J Inf Process Syst, Vol.14, No.2, pp.322~345, April 2018
https://doi.org/10.3745/JIPS.04.0067

ISSN 1976-913X (Print)
ISSN 2092-805X (Electronic)

JOURNAL OF INFORMATION PROCESSING SYSTEMS JIPS

Sustaining Low-Carbon Emission Development: An Energy Efficient Transportation Plan for CPEC

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Abstract

Climate change has become a major challenge for sustainable development of human society. This study is an attempt to analyze existing literature to identify economic indicators that hamper the process of global warming. This paper includes case studies based on various countries to examine the nexus for environment and its relationship with Foreign Direct Investment, transportation, economic growth and energy consumption. Furthermore, the observations are analyzed from the perspective of China-Pakistan Economic Corridor (CPEC) and probable impact on carbon emission of Pakistan. A major portion of CPEC investment is allocated for transportation. However, it is evident that transportation sector is substantial emitter of carbon dioxide (CO2) gas. Unfortunately, there is no empirical work on the subject of CPEC and carbon emission for vehicular transportation. This paper infers that empirical results from various other countries are ambiguous and inconclusive. Moreover, the evidence for the pollution haven hypothesis and the halo effect hypothesis is limited in general and inapplicable for CPEC in particular. The major contribution of this study is the proposal of an energy efficient transportation model for reducing CO2 emission. In the end, the paper suggests strategies to climate researchers and policymakers for adaptation and mitigation of greenhouse gases (GHG).

Keywords

Carbon Emission, Climate Change, CPEC, Green ICT, ITS

1. Introduction

In recent decades, environmental problems and global climate change issues caused by greenhouse gases have become the focus of international attention. Previous studies suggest that economic growth and energy consumption are the two most important variables related to environmental degradation. In fact, they have become a decisive factor in contributing to environmental pollution. The majority of studies limit their analyses only to environmental pollution, particularly CO_2 emissions, which correlates with energy consumption and economic growth. But it will be unfair to explain carbon emission only on the basis of energy consumption and economic growth. Global distribution of foreign investment not only promotes economic growth but also transfers its environmental hazards to the host countries. More sustainable developmental path is needed and funding for new technologies that are

Manuscript received November 26, 2017; first revision December 18, 2017; accepted December 29, 2017.
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less energy intensive with greater emphasis on renewable energy must be followed. One of the major projects under the revival of Silk route is China-Pakistan Economic Corridor (CPEC). It is a remarkable project named initiated with an intention to interconnect regions at a global level [1]. CPEC includes various projects of transport, communication, energy and infrastructural development.

It opens an eternal route for trading, industrialization and energy generation to put the country on the path of economic development. The CPEC consists of a long transportation route that expands over an area of about 3,000 km. This corridor enjoys its eminence because it connects Western China's Kashgar to seaport cities of Pakistan including Gwadar and Karachi via a route of Islamabad. The government of Pakistan believes that this project will prove to be a game changer for Pakistan's economic trend [2].

The major contributions of this study are:

We have analyzed existing literature to determine the relationship for FDI, energy consumption, trade openness, economic growth, transportation, and technology transfer towards CO_2 emission.

- We have evaluated the impact of CPEC project on Pakistan's environment based on various case studies.
- We have presented strategies for policy makers to adapt and mitigate greenhouse gases (GHG).
- We have proposed Green ICT based energy efficient Intelligent Transportation model for CPEC route to reduce vehicular carbon emissions.

1.1 CPEC: A Project of One Belt One Road

CPEC project was initially proposed by China in May 2013. In April 2015, Chinese president Xi Jinping visited Pakistan to sign various contracts for CPEC which possess a value of approximately US$28 billion. This caused a significant momentum in the political wings due to huge investment [3]. The reason for considerable debate on this project is probably due to unprecedented amount of investment and the risk of undesirable consequences associated with this project in the form of environmental degradation. Therefore, significant endeavors are planned for sustainable development while driving maximum benefit from this mega-project [4].

In the past century, the impact of climate change has been hazardous and gradual warming across the globe has become a grave risk to attain sustainable advancement of human society. Under prevailing scenario, remedial measures are required to mitigate the imprints of GHG emissions and energy consumption from the sectors which are high emitters of these gases. In this regard, transportation alone contributes manifold in global warming. It is found that refrigerants used in vehicles for automotive air conditioners also contribute in GHG emissions which are of insignificant amount but have relatively high potential of global warming. China has become the largest carbon emitter in the world with the share of 24.2% in 2009 [5].

1.2 The Role of Pakistan's Ideal Geographical Location

OBOR is a vast project comprising of the Silk Road Economic Belt and the 21st century Maritime Silk Road (MSR). A well contemplated gateway of CPEC has gathered a great heat in the region's strategic and economic dynamics. This project is expected to imprint vivid impression on strategic and economic dynamics of the region. Pakistan occupies an eminent strategic position in South Asia. The

role of Pakistan becomes prominent because it provides a feasible gateway to Central Asia and West Asia. It also fulfills the role of joining Eurasia with the Gulf States. Moreover, the Silk Route intends to connect Maritime Silk Route at Gwadar port. Fig. 1 shows national highway route of Pakistan planned to be constructed under CPEC.

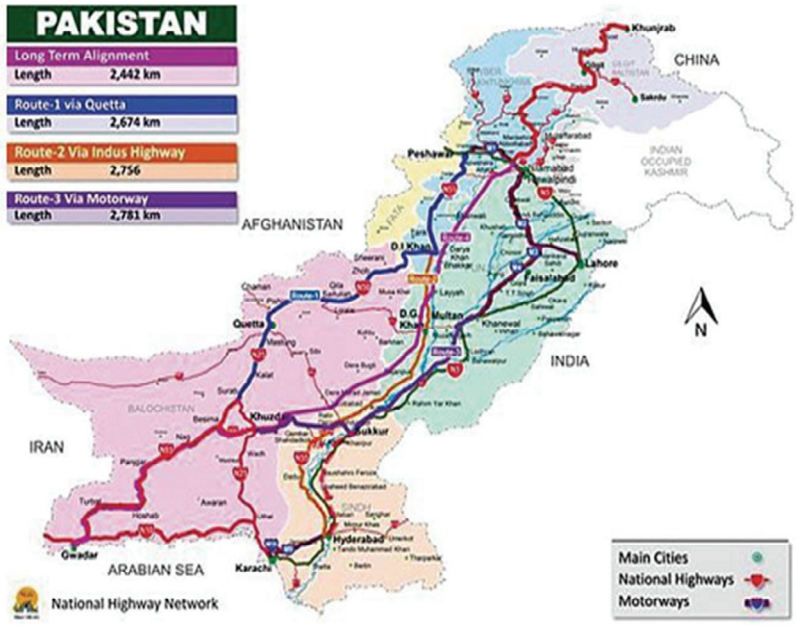

Fig. 1. Map of Pakistan showing national highways routes planned under CPEC (Source: Planning Commission of Pakistan).

