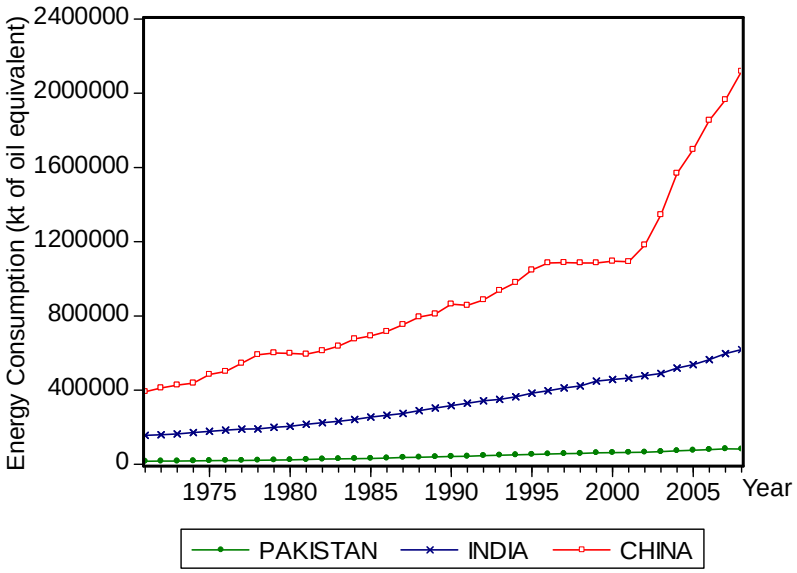
The GDP per capita of China, Pakistan, and India in 1971 was US$ 157, US$ 277 and US$ 212 respectively, Pakistan GDP per capita was greater. But in 2008, the picture changed because GDP per capita of China, Pakistan and India was US$ 2,033, US$ 642, and US$ 712 respectively as shown in Figure 3.

Figure 3: GDP Per Capita: Pakistan, India and China from 1971-2008



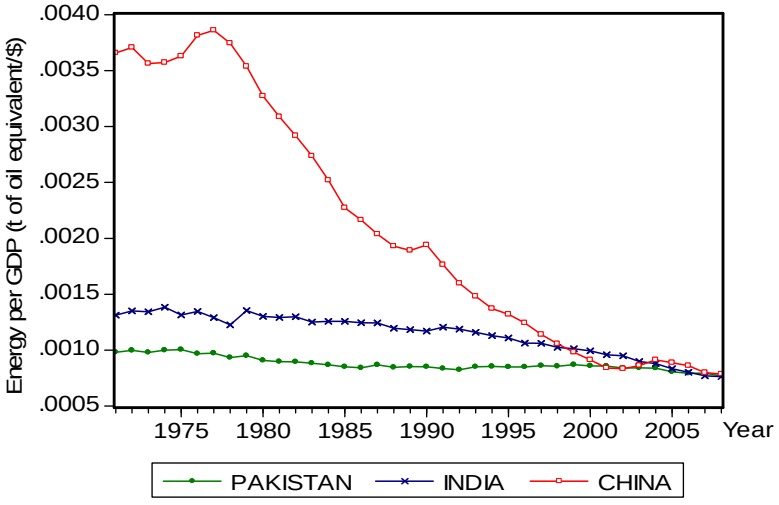
The world total energy consumption was 12.03 billion Mt in 2007. In 1971, China, Pakistan and India the consumption was 391.71 million Mt, 17.37 million Mt and 156.20 million Mt respectively. But the energy consumption of China increased with high rate; it was 2.11 billion Mt, as compared to Pakistan and India that was 82.77million Mt and 619.02 million Mt respectively in 2008 as shown in Figure 4.

