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Article

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Nexus between Sources of Electricity Production and Environmental Degradation in Context of EKC Hypothesis: A Time Series Study for Pakistan

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ABSTRACT

This time series study is carried out to determine effect of sources of electricity production on environmental degradation in Pakistan in context of environmental Kuznets curve (EKC) hypothesis. Moreover, this study also examines effect of rural and urban population on environmental degradation. This study considers carbon emissions from electricity and heat as a proxy for environmental degradation. Unit root tests are applied to determine level of integration of time series variables. Bounds test is applied to examine long run relationship among variables. This study finds that hydro, natural gas and nuclear sources of electricity production have negative significant effect on environmental degradation whereas electricity production from oil sources has positive and significant effect on environmental degradation. Electricity from coal has positive effect on environmental degradation but its effect is not significant. Results of the study confirms EKC hypothesis in Pakistan. Besides, results indicate that rural population and urban population is negatively and positively associated with environmental degradation respectively. This study suggests that energy policy has to be design in such manner that on one hand, it tackles energy crisis, on other hand, it leads to sustainable development in Pakistan.

Keywords: Energy Policy, Sources of Electricity, EKC Hypothesis, Population, Bounds Test, Pakistan
JEL Classifications: Q40, Q48, Q53, Q56

1. INTRODUCTION

Energy plays a crucial role as a factor in determining economic growth (Apergis and Danuletiu, 2012). It generates economic activities and leads to economic development (Cassim and Jackson, 2004) and Wolde-Rufael (2005) argued that economic development is not possible without use of the modern energy as energy improves welfare of the people by stimulating sectors like education, health, industry, agriculture, commerce and trade. Moreover, all types of sources of energy affect economic growth thus; reduction or exhaustion of sources of energy may disrupt economic pace of the economy (Ighodaro, 2010; Ozturk et al., 2010). Although energy is integral factor of economic growth but its effect on environment grab attention from researchers as energy use may be unfavorable to environmental quality. The reason that it decreases environmental quality as energy use emits greenhouse gases (GHG) emissions and carbon emissions are chief elements of GHG (Sek and Chu, 2017; Ritchie and Roser, 2018). Besides, energy emissions are responsible for global warming. Moreover, global warming is resulting in climate change around the globe whereas climate change is posing severe effects on cropping pattern, food security, water, and energy security. The severity of climate change varies across the countries. However, climate change has badly affected Pakistan and is 7th most climate change affected country (Govt. of Pakistan, 2017).

As for as energy sector is concerned in Pakistan, government of Pakistan established water and power development authority (WAPDA) in 1958 which was assigned responsible for water and power availability except thermal power. WAPDA initiated feasibility of Mangla Dam after its inception and it was completed between 1962 and 1967. The current capacity of the power station at Mangla Dam is 1000 megawatts (MW). WAPDA completed another hydro project, Tarbela Dam, in 1976 and currently its capacity is 3478 MW. Besides, numerous small dams were also constructed. As for as energy policy is concerned, the government announced its first ever power policy in 1994. The government setup Private Power and Infrastructure Board to offer one window operation to Independent Power Producers (IPPs) in order to enhance energy conservation and electricity generation up to 13000 MW. Besides, the government under energy policy 1994 provided exemption to IPPs from income tax, sales tax, and custom duties on importing equipment. Moreover, the energy policy 1994 introduced foreign exchange risk insurance for IPPs while fuel supply and power purchase agreements were also introduced. As a consequence of the commencement of this policy the energy mix in Pakistan reversed from 60: 40 (hydro: thermal) to 30: 70 (hydro: thermal) (Govt. of Pakistan, 1994; Govt. of Pakistan, 1995). The government unbundle the National Electric Power Regulatory Authority (NEPRA) into distinct companies (thermal power, transmission, and distribution) in the origination of energy policy 2002. Moreover, the energy policy 2002 ensured steps for fuel supply and power purchase agreement. Besides, the government encouraged the local industry to form joint venture for the development of power projects to reach the national capacity of energy to 20,000 MW in 2015. If we look into these policies discussed none of them were devised to take environment into account. The government announced first ever environmental friendly energy policy in 2006. This policy aims to generate and encourage energy from non-conventional energy sources. This policy encouraged electricity from biofuel technologies, small hydropower, solar and wind energy. The government announced exemptions of machinery for renewable energy projects from taxes (Govt. of Pakistan, 2006).