1.3 Gwadar Port: A Free Trade Zone

Gwadar is planned to be developed as a free trade zone due to its eminent geographical location. A deep sea port is constructed on Gwadar which allows China to access Arabian Sea. A Chinese firm named as "China Overseas Ports Holding Company" (COPHC) is administering this port that will allow China to access the Indian Ocean directly providing an option to evade Malacca Strait. Keeping in view the politically instable scenario in the South China Sea, the alternate access proves to be strategically preferable for China. China aims to convert the Gwadar port into a prominent Indian Ocean port by creating a free-trade zone. This zone will interconnect Iran, Afghanistan and India by developing trade routes which will join them together.

1.4 Financing Plan

The grandiose project of One Belt and One Road is based on huge investment exceeding US$ 1 trillion. Most of the finance is provided by Chinese state-owned banks and a series of government and multilateral funds, including a Silk Road Fund (SRF), the Asian Infrastructure Investment Bank (AIIB), and the BRICS New Development Bank. China, in 2014 launched two new financial institutions, the

AIIB and the SRF to bridge the financing gap for infrastructure investment in Asia. A new multilateral development bank (MDB), is set up in 2016 with a view to complement and cooperate with the existing MDBs in order to address infrastructural needs in Asia. AIIB has 57 prospective founding members including India. The US$40 billion SRF is established in December 2014 that is jointly funded by China's State Administration of Foreign Exchange, the China Investment Corporation, the Export Import Bank of China and the China Development Bank. It will provide an outlet to China for marketing its excess production capacity in international market. This will enhance domestic production creating job opportunities and revenue generation, while exports of goods and services will lead to higher foreign exchange earnings. It will also lead to greater integration between China and its neighboring countries and will allow China to access oil and gas transportation lines diversifying its energy sources [6].

New institutions are established to finance OBOR policy to fund approximately US$40 billion including New Silk Road Fund (NSRF). Other financial institutions like the Contingent Reserve Arrangement ($100 billion) and the New Development Bank or the BRICS Bank ($50 billion may increase approximately $100 billion) are also established by China to support this project. The NDB may fund infrastructure related projects and will work in collaboration with the AIIB although, it is not established as a part of this project. Shanghai Cooperation Development Bank is also proposed to be established. China plans to utilize its enormous financial reserves through these funding institutions especially when IFI's reforms are not immediately available [7].

As far as Pakistan is concerned, a huge amount of US$45.6 billion is reserved for different projects related to energy and infrastructure in Pakistan [8]. It comprises of an amount worth US$10 billion of commercial loans [9]. Whereas, rest of the amount will be accumulated via export credit and non-reimbursable assistance by Export-Import Bank of China, the Industrial and Commercial Bank of China Ltd (ICBC), China Development Bank, and other financial institutions. Three Gorges Corp and the China Power International Development Ltd is responsible for the key investment in Pakistan's energy sector [10]. Fig. 2 shows total investment in Pakistan between 2010–2017 and China's contribution during that time span.

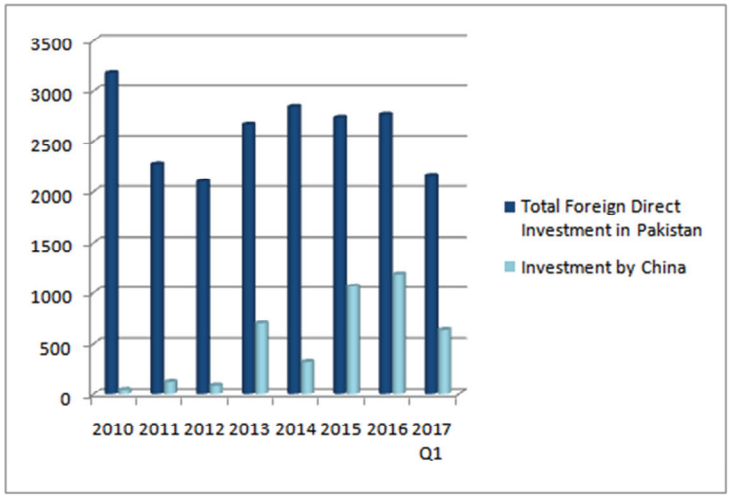

Fig. 2. Total FDI inflows in Pakistan and China's contribution.

1.5 Plan for Infrastructural Development

The policy aims to establish six economic corridors that extend through Asia, Europe and Africa. This will allow China to enter these regions for trade and communication. These economic corridors are given below and their construction plan is illustrated in Fig. 3 as given below:

1. The new Eurasia Land Bridge Economic corridor
2. China-Mongolia-Russia Economic corridor
3. China-Central Asia-West Asia Economic corridor
4. China-Indochina Peninsula Economic corridor
5. China-Pakistan Economic corridor
6. Bangladesh-China-India-Myanmar Economic corridor

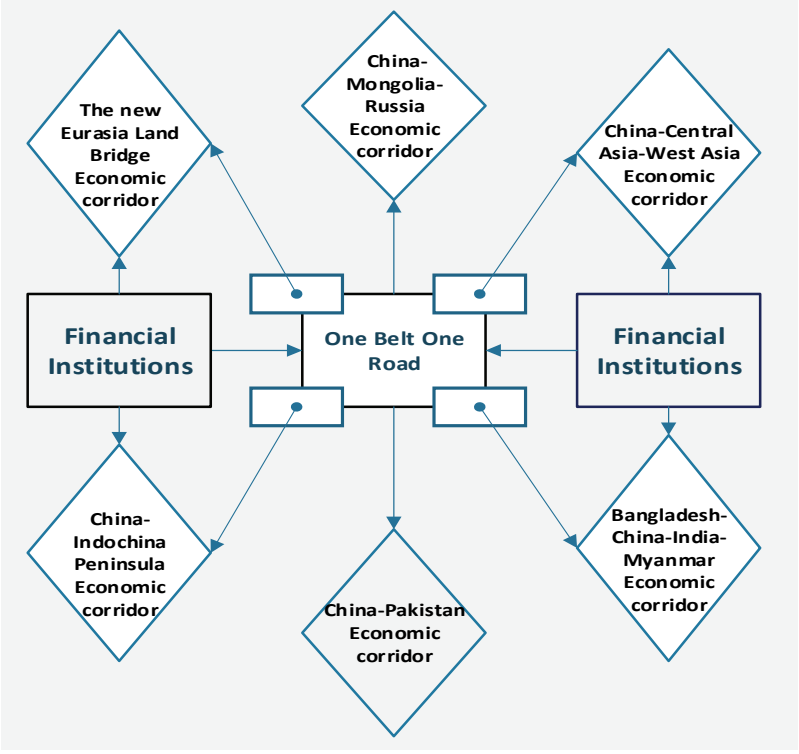

Fig. 3. Construction plan of six economic corridors under One Belt One Road Policy (OBOR).