Figure 4: The Energy Consumption: Pakistan, India and China from 1971-2008



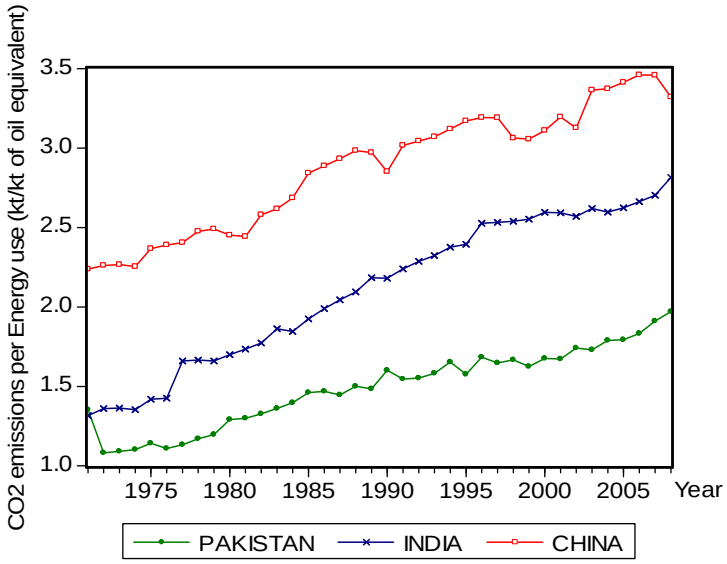
The energy per GDP of China, Pakistan and India was 0.36 %, 0.09and 0.13% respectively in 1971. In 2008, the energy per GDP of China and India decreased to 0.078%, 0.077% and 0.076% respectively, as shown in Figure 5.

Figure 5: Energy per GDP: Pakistan, India and China from 1971-2008



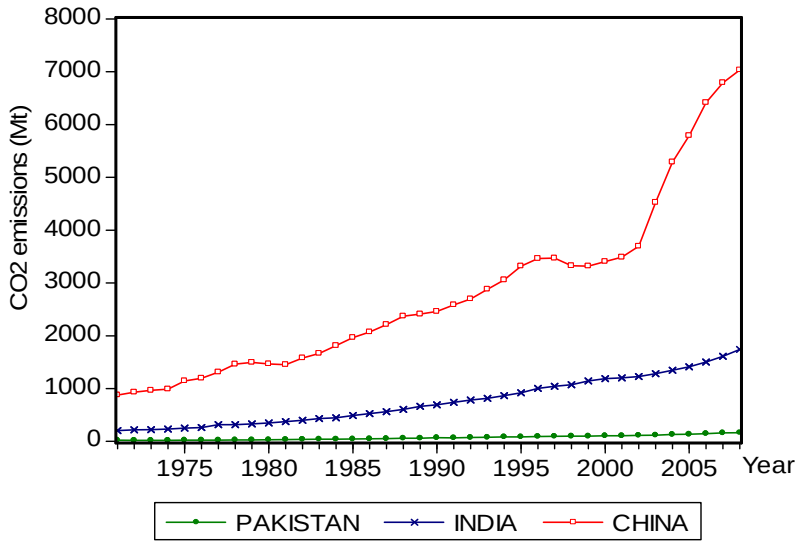
The emission of CO_2 from the energy consumption in case of China is increasing with high rate as compared to Pakistan and India as shown in Figure 6.

Figure 6: CO_2 per Energy Consumption: Pakistan, India and China from 1971-2008



The total production of CO_2 in 1971 was 14.10 billion ton, the share of China, Pakistan and India was 877.63 Mt, 23.06 Mt and 205.87 Mt respectively. But in 2008, the total CO_2production became double, cross the limit of 28.96 billion ton. The share of China and India increased with high rate as compared to world production; it was 7,031.92 Mt and 1,743.7 Mt respectively. But the CO_2production in Pakistan was 163.1 Mt as shown in Figure 7.

Figure 7: Total CO_2 Production: Pakistan, India and China from 1971-2008



The results of decomposition analysis are shown in Table 4.