The government announced short-term energy policy 2010-2012 which mainly focused on energy conservation. However, the most controversial Rental Power Plants (RPPs) was also part of energy policy 2010-2012 (BBC, 2010). After the general election in May, 2013, the elected government announced energy policy 2013. The objectives of this policy are to generate affordable electricity from indigenous primary resources of energy, to promote energy conservation and to meet the energy demand of the country on sustainable basis. The energy policy 2013 planned competitive bidding and upfront tariff to lessen the cost of electricity generation. However, targets were set for reduction in subsidies to energy sector as the government did not absorb the pressure from international financial institutions (Govt. of Pakistan, 2013).

In 2015, the government announced another energy policy "Power Generation Policy 2015". The objectives of this policy resembles with that of energy policy 2013 however, to shorten the demand supply gap, the government offered incentives and eased the process for investors in energy sector. The government encouraged the public-private partnership (PPP) in the energy sector in accordance with the applicable laws. The energy policy 2015 can be regarded as sustainable energy policy as it differs from early energy policies in the sense that it has a provision of affordable electricity generation from internal resources along with taking care of the environment. This policy provided utmost priority to hydropower sites for cheaper and cleaner energy resources. The government is committed to work for the fulfillment of vision 2025 according to which government planned to increase capacity of electricity up to 45000 megawatts. However, government under "China-Pakistan Economic Corridor" project plans to get 2400 megawatts from coal in Sindh province. Besides this, three private companies are working in Sindh to generate a sum of 1310 megawatts from coal. Thus, more than 3000 megawatts till 2018 will be generating from coal consumption. Recently, Chashma-II nuclear project injected 350 megawatts to national grid while Chashma-I nuclear is already producing 300 megawatts. Both these projects are part of Pak-China energy projects. Although, the government put serious efforts behind every energy policy but future energy policies should be devise in such manner that it should focus on depletion of indigenous resources on one hand and has to addressed the environmental issues and affordability of energy on the hand (Govt. of Pakistan, 2018).

Energy policy influences energy mix as well as sources of electricity in a country. If one looks into sources of electricity in Pakistan the share of these sources changed over time. Table 1 presents the share of electricity sources in total electricity production in Pakistan. During 1970s, more than 51% electricity was produced from hydro sources and its share went up to more than 54% further in 1980s. However, since 1990, the share of hydroelectricity remains around 30%. The share of nuclear electricity was more 3.57% on average during in 1970s but its share experienced decrease in 1980s and 1990s. But, during 2000-2014, nuclear sources share once again is above 3% in electricity production. The share of coal in electricity production is remains <1% since 1972. The share of natural gas on average was just above 40% and 32.46% in 1970s and 1980s respectively. Its share fell below 30% on average in 1990s however, its share on average is above 34% during 2000-2014. Interestingly, oil is the only source of electricity that its share is continuously increasing in Pakistan. Its share on average was below 5% in 1970s and its share went more than double in 1980s. On average, share of oil in electricity production crossed more than 30% in 1990s and during 2000 and 2014, its share stood at 31.66%. Thus, it can be concluded from these figures that share of oil in electricity production increases more than 5 times during period from 1972 to 2014. This is the reason that electricity is becoming expensive day by day in Pakistan.