1.6 Threats

Certain global challenges faced by this project include the South China Sea dispute, Russia's grievances on China's growing authority in Central Asia, the futuristic plan of the Trans Pacific Partnership, India's grievances on China's grasp in the Indian Ocean, the Trans-Atlantic Partnership, Japan-European free trade union, and Africa's hesitation over the potential benefit of China's investment and trade. Moreover, the grandiose investment of $47 billion in rail and road infrastructure that passes through Pak occupied Kashmir will give an access to China to carry oil and gas from Iran

and Arab countries via Gwadar port. Security of the CPEC is also greatly influenced by regional geopolitics. Chaos in Afghanistan, Iraq, Turkey, and India's concerns over the project may also pose threat. India bears serious grievances against recent tread by China that connects West China to the strategic Gwadar port in Pakistan. It shows apprehension on Chinese influence in the Indian Ocean. Additionally, it also criticizes certain transportation routes that pass through disputed territory of Jammu and Kashmir like the route through Gilgit-Baltistan. There also exists a hindrance in the form of Chinese Separatist Uyghurs who may team up with the violent militant forces. This is also evident from repeated violent attacks on Chinese labor force to malign this project.

On the other hand, there exists controversial perspective in Pakistan on whether China's initiative policy with specific reference to CPEC represents a threat or an opportunity. Pakistan itself is facing numerous internal as well as external threats. The internal threats include aggravating divisions within Pakistan and heightening tensions between Islamabad and other regional players. The hostile forces of Balochistan (the province of Pakistan adhering to strict tribal restrictions), criticizes the investment by CPEC. It has a border with Afghanistan which is already a hub of anarchy and terrorism. Therefore, the construction phase of the project may face various security challenges. Also, the CPEC project has infrastructure routes that passé through areas undergoing conflict and civil war. Therefore, Pakistan's government has also requested to ensure the security of Pakistani and Chinese nationals deployed on the construction [11]. CPEC plans to pass through Khyber-Pakhtoonkhwa KPK connected with Federally Administered Tribal Areas FATA. FATA and Balochistan may pose security threats because of their politically deviant perspectives [12]. Hence, internal major challenges in the path of successful completion of this project include political instability and security issues [13].

The rest of the survey is structured as follows: Section 2 presents a literature review. Section 3 gives an overview of Pakistan's climate change policy, Green ICT, and role of Intelligent Transportation System (ITS). Section 4 presents recommendations. Section 5 presents conclusion and policy implications.

2. Literature Review

The impact of foreign direct investment in a country has remained a topic of concern for a long time. In order to understand the prospective impact of CPEC in Pakistan, we examine the existing literature based on case studies from various countries across the globe. The consequences of investment by China in the form of CPEC will derive far reaching outcome in Pakistan's regional market and industrial sector. It is revealed that financial development in China proves to be a significant factor for increase in carbon emissions potion. Nevertheless, its direct impact on Pakistan's carbon emission ratio is crucial to be monitored. It is therefore imperative to explore the impact of CPEC from broader development frameworks. This study is an attempt to analyze and gauge the impact of CPEC on Pakistan's overall economic development in general and GHG emission in particular.

2.1 Impact of Investment on Environment

Recent studies stress that rapid climate change has emerged as a matter of grave concern for the international community. The role of living creatures in contaminating the environment is evident from vivid increase in global anthropogenic GHG emissions which has currently reached to highest in

history. The ultimate effect of climate change is undoubtedly evident on human and natural systems. Presently, numerous studies on foreign investment have centered their attention on analyzing the impact of investment on human atmosphere. Literature analysis reveals that foreign investment can not only be a grave threat to the environment on one hand, but can also lead to reducing energy availability on the other hand. In fact, there exist numerous studies evaluating the influence of foreign investment on global climate. Nonetheless, final verdict regarding its impact is indecisive yet. Some of the studies support positive effect of FDI [14,15]. They suggest that the inflow of FDI helps to promote energy efficiency of host countries and cut their environmental quality. However, there is also extensive literature evidence that presents conflicting arguments. Some earlier studies favor halo effect hypothesis [16]. According to this hypothesis, foreign organizations possess energy efficient technologies and practice improved managerial skills that tend to establish clean environment in host countries. This is also supported by a recent study which states that when FDI inflows in less-developing states, they are more conducive to clean environment [17]. On the other hand, a study conducted on G20 countries investigates the impact of foreign direct investment and output growth on energy consumption and clean energy demand. The author reaches to contrary assessment and infers that foreign investment tends to enhance environmental contamination as the relation between them is proved to be co-integrated [18].

There are some researchers that support the pollution haven hypothesis (PHH). This phenomenon explains that when developed countries make huge financial investment abroad, they not only improve technology and cause economic growth but also transfer polluting industries or commodities into developing countries. Moreover, developing countries with relaxed environmental regulations are more prone to risk of becoming pollution havens gradually. As a matter of fact, most of the developing countries possess relaxed environmental standards for FDI flow which immensely contributes in CO_2 emissions [19]. In this context, CPEC investment also portrays a risk of transferring its pollution to Pakistan along with its economic benefits. Nevertheless, this may be achieved at the cost of Pakistan's environmental deterioration. This confirms with the concept of pollution haven hypothesis in economic theory which explains that developing countries are often lenient towards environmental regulations so as to attract foreign direct investment.

Finally, the technical effect occurs as pollution decreases due to the application of new production techniques and/or technology. This relationship is known as the EKC because the idea of an inverted-U shape relationship originated from Kuznet [20].This has become a source of reference for many present studies to base econometric models. Therefore, the basic model may be represented as:

$$C = Y\,x\,S\,x\,T \tag{1}$$

In (1), C denotes CO_2 emission, Y denotes economic production, S denotes industry structure, and T denotes technology.

2.2 Impact of Investment on Energy Consumption and Carbon Emission

Considerable amount of research has been conducted to analyze the impact of foreign investment on carbon emissions in developing nations [21,22]. This raised curiosity for many scholars to study FDI–pollution nexus. As a result, two conflicting hypotheses appeared on horizon namely; the pollution

haven hypothesis and the halo effect hypothesis. In order to validate these hypotheses, some researchers carried out correlation analysis between carbon emissions and foreign investment inflow for a period of 1980–2011 in selected MENA states. The authors confer that FDI and carbon emission nexus bear a weak relationship [23].