Table 4: Decomposition Analysis: Pakistan, India and China from 1971-2008

Region	CO_2 Change 1971-2008		%age Contribution to CO_2 Change			
			Activity Level		Energy Intensity	Fuel Mix
	$MtCO_2$	%age	Population	GDP/capita	E/GDP	CO_2/ E
Pakistan	140	85.87	63.55	55.61	-27.50	31.36
India	1,537	88.18	50.85	70.08	-72.22	53.26
China	6,155	87.53	36.50	93.75	-365.16	32.61

Note: Decomposition Analysis of Pakistan, India and China from 1971 to 2008

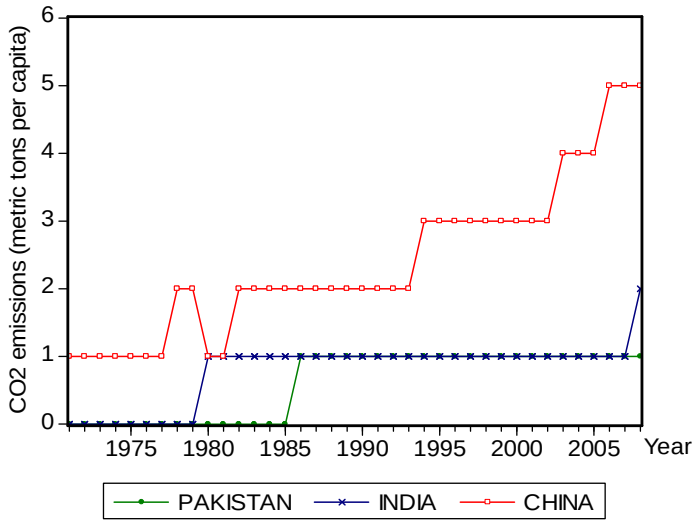
The change in CO_2 emission from 1971 to 2008 is at the rate of 51.33% globally. But in case of Pakistan it increased with minimal low rate which is 85.87% as compared to its neighbor countries like China and India which had 87.53% and 88.18% respectively. The population contribution by Pakistan is high, 63.55%, but GDP per capita is low. But the emission of CO_2 from the consumption of energy is low as compared to China and India. The per capita emission of CO_2in case of Pakistan is low as compared to China and India as shown in Table 5 and Figure 8:

Table 5: Per Capita Emission: Pakistan, India and China from 1971-2008

Region	Per Capita Emission from 1971-2008	
	In 2008	%age
Pakistan	1.00	61.23
India	2.00	75.96
China	5.00	80.37

Note: Per Capita Emission of Pakistan, India & China from 1971 to 2008

Figure 8: CO_2 per Capita: Pakistan, India and China from 1971-2008



5. Conclusion and Discussion

Low Carbon Economy (LCE) is the today reality, which we can't hinder. The CO_2 is adversely effecting the environment which is against the sustainable goals. Now, the relationship between the energy consumed and economic growth is mainly concerned while investing in the power generation sector. The race of being the Asian power is not out of sight in the region. It is suggested that these three PIC nations must define and discuss their problems in order to reach the economic growth.

Pakistan had the maximum GDP in the region in1971.But the impractical economic reforms, kept Pakistan's economy at the same level as that was in 1947whereas the problems are building day by day. The activity level and energy intensity are in unfavorable condition as well. New policies are built and projects are sanctioned but no positive result are found in short run, expected to be in long run, as Rome was not build in a day. Pakistan's industry is now destroying due to the present energy and power crisis, the question arises: "How it is possible to formulate or implement new strategies?" which is like awakening the death body.

India had one philosophy to keep the political tensions in the region. Its more than 400 million of population is earning less than $ 1 a day. But instead of boosting the economic growth in the region, which will be not beneficiary for it as well for its neighbors, but it doesn't want to do so. China is the emerging economic leader of the today's world. In a few years, it is possible that that it will make its proper position in developed nation's category. It is using its human capital in right way, which was considered to be the barrier for economic growth. The Chinese's government is much focus on the environmental friendly economic growth. They always suggested that it will be only possible to control the GHG emissions, if the developed nations played the effective role in implementing these controlling policies.

According to Xie (2009) low carbon technologies are the best key for the development of the world economy. He presented the diversification strategy for the energy, which consists of three parts: the energy resources, energy production and end use of energy. He stated "The essence of the diversification of energy resources is to reduce the coal consumption ratio in the total energy consumption; to fast develop the natural gas industry; to make full use of domestic energy, and reasonable use of international ones; and to exploit the hydro electric, nuclear, and renewable energy, for the realization of diversified energy supply pattern".

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