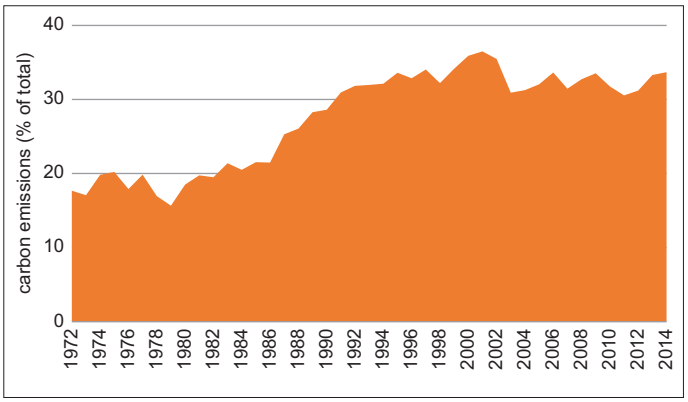
Figure 1 depicts carbon emissions from electricity and heat in Pakistan. Carbon emissions from electricity and heat was around 20% of total carbon emissions during 1972 and 1984 and it was its at minimum value in 1979 as Pakistan was producing more than 58% of its electricity from hydro sources in 1979. As the share of

Table 1: Sources of Electricity Production (% of total electricity production)

Period	Hydro	Nuclear	Coal	Natural Gas	Oil
1970s	51.10	3.57	0.72	40.03	4.60
1980s	54.45	1.04	0.15	32.46	11.91
1990s	29.32	0.79	0.40	29.13	30.80
2000-2014	30.35	3.36	0.19	34.32	31.66

Source: World Bank, 2021

Figure 1: Carbon emissions from electricity and heat



Source: World Bank, 2021

electricity from thermal sources increased compared to hydro sources then carbon emissions from electricity increased above 30% in 1990s as share of hydroelectricity fall below 30% in electricity production. Carbon emissions from electricity and heat reached its maximum value in 2001 in which share of hydroelectricity fall to around 25% whereas share of oil in electricity production from oil sources was above 35%. Carbon emissions from electricity and heat is fluctuating between 31 and 33% during 2004 and 2014 whereas share of thermal (coal, oil and gas) remains above 60% during same period.

Energy policy changes energy mix in a country and energy mix has been changed over the years in Pakistan. The share of fossil fuel in electricity has been increased in last two decades and currently its share in electricity is more than 60%. It is recommended to examine nexus between sources electricity production and environmental degradation in Pakistan. Thus, this study is designed to investigate effect of electricity production on environmental degradation in the framework of EKC hypothesis in Pakistan. This study is unique on bases of following points. First, this study is first ever study for Pakistan to proxy environmental degradation by carbon emissions from electricity and heat as in past most of previous studies used total carbon emissions for environmental degradation in Pakistan. Second, we did not come across any study that examined effect of sources of electricity production on environmental degradation in Pakistan. These sources of electricity production are hydroelectricity, the share of fossil fuel (coal, natural gas, oil) in electricity production and nuclear electricity production in Pakistan. These sources of electricity production are decided on basis of availability of data. Third, this is pioneer study to examine EKC hypothesis for carbon emissions from electricity and heat for Pakistan. Fourth, this study also examines effect of population distribution on environmental degradation as it introduces rural and urban population as control variables.

2. LITERATURE REVIEW

The nexus between national income and environmental degradation is referred as EKC hypothesis after pioneering study of Grossman and Krueger (1991). The EKC hypothesis proposes an inverted U-shape association between income and environmental degradation which assumes that environmental degradation in the initial stages of development is increasing with per capita income, reaches to a maximum level and then, starts to decline in the later stage of development. Numerous empirical studies are carried out to examine the validity of the EKC hypothesis. However, empirical studies have provided mixed results about the relationship between economic growth and environmental degradation in their studies based on sample of countries and econometric techniques. Some of research findings confirmed the EKC hypothesis (for instances: Nasir and Rehman, 2011; Ozturk and Acaravci, 2013; Wang et al. 2011; Rahman et al. 2019) while results of some empirical studies have not supported the EKC hypothesis (for instances: Ozturk and Acaravci, 2010; Haq et al. (2016); Gamage et al., 2017; Liu et al., 2019).