Whereas, a case study conducted in China implements PHH to analyze the impact of an investment on percentage of carbon emissions released by China during market-oriented reforms. The outcome reveals that FDI directly promotes China's CO_2 emissions [24]. In another study conducted in China, FDI's impact on carbon emissions is analyzed from 2001 to 2012. Spatial lag model and spatial error model is used to find that carbon emissions are hugely influenced by the industrial structure, economic scale, and technological development. This study denies Pollution haven hypothesis with relevance to China [25]. In the similar context, another study observes that an investment in a new project causes an increase in carbon emission and energy consumption [26]. Similarly, a study carried out recently confers that energy consumption positively affects CO_2 emissions [27,28]. Whereas, in another study conducted in 2011, the authors argue that domestic production is affected by foreign investment however, it does not affect the energy intensity of a country [29]. A more practical approach is adopted in a study that empirically investigates the influence of foreign direct investment on energy consumption. It is revealed that the variation in economic environment, economic structure, development stage, and energy prices produce variable outcome [30].

Conversely, there is also a huge literature available that conflicts with existing studies and suggest that CO_2 emissions have no relation with energy consumption [31-33]. They emphasize that previous studies had the limitation that they were based on only two or three variables. This forced them to apply omitted-variable bias. The investigation on FDI and energy intensity nexus for USA and China reveal similar findings. It supports the evidence that foreign investment decreases energy consumption through technological innovation. Later on, this was supported by some other researchers when investigating the relationship between foreign direct investment and energy intensity for both USA and China [34-36]. Fig. 4 shows global fossil fuel energy consumption and energy-related CO_2 emissions as given below:

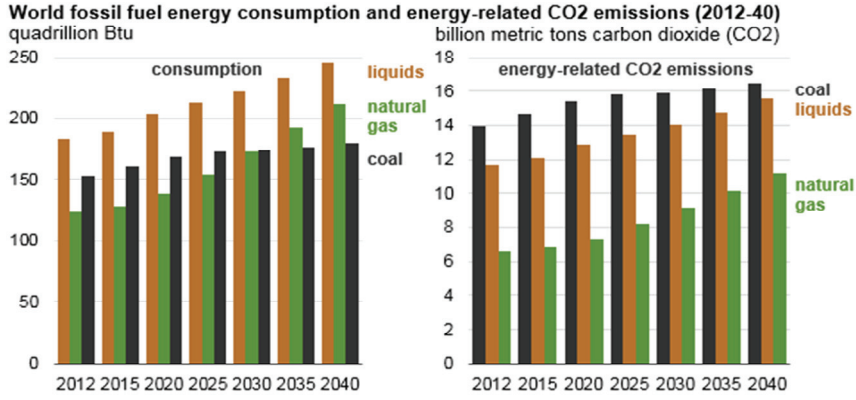

Fig. 4. Global fossil fuel energy consumption and energy-related CO_2 emissions (2014–2040).

Apart from analysis based on inter-country data, there also exists considerable amount of literature that supports PHH based on intra-country data in developed countries like USA [37-39]. A research

carried out in China also finds evidence that favors PHH [40]. Researchers have analyzed the impact of China's market-oriented reform on China's regional energy and carbon efficiency to determine FDI's effect on China's environment [41]. It is found that it has a positive effect on efficiency of energy use and CO_2 emission.

A study carried out in Pakistan confirms that EKC portrays a long-run phenomenon. It also stresses that a number of explanatory variables including population density can influence the quality of environment in the case of Pakistan [42]. Hence, based on the previous studies [43-45], the relationship between CO_2 emissions, energy consumption, economic growth and financial development can be represented respectively through following equation:

$$CO_2 = f(X, X2, EC, D2) \tag{2}$$

Furthermore, in order to determine the impact of foreign direct investment, clean energy consumption, trade openness, carbon emissions and economic growth on energy consumption, the general form of energy demand equation is constructed as follows:

$$E_t = f(F_t, G_t, TR_t, C_t, Y_t) \tag{3}$$

Now on the basis of EKC hypothesis, we can form a linear quadric function which creates relationship between carbon dioxide emission and energy consumption, economic growth, trade openness, FDI and transport vehicle emission. The variables are denoted in Table 1.

$$lnE_t = \alpha_o + \alpha_1 lnY_t + \alpha_2 (lnY_t)^2 + \alpha_3 (lnY)^3 + \alpha_4 lnEN_t + \alpha_5 lnX_t + \alpha_6 lnV_t + \alpha_7 lnFCPEC_t + \varepsilon_t \tag{4}$$

Table 1. Variables and denotation

Denotation	Variable
lnE_t	Natural log of CO_2 emission per capita
lnY_t	Natural log of real income per capita
$lnEN_t$	Natural log of energy consumption per capita (metric tons)
lnX_t	Natural log of trade openness ratio
lnV_t	Natural log of transport vehicle emission per capita
$lnFCPEC_t$	Natural-log of real foreign direct investment for CPEC per capita
ε_t	A standard error term

2.3 Impact of Investment on Economic Growth

Earlier studies were initiated in previous century that investigated the impact of investment on economic growth of a country [46-48]. The research was later extended by other scholars [49] and studied from both microeconomic [50-54] and macroeconomic perspectives [55-59]. It is established that contradictory results are found when the microeconomic and macroeconomic aspects of FDI on economic growth are studied [60]. A positive relation is observed for FDI inflows and economic growth for a panel of 72 developed and developing countries during the period 1960–1995 [61]. In a study, the impact of FDI on economic growth in developing economies is investigated [61]. It is found that with

an export base strategy, FDI does not support economic growth in receiver country. However, with an import substitution strategy, FDI-growth nexus is positive.

Similarly, the study based on intra-industry panel work in developing, developed and transitional economies show little evidence to support the positive impact of investment in a country. Whereas, an empirical analysis of micro literature shows an evidence supporting positive effect of FDI in receiver countries [62]. Furthermore, it is revealed that there exists no reliable linkage between the volume of inward FDI stocks or flows relative to GDP and growth subsequently negating FDI-growth nexus. Moreover, when a country is financially prosperous, credit policies are conducive to consumers' loan activities and instigate to acquire luxury items like automobiles, houses, refrigerators, air conditioners, washing machines, etc. This collectively contributes to enhanced release of carbon emission [63].