Salahuddin et al. (2015) conducted study to find out impact of electricity consumption on carbon emissions for Gulf Cooperation Council (GCC) countries. They applied FMOLS and dynamic ordinary least squares cointegration regressions to get long run results. Results of their study showed that electricity consumption along with economic growth is accumulating carbon emission in atmosphere. Moreover, their results documented unidirectional causality from electricity consumption to carbon emissions where two-way causality was confirmed between carbon emissions and economic growth in GCC countries.

In time series study conducted by Ozturk and Al-Mulali (2015), who proxy energy consumption by electricity consumption, determined effect of energy consumption on carbon emissions in the EKC hypothesis context in Cambodia. Results of their study did not confirm EKC hypothesis and documented positive and significant effect of energy consumption on carbon emissions in Cambodia. Similarly, Haq et al. (2016) also used electricity consumption as a proxy for energy consumption to find out effect of energy consumption on carbon emissions in the EKC hypothesis for Moroccan economy. They used time series data and applied Johansen cointegration for long run relationship among variables after time series data had been checked for unit root problem. Results of their study showed that energy consumption has positive and significant effect on carbon emissions. Moreover, their study did not confirm EKC hypothesis for Moroccan economy.

Salahuddin et al. (2017) analyzed impact of electricity consumption on carbon emissions in Kuwait. They analyzed time series data through autoregressive distributed lagged (ARDL) bounds test. They concluded that electricity consumption and economic growth posit positive and significant effect on carbon emissions not only in short run but also in long run. Likewise, Shaari et al. (2017) also applied ARDL bounds testing approach to analyze effect of electricity on carbon emissions in Malaysia. Results of this study showed that electricity consumption and economic growth positively affected carbon emissions in long run but insignificant effect is found for these variables in short run.

Zhang et al. (2018) carried out study for Pakistan to examine effect of energy production on carbon emissions in EKC hypothesis frame work. However, this study restricted energy production to fossil fuel production (coal, oil and natural gas). This study also included urbanization and trade as determinants of environmental degradation. They applied ARDL bounds test approach for long run and short run estimates. Results of this study showed that energy production has positive and significant effect on carbon emissions

in both long run and short run. This study found that urbanization has negative effect on carbon emissions in long run but it has positive effect on carbon emissions in short run. Moreover, this study confirmed EKC hypothesis in Pakistan.

Njoke et al. (2019) carried out study for Cameroon to examine effect of electricity consumption on carbon emissions. They applied ARDL bounds testing approach on time series data for this purpose. Results of this study confirmed that electricity consumption, economic growth and carbon emissions are cointegrated in long run. This study also confirmed EKC hypothesis in Cameroon. Causality analysis indicated that electricity consumption is leading to carbon emissions in Cameroon. They recommended that Cameroonian government should enhance electricity production from renewable sources to tackle environmental degradation. In a study, Rahman et al. (2019) determined effect of energy production (coal, oil and gas) on carbon emissions in EKC hypothesis. They concluded that coal and oil aggravated environmental degradation as these sources of energy posit positive and significant effect on carbon emissions whereas gas production has negative and significant effect on carbon emissions. Moreover, their study confirmed EKC hypothesis and recommended that investment is needed in low-carbon intensive sources of energy for sustainable environment.

Population is a vital source of economic development but it is a threat to environmental quality whenever it exceeds a threshold level. It damages environmental quality primarily through consumption of natural resources and production of wastes. Moreover, population also put pressure on biodiversity, arable land and leads to air and water pollution (UNRISD, 1994). Population growth is accelerating energy demand and leading to growing transport sector so, consequently leads to environmental degradation. Moreover, high level of led and carbon emissions are causing serious health issues due to air pollution in urban areas (Govt. of Pakistan, 2010). This is the reason that some researchers analyzed effect of population on environmental degradation (Bilsborrow, 1992; Zaman et al., 2011; Ray and Ray, 2011; Alam et al., 2016) and research study like Rudel (1991) analyzed effect of population in rural areas of developing countries whereas Cole and Neymar (2004) analyzed effect of demographic factors on environmental degradation. Likewise, there are number of research studies who analyzed effect of urbanization on environmental degradation (Poumanyvong and Kaneko, 2010; Zhang and Lin, 2012; Shahbaz et al., 2014; Azam and Khan, 2016; Wang et al., 2016; Gasmili et al., 2019).

Thus, on basis of the above literature, this study developed empirical model that is presented in Equation 1 as follows:

$$lnCEE_t = b_0 + b_1 lnCO_t + b_1 lnHYD_t + b_1 lnNUC_t + b_1 lnNG_t + b_1 lnOIL_t + +b_2 lnPC_t + b_3 lnPCS_t + b_1 lnRP_t + b_1 lnUP_t + u_t \quad (1)$$

Whereas, *CEE*, *CO*, *HYD*, *NUC*, *NG*, *OIL*, *PC*, *PCS*, *RP* and *UP* symbolizes carbon emissions from electricity, electricity production from coal, electricity production from hydro, electricity production from nuclear, electricity production from natural gas, electricity production from oil, gross domestic product (GDP) per capita, GDP per capita squares, rural and urban population respectively. Similarly, *ln*, *t* and u_t denotes natural log, time period and disturbance term respectively whereas b_i presents respective variable coefficient. Moreover, natural log is taken to take care of heteroscedasticity at the initial stage.

3. RESEARCH METHODOLOGY

The prime objective of this study is to explore the effect of sources of electricity production on environmental degradation in the context of EKC hypothesis in Pakistan. For this purpose, time series data will be analyzed covering the time period from 1972 to 2014. Environmental degradation is measured through the emissions of carbon dioxide from electricity and heat. Description of variables of the study along with measuring units are provided in Table 2. Data has been collected from World Bank database (2021) and time period of study spans from 1972 to 2014 due to availability of data. Figures 2-6 depicts electricity production from coal, hydro, nuclear, natural gas and oil sources over study period in Pakistan.

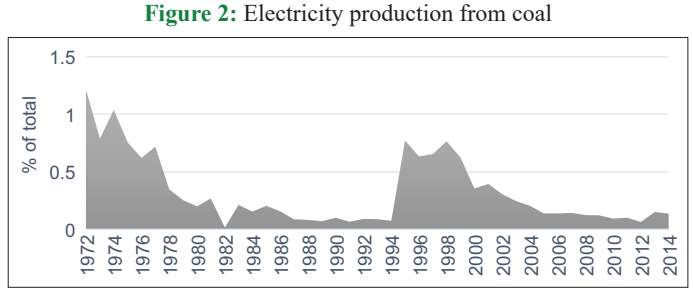
This is a time series study thus; time series data will be checked for unit root problem as most of time series data suffer from this problem. If data is not checked for unit root problem, and regression is applied, then estimates are not reliable as a result of spurious regression. Thus, unit root problem will be deducting through Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) and Phillips-Perron (PP) test (Phillips and Perron, 1988). The researchers will apply ARDL bounds testing approach (Pesaran et al., 2001). There are number of advantages associated with ARDL bounds test. For example, it gives efficient estimates and can distinguish between dependent and independent variables. Similarly, it can be applied to small sample size. Besides, it is not essential for this technique that variables of the model have to be integrated of the same order. It can be applied to

Table 2: Description of variables

Variable	Description
CEE	Carbon emissions from electricity and heat (% of total fuel combustion)
CO	Electricity production from coal (% of total)
HYD	Electricity production from hydro (% of total)
NUC	Electricity production from coal (% of total)
NG	Electricity production from natural gas (% of total)
OIL	Electricity production from oil (% of total)
PC	GDP per capita at constant 2010 US dollars
PCS	GDP square of per capita at constant 2010 US dollars
RP	Rural population
UP	Urban population

Source: World Bank, 2021

Figure 2: Electricity production from coal



not only to same order of integration but even can be applied when variables are mixture of integration I (0) and I (1). However, it cannot be employed when variables are integrated of higher order than first order integration I (1). Besides, one can obtain long run and short run estimates through ARDL for an empirical model. Moreover, ARDL bounds testing approach encompasses error correction term and if error correction term turns out to be negative and significant then model will be in equilibrium. In other words, the model will be dynamically stable and one can predict that model will take how much time to adjust itself from any external shock.