On the contrary, there exist a number of earlier studies that reject the existence of positive impact of foreign direct investment on a receiver country [64]. Based on this study, the effect of FDI on economic growth was empirically examined. It was found that FDI does not influence economic growth but FDI is found to be positively linked with growth of per capita income. This is also supported by a similar study within the same timeframe but conducted at a different region. A panel of 75 developing countries for FDI-growth nexus was studied during the period 1970–1980 [65]. It explores that the relation between FDI and growth is negative. The result coincides with a later study conducted in the beginning of 21st century. This study also observed a negative impact of foreign direct investment with economic growth for transition countries [66]. Fig. 5 shows sector-wise FDI inflows in Pakistan as given below:

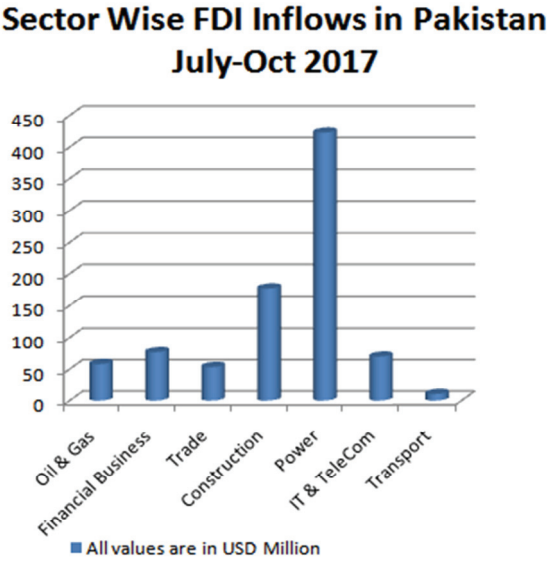

Fig. 5. Sector-wise FDI inflows in Pakistan.

2.4 Impact of Investment on Transportation and Carbon Emission

Transportation is one of the significant factors conducive for a huge quantity of fuel consumption and accounts for a major portion of global emission. There is well established literature on strategies focusing on lowering fuel consumption and CO_2 emissions. Lowering traffic congestion, ensuring

smooth traffic flow, adopting more efficient modes of travelling, and switching to Green ICT vehicles with clean fuel technologies are few of the remedies for reducing GHG emission [67,68]. Recent findings suggest that carbon emissions may be reduced when miles traveled by a vehicle are cut down [69]. In this regard, there is limited evidence to determine the extent to which institutional drivers affect our ability to reduce GHG emissions from transportation systems [70]. In order to reduce CO_2 emissions in the future, policy makers are working on devising vehicles that are more efficient. Also, increasing the use of carbon-neutral alternative fuels is reiterated.

In addition, CO_2 emissions can also be lowered by improving traffic operations, specifically through the reduction of traffic congestion. It has been found [71] that CO_2 emissions can be reduced to a great extent by implementing:

1. Green ICT based techniques: Green ICT is incorporated in addition to the use of more fuel-efficient vehicles and carbon neutral alternative fuels. Green ICT in eco-driving allows a driver to change his driving behavior in a static (e.g., do not accelerate too quickly, reduce speeds, etc.) or dynamic manner (e.g., advice is given based on real time scenarios).
2. Congestion mitigation strategies: It allows traffic to flow at smooth speed by decreasing traffic blockage.
3. Speed management techniques: It aids to decrease high speeds to more moderate conditions.
4. Shock wave suppression techniques: It removes the events that force driver to accelerate/ decelerate speed during congested conditions.

To mitigate the adverse effects of GHG emissions (particularly carbon dioxide CO_2), policy makers are encouraging to adopt more fuel efficient transport sources and are proposing to adopt alternative fuels. Moreover, it is also inferred that implementation of an efficient traffic operational strategy aids in smooth traffic flow by reducing traffic congestion. This ultimately contributes in remarkable decrease in CO_2 emission from transportation sector. Table 2 presents comparison of current literature survey.

Table 2. Comparison of literature survey

	Ref.	Description
Impact of CPEC investment on environment	[15]	The survey suggests that inflow of FDI helps to promote energy efficiency of host countries and cut their environmental quality.
	[19]	This survey focuses on the parameters of adherence to governmental policies for climate change. It states that most of the developing countries possess relaxed environmental standards for FDI flow which contributes in CO_2 emissions immensely.
	[17]	According to this survey, when FDI flows in less-developing states, they are more conducive to clean environment. However, this is contrary to pollution haven hypothesis.
	[18]	In a survey conducted on G20 countries, the author infers that foreign investment tends to enhance environmental contamination as the relation between them is proved to be co-integrated.
Impact of investment on energy consumption and carbon emission	[25]	In a survey conducted in China, FDI's impact on carbon emissions is analyzed from 2001 to 2012. Spatial lag model and spatial error model is used to find that carbon emissions are hugely influenced by the industrial structure, economic scale, and technological development. This study denies pollution haven hypothesis with relevance to China.

	Ref.	Description
	[39]	Another recent survey is based on intra-country data in developed countries like US and supports pollution haven hypothesis.
	[24]	A case study conducted in China implements pollution haven hypothesis (PHH) to analyze the impact of an investment on percentage of carbon emissions released by China during market-oriented reforms. The outcome reveals that FDI directly promotes China's CO_2 emissions.
	[40]	Another survey carried in China also found evidence that favors PHH.
Impact of investment on economic growth	[59]	A positive relation is observed for FDI inflows and economic growth when FDI inflow growth nexus for a panel of 72 developed and developing countries is surveyed during the period 1960–1995.
	[66]	The result coincides with a later study conducted in the beginning of 21st century. This survey also observes a negative effect of foreign direct investment on economic growth for transition countries.
	[63]	This survey finds that, when a country is financially prosperous, credit policies are conducive to consumers' loan activities and instigate to acquire luxury. This collectively contributes to enhanced release of carbon emission.
	[60]	It is established that contradictory results are found when the microeconomic and macroeconomic aspects of FDI on economic growth are surveyed.
Impact of investment on transportation and carbon emission	[69]	This survey infers that lowering traffic congestion and ensuring smooth traffic flow, adopting more efficient modes of travelling, and switching to green ICT vehicles with cleaner fuel technologies are few of the remedies for reducing GHG emission
	[71]	This survey reveals that carbon emissions may be reduced when miles traveled by a vehicle are cut down.
	[68]	In order to reduce CO_2 emissions in future, policy makers are working on devising vehicles that are more efficient and using carbon-neutral alternative fuels. In addition, CO_2 emissions can also be lowered by improving traffic operations, specifically through the reduction of traffic congestion.
	[70]	This survey concludes that there is limited evidence to determine the extent to which institutional drivers affect our ability to reduce GHG emissions from transportation systems.
Limitations of existing literature	-	Past surveys on this subject suffer from certain shortcomings. Some of these studies have applied co-integration techniques. This technique is adopted from previous models based on Engle and Granger co-integration test or the maximum likelihood test based on Johansen. However, this method may be misleading when it is applied on a sample which is too small. In some previous studies, cross sectional data is used while ignoring distinct issues and challenges of a country. The results from existing surveys in this field are diversified. It is observed that some results for same countries with similar datasets and time span vary only because of different causality techniques and bivariate or multivariate models applied. For bivariate models, the use of only two variables causes a disguise of channels of causality apart from omitted variable bias. Another shortcomings observed is that for some developing economies, limited data sets are available for a sufficiently long period of time in order to obtain a meaningful time series analysis like Pakistan. In such cases, energy prices are often unavailable. Therefore, consumer price index is rather used as a price variable. Moreover, the use of not-matching variables causes problems. Another loophole of these studies is that most of them ignore the structure of each economy, social and economic indicators and its stage of development for determining their energy-economy interactions.

	Ref.	Description
Our contribution	-	Despite existence of abundant literature on FDI, trade, economic growth, energy consumption and carbon emission, very few such studies are found specifically for Pakistan. Unfortunately, there is no empirical work on the subject of CPEC and carbon emission for transport route of Pakistan in particular. The current survey is one of its kinds because it investigates the relationship between the investment made by China for CPEC and its impact on carbon emission of Pakistan in the light of inferences derived from existing literature survey. In order to determine this, case studies of various countries are surveyed to examine the relationship between FDI and environment, energy consumption, trade, technology transfer and transportation. Ultimately, we present green ICT based ITS model for transportation and draw important guidelines for policy makers in their pursuit for a more effective plan to promote sustainable growth in Pakistan.

3. Carbon Emission in Pakistan

Pakistan is going through a critical phase in its endeavors to combat GHG emissions. Statistics reveal that carbon emission collectively contributes a total of 87% of national GHG emissions. According to the statistics by Economic Survey of Pakistan, the energy sector is the highest contributor of GHG emissions in Pakistan (Economic Survey of Pakistan, 2012–2013). In the year 2011, global liquid fuel consumption accounted for 88.4 million barrels per day whereas, 89.0 million barrels per day in 2012. Additionally, global statistics reveal that oil, gas and coal are the major sources of energy consumption with an increase in global demand for liquid oil by 0.8% (Economic Survey of Pakistan, 2012–2013) [72]. According to the World Resources Institute's Climate Analysis Indicator Tool (WRI CAIT), 46% of Pakistan's total annual GHG emissions are from energy sector out of which 26% is attributed to electricity consumption, 25% to manufacturing, 23% to transportation and the remaining 25% to other energy subsectors. Whereas, agricultural sector contributes approximately 41% of total GHG emissions, out of which, 46% is contributed by enteric fermentation. Moreover, GHG emission by industrial sector is 5% and waste contribute around 2% of emission [73].

Statistics show that from 1990–2012, Pakistan's total GHG emissions grew 87%. The increase in energy emission observed in the same period is by 87 $MtCO_2e$ that contributes to 55% of total emissions growth. Whereas, agriculture emissions observed an increase of 62 $MtCO_2e$ and contributed 39% of the total increase. Transportation subsector was one of the main drivers of energy sector emissions growth after electricity and contributed 27%, of the total energy sector increase. But the most appalling revelation is that GHG emissions grew by 89% over the period 1990–2012. It averages just under 3% annually. Within the same timeframe, the increase in GDP was 136%, averaging 4% annually [73]. This shows that there is potential to reduce Pakistan's GHG emissions relative to GDP as the carbon intensity of Pakistan's economy is at almost four times the world average. China has the most contribution in Pakistan's FDI inflows as shown in Fig. 6.

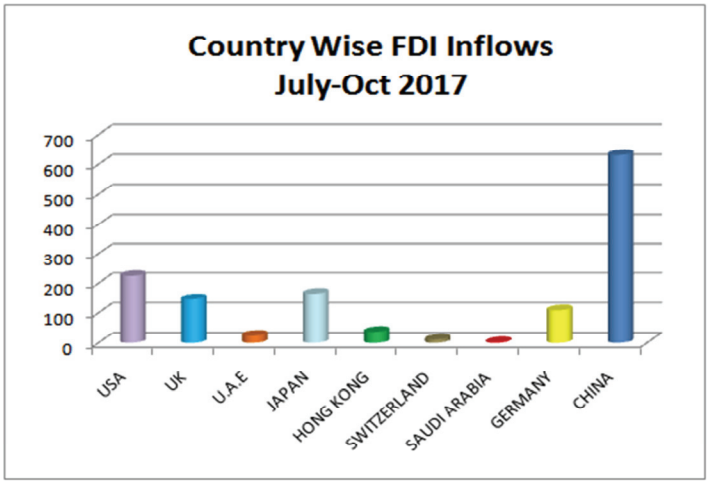

Fig. 6. Total FDI inflows in Pakistan and China's contribution.

3.1 Pakistan's Climate Change Policy

In 2003, Pakistan submitted Initial National Communication report (INC). This report includes national GHG information for the period of July 1993 to the period of June 1994. However, the government fails to update it on a regular time interval. The government of Pakistan joined Kyoto Protocol in 2005 which is administered under the Ministry of Environment & Climate Change [74]. Under this agreement, the Clean Development Mechanism (CDM) has been initiated with an objective of mitigating GHG and for promotion of green environment. GHG information for year 2008 is also developed that is referenced in the Final Report of the Task Force on Climate Change published in 2010. The Task Force on Climate Change that works along with the Planning Commission of Pakistan, released its final report in 2010 [75].

3.2 Pakistan's Intended Nationally Determined Contribution

In 2012, National Climate Change Policy of Pakistan clearly states that an Action Plan will be developed for implementing climate change mitigation measures in different sectors including transportation, energy and agriculture [76]. Also, the report states that alternate renewable energy sources will be promoted. Carbon mitigation and energy conservation measures will be undertaken. The report also states that implementation of vehicle emission standards will be made mandatory. Later on, the report submitted by Pakistan's Intended Nationally Determined Contribution (INDC), in November 12, 2015, fails to elaborate specific targets for reducing carbon emissions in Pakistan. It also does not explain a set of mitigation activities [77]. So far, the government has not been able to fulfill its climate change mitigation targets. Serious efforts need to be initiated to curb increasing GHG emission in Pakistan by incorporating Green ICT in the new projects under CPEC that are in their early phase. Such endeavors will ultimately affect future emissions.

3.2 Green ICT

Green Information and Communications Technologies (ICT) have the potential to significantly curb

GHG emissions worldwide. There is a need to focus on ICT research and development efforts to curb GHG emissions instead of targeting to achieve energy efficiency goals only. ICT's potential as a GHG emission reduction agent is described in recent development with respect to creation of international standards for quantifying ICT GHG emission reductions. It is found that climate change effect may be reversed with the assistance of greenhouse gas reduction techniques by using renewable sources with effective ICTs [78]. This is also validated by some other researchers [79,80].