4. RESULTS INTERPRETATION AND DISCUSSIONS

This study is designed to investigate effect of sources of electricity production on environmental degradation in context of EKC hypothesis in presence of rural and urban population as control variables. A time series data has been analyzed for this purpose through unit root tests and bounds testing approach. The first step in time series analysis is to check unit root problem. Henceforth, this study applied two distinct unit root tests (ADF and PP) to determine whether variables of the study are free from unit root at their level or at first difference. The results of ADF test are given in Table 3 while results of PP unit root test are given in Table 4. Some of variables of the study are carrying unit root (non-stationarity) problem at their level. However, the unit root problem can be removed through taking differencing of variables. It can be evidence from unit root tests that some of variables are free from unit root problem at their first difference. Hence, variables of the study are combination of I (0) and I (1). Thus, after getting these results one cannot apply ordinary least squares for long run estimates as results findings will be not reliable because in such case ordinary least squares regression will be spurious regression. Besides, one cannot apply cointegration test like Johansen cointegration (Johansen and Juselius, 1990) test as variables are combination of I (0) and I (1). Hence, this is the reason that this study applied bounds testing approach to examine long run relationship between variables of the study. The cointegration result of bounds test is provided in Table 5. It can be observed that F-value (calculated) is greater than upper bound critical value at 5% level of significance thus; it is concluded that variables of specified model of the study are cointegrated in long run.

Once long run relationship between variables is established, we move on to get long run estimates of the model of the study. These results are presented in Table 6. Long run results indicate that all explanatory variables are significant factors of environmental degradation except electricity production from coal sources. The effect of electricity production from hydro, nuclear and natural gas on environmental degradation is negative as coefficients of these variables are negative and significant. The effect of electricity from oil sources on environmental degradation is positive as coefficient of oil is not only positive but is significant as well. This study finds that EKC hypothesis exists in Pakistan as coefficient of income per capita and its squares are carrying positive and negative sign respectively and both coefficients are significant. Besides, population is significant factor of environmental degradation as rural as well as urban population are significant factors of environmental degradation. The effect of rural population is significantly negative on environmental degradation whereas urban population is significantly contributing to environmental degradation.

Short run dynamic results are presented in Table 7. Result estimates in short run are like long run as for as electricity production from hydro, nuclear, natural gas and oil resources are concerned as electricity from hydro, nuclear and natural gas positing negative effect on environmental degradation whereas electricity from oil