Based on detailed literature analysis, it is imperative to suggest that green ICT can be implemented on CPEC route to develop an energy efficient transportation system. This will not only help to reduce carbon emission in Pakistan but will also make vehicular transportation to conserve energy. Our sustainable existence on this planet requires that our dependency of technology needs to be environment friendly. However, enhanced energy efficiency does not necessarily guarantee reduction in carbon emission which is an "efficiency paradox" [81]. Enhanced efficiency often results in enhanced energy consumption by ICT. Thus, the paradigm of Green ICT fumbles due to greater carbon emission [82]. Therefore, there exists a need to determine the impetus of energy efficiency evolving inherently from Green ICT equipment. System Flow diagram is presented in Fig. 7.

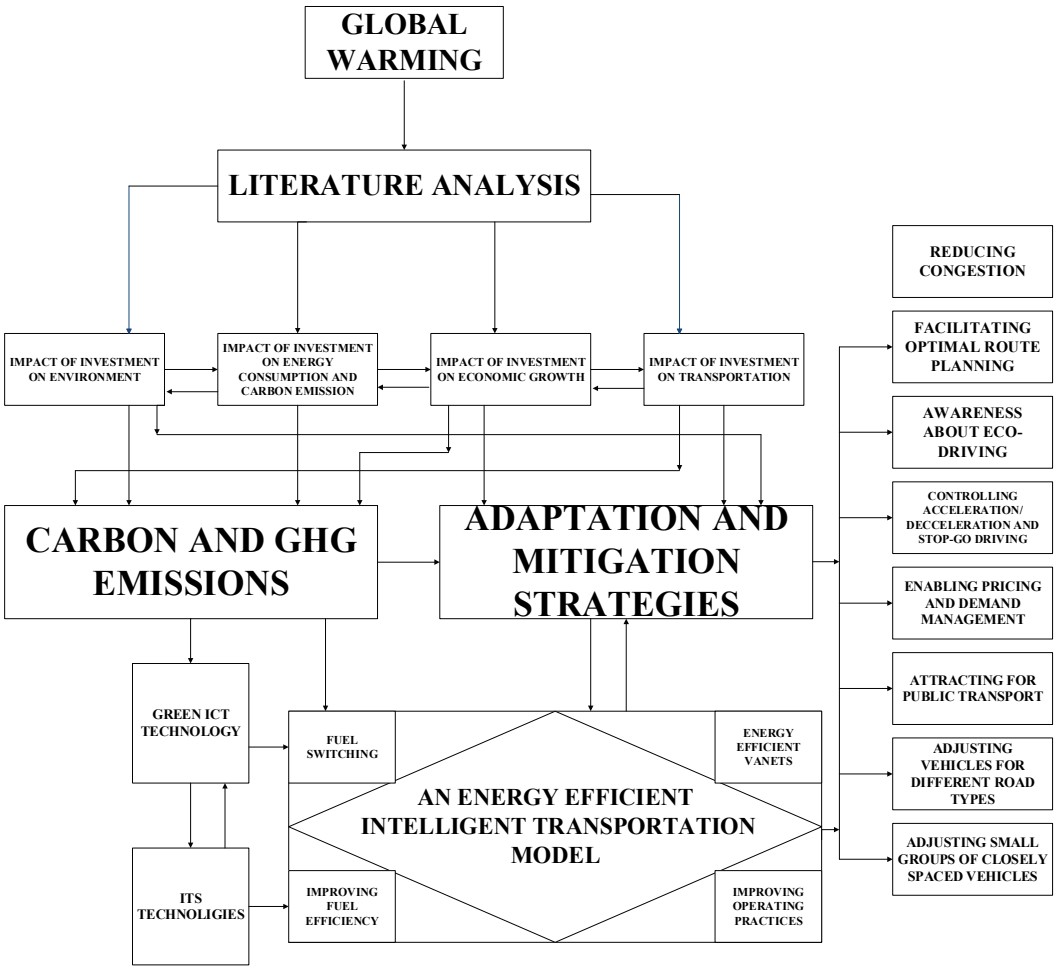

Fig. 7. System flow diagram.

3.3 Intelligent Transportation System

Intelligent transportation system (ITS) is an advanced transport system that involves wireless, electronic, and automated technologies. This system works by integrating Green ICT based smart vehicles, system users, and infrastructure. An automated technology assists in precision parking, automated guidance, and accident avoidance systems. It is noteworthy that the technological development in the field of road transportation has offered strategies to fight against global warming. ITS, automotive fuel technologies and mobility management strategies not only assist in lowering overall carbon emission but also discourage private possession of vehicles. Development in the field of innovative engine system and advanced vehicular technologies also assist in combating impacts of climate change.

Significant ITS technologies that aid in reducing carbon emission include traffic signal control system, electronic collection of toll, bus rapid transit, and travelers' information protection. Whereas, mobility management approaches include road pricing policies and car sharing (short time vehicle access). These strategies have so far, established the greatest potential for reducing CO_2. Some other strategies for discouraging carbon emission involve implantation of integrated regional smart cards, driving the vehicles at a lower speed limit, park and ride services for vehicles, parking cash out and carpooling facility. While ITS technologies are still in the early phases of deployment, many have the potential to reduce energy use and CO_2 emissions. Therefore, it is proposed that the new route developed between Pakistan and China can deploy Green ICT based ITS, that will not only speed up the vehicle mobility for trade purpose but will also make the transition cost effective and secure. For this, we present a model for Green ICT based ITS for CO_2 reduction as shown below in Fig. 8.

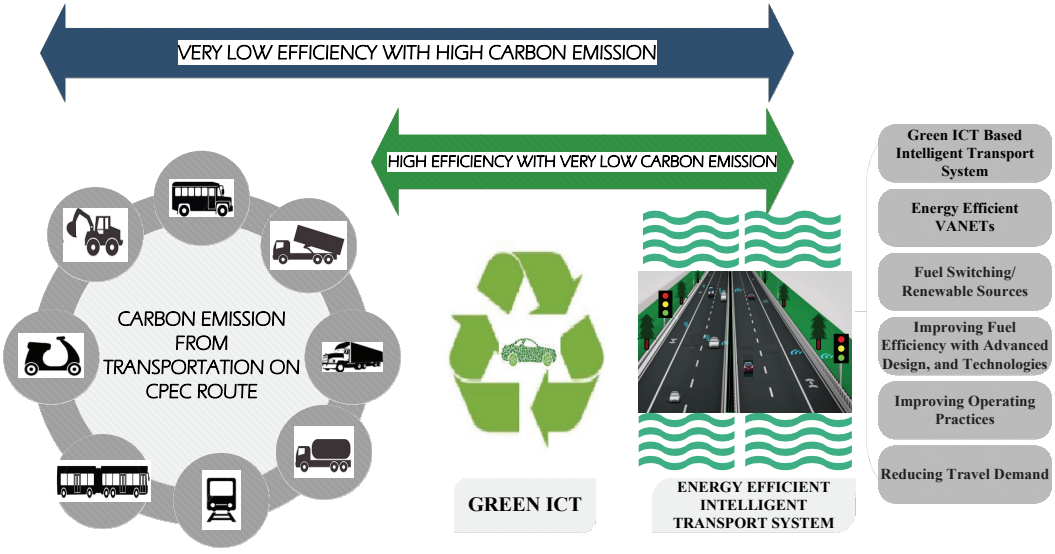

Fig. 8. A model for Green ICT based intelligent transport system for CO_2 reduction.

3.4 Perspective for Low Carbon Development

Last few decades have witnessed the role of FDI in elevating financial development in Pakistan. FDI has brought stability in numerous economical sectors especially in the field of ICT. The primary focus

of foreign investment allocated for CPEC has been on energy and transportation projects probably due to severe scarcity of energy resources in Pakistan. China has drastically enlarged its investment in Pakistan since 2010 surfacing up as a chief investor in Pakistan's foreign investment. However, China's GHG ratio has increased in recent years at an alarming rate. The early harvest projects under CPEC investment have also been allocated for economic development in this sector. China claims to make sustainable development under OBOR by exploring renewable energy resources to avoid hazardous carbon imprints. Due to the graveness of prevailing scenario, considerable number of power plants and coal power projects will be shut down in Pakistan due to high carbon emission. Therefore, adequate measures need to be taken to implement Green ICT technologies for renewable energy resources. The Green ICT has potential to make a fundamental difference in the lives of people by promoting green energy and environment-friendly technology.

3.5 Pathway for Sustainable Development

Developing countries endeavor to raise their per capita income by attracting foreign investment and stimulating economic operations and industrialization. CPEC is a joint venture where the primary focus is on Gwadar Port while transport sector, infrastructure development, energy efficiency and industrial cooperation are other major components. Despite the fact that the investment is enormous, it is indispensable to ensure that environmental sustainability is not endangered.

The biggest challenge towards sustainable development is climate change across the globe. Its widespread impact is vivid on our ecosystem as well. On one hand, it causes extreme change in climatic conditions resulting in floods, droughts, typhoons and earthquakes. While on the other hand, it affects the production of food, water availability, forests, biodiversity, coastal and marine environment [83]. Due to the adverse impact of climate change in Pakistan, it ranks 16th in terms of index of vulnerability among 170 nations [84], 135th internationally with regard to global GHG emissions per capita. Average annual temperature in Pakistan has increased by 0.6 degree Celsius during the last century. The 2012 Global Climate Risk Index of Germanwatch ranks Pakistan as eighth among 180 nations of the world [85].

For this purpose, a new infrastructure which is compatible with Green ICT needs to be incorporated on CPEC route for reducing the environmental impacts of existing infrastructure. Investment in infrastructure, which enables the use of renewable energy, is an important initiative to promote development in Pakistan that is environmentally sustainable. In view of prevailing huge GHG deposits in the atmosphere, Pakistan may not further stake the environmental deterioration by accepting emissions-coated FDIs and vows to clean up pollution in future. The region is however, at the edge of accelerating carbon release because of its rapid development in recent decades.

4. Recommendations

Under the prevailing scenario and in view of literature survey of existing studies, the government of Pakistan needs to strictly precede and adhere to a distinct growth plan by incorporating Green ICT for all projects under the head of CPEC. Whereas, it needs to improve transportation system on CPEC route by implementing ITS using energy efficient technologies. Renewable and cleaner sources of

energy need energy efficient infrastructure that must be developed under this project for reducing carbon intensity of output in the long run. This may be achieved by funding for new technologies that are less energy intensive with greater emphasis on renewable energy resources. In this regards, following steps need to be taken to ensure sustainable development of Pakistan under CPEC:

1. Climate change policy needs to be revised in such a way that it clearly defines the role of federation, provinces and individual organizations to take necessary measures to curb the issue of increased GHG emissions.
2. Climate change monitoring and impact assessment activities need to be organized on scientific basis by filling the observational gaps.
3. Climate resilient infrastructure needs to be built along the routes of CPEC.
4. It is recommended for Chinese manufacturers to implement and transfer renewable energy sources to the local producers of Pakistan.
5. This study also proposes the promotion and adoption of green ICT to encourage people and business entities to reduce GHG emissions. The future research in this area can be designed on some other model for green ICT based energy efficient transportation system in order to reduce carbon emission by vehicles on CPEC route.

5. Conclusion

The process of economic development requires reduction of large scale GHG emissions for sustainable development. This study analysis the nexus for FDI and its impact on climate change in order to prepare ourselves for the consequences derived from investment under China Pakistan Economic corridor (CPEC). It is inferred that empirical findings of existing literature are not unanimous. Moreover, some of these studies have applied co-integration techniques based on previous models by Engle and Granger co-integration test or the maximum likelihood test based on Johansen. However, these methods can be erroneous when applied on a very small sample size. Current studies also stress on the existence of co-integration between social indicators like FDI, GDP, trade, energy consumption and transportation. This shows that the creation of a multi-billion dollar and multi-faceted investment of CPEC not only promises to put Pakistan on the path of economic development but simultaneously, it portrays a great risk towards global climate change. Therefore, it is imperative to mention in the same breath that certain pre-conditions need to be strictly adhered to discourage CO_2 emission. Based on the observations from existing literature, it is imperative for CPEC project to focus on sustainable development by incorporating green buildings infrastructure and green transportation plans. In this regard, we presents Green ICT based ITS model for vehicular transportation to mitigate the risks of environmental degradation. Future work may depend upon infrastructural designs that include heat insulation materials, energy efficient heating, lighting, and ventilation systems. A comprehensive traffic control plan comprising of rapid rail transit system, low carbon fuel vehicles, solar cars and energy efficient electric vehicles may be developed. In the long run, more advanced technologies like power electric vehicles (generated from water, wind or solar power) or converting electricity drive fuel cell vehicles may be adopted to tackle the dilemma of climate change with special reference to Pakistan. However, it will take a length of time to accept such transitions for complete replacement and incorporation of dynamic measures in ITS infrastructure. The future research may benefit from the pre-determined utilization of other renewable energy resources.

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