Figure 3: Electricity production from hydro

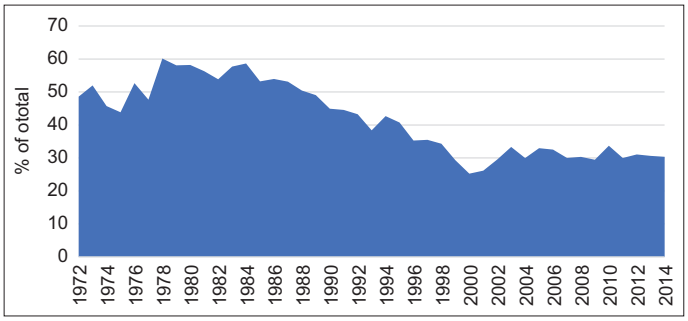


Figure 4: Electricity production from nuclear

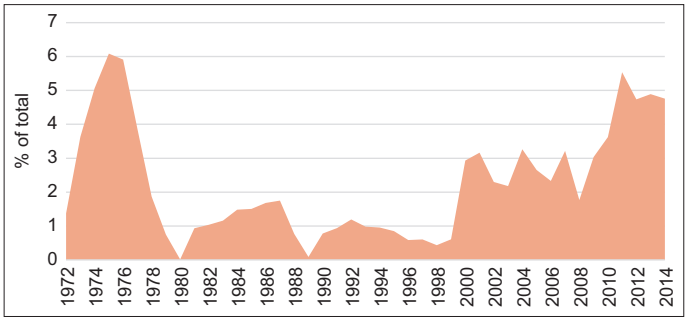


Figure 5: Electricity production from natural gas

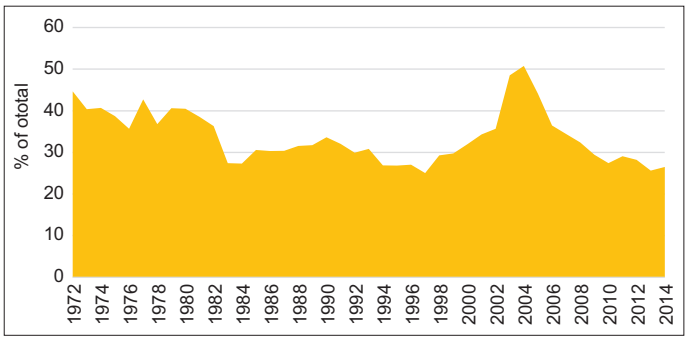
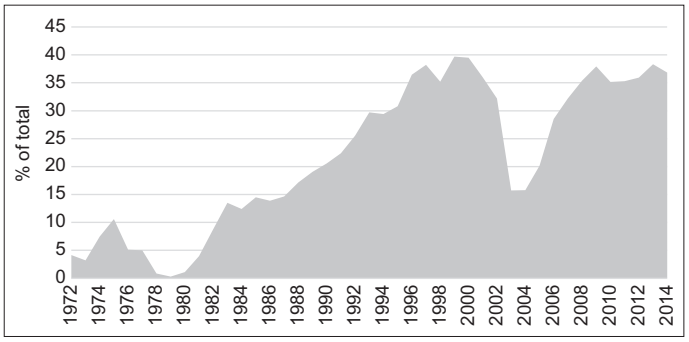


Figure 6: Electricity production from oil



is aggravating environmental degradation in short run. As for as electricity from coal is concerned, coefficient of coal is positive but insignificant and this result is same what this study got in long run estimates. Short run results did not confirm EKC hypothesis as coefficients of income and its squares are not significant. The effect of rural and urban population is same like results in long run as effect of rural population is negative whereas urban population is aggravating environmental degradation as its coefficient is positive and significant. Moreover, negative and significant coefficient of ECT is confirming that model of the study is dynamically stable and it will adjust itself from external shock within a year.

This study found that sources of electricity, income level, rural and urban population are factors of environmental degradation as all variables of the study are in long run relationship in Pakistan. Results of the study showed that electricity from coal sources is having positive effect on carbon emissions but its effect is not significant. Coal is not a significant contributor of environmental degradation arising from electricity production is that during study period the share of coal in electricity production is <>1% for most of years. This implies that whenever share of coal in electricity production increases it will aggravate environmental degradation in Pakistan. Electricity production from hydro, nuclear and natural gas has found to have significant negative effect on environmental degradation in long run as well as short run. Electricity production from oil sources has positive and significant effect on environmental degradation in long run as well as in short run. The reason for positive effect of electricity from oil sources is that during study period its share in electricity has been increased especially if one looks into its share after first energy policy of Pakistan in 1994.

In order to have a clear picture about emissions from electricity production let have a look on how much GHG emissions are emitting by producing one kilowatt-hour electricity from different sources. According to Gagnon and Van de Vate (1997) argued that GHG emissions from hydropower are 30-60 times less than thermal electricity (fossil fuel) whereas according to International Hydropower Organization (2021) global median GHG emissions from hydropower is 18.5 g of carbon dioxide equivalent per kilowatt-hour of electricity compared to 820 and 490 g of carbon dioxide equivalent per kilowatt-hour of electricity generated from coal and gas respectively. Likewise, global median GHG emissions from nuclear power is just 12 g of carbon dioxide equivalent per kilowatt-hour of electricity. GHG emissions from electricity generation from natural gas is half than GHG emissions by producing one kilowatt-hour from coal or oil (EIA, 2021). These are the reasons that Ang et al. (2011) documented that one third energy related carbon emissions are emitted from electricity production globally and argued that this sector has greater potential for reduction in carbon emissions if certain measures are taken and these measures include fuel switching and improvement in electricity production efficiency. Thus; Pakistan can improve environmental quality by changing the composition

Table 3: Results of ADF unit root test

Variable	t-stat.	Variable	t-stat.	Conclusion
lnCEE	−1.37	*ΔlnCEE*	−7.38***	I (1)
lnCO	−3.14**	*ΔlnCO*	--	I (0)
lnHYD	−0.93	*ΔlnHYD*	−8.02***	I (1)
lnNUC	−3.46**	*ΔlnNUC*	--	I (0)
lnNG	−2.06	*ΔlnNG*	−5.60***	I (1)
lnOIL	−2.06	*ΔlnOIL*	−4.32***	I (1)
lnPC	−1.35	*ΔlnPC*	−4.98***	I (1)
lnPCS	−1.16	*ΔlnPCS*	−4.90***	I (1)
lnRP	−3.57**	*ΔlnRP*	--	I (0)
lnUP	−3.51**	*ΔlnUP*	--	I (0)

*** and ** shows significance at 1 and 5% level. The regressions contain intercept

Table 4: Results of PP unit root test

Variable	Adj. t-stat.	Variable	Adj. t-stat.	Conclusion
lnCEE	−1.35	*ΔlnCEE*	−7.38***	I (1)
lnCO	−3.06**	*ΔlnCO*	--	I (0)
lnHYD	−0.76	*ΔlnHYD*	−8.02***	I (1)
lnNUC	−3.44**	*ΔlnNUC*	--	I (0)
lnNG	−2.30	*ΔlnNG*	−5.99***	I (1)
lnOIL	−1.78	*ΔlnOIL*	−4.19***	I (1)
lnPC	−1.77	*ΔlnPC*	−5.04***	I (1)
lnPCS	−1.52	*ΔlnPCS*	−4.97***	I (1)
lnRP	−3.88***	*ΔlnRP*	--	I (0)
lnUP	−10.65***	*ΔlnUP*	--	I (0)

*** and ** shows significance at 1 and 5% level respectively. The regressions contain intercept

Table 5: Cointegration results of bounds test

F-value (calculated)	3.81**	K = 9
Bounds Critical Values		
Significance	**Lower Bound Value**	**Upper Bound Value**
10%	1.88	2.99
5%	2.14	3.30
1%	2.65	3.97

** shows significance at 5% level

Table 6: Long run results of bounds test

Dependent Variable: *lnCEE*			
Regressors	**Coefficient**	***t*-stat.**	**Prob.**
lnCO	0.012	1.34	>0.10
lnHYD	−0.52***	−5.07	<0.01
lnNUC	−0.02***	−2.77	<0.01
lnNG	−0.16***	−2.59	<0.01
lnOIL	0.05***	3.17	<0.01
lnPC	24.62***	7.20	<0.01
lnPCS	−1.81***	−6.76	<0.01
lnRP	−5.59**	−2.10	<0.05
lnUP	3.13*	1.780	<0.10
Constant	−29.86	−1.39	>0.10

***, ** and * shows significance at 1, 5 and 10% level respectively

Table 7: Short run results

Dependent Variable: *ΔlnCEE*			
Regressors	**Coefficient**	**t-stat.**	**Prob.**
ΔlnCO	0.01	1.29	>0.10
ΔlnHYD	−0.33***	−3.63	<0.01
ΔlnNUC	−0.02***	−3.04	<0.01
ΔlnNG	−0.16**	−2.48	<0.05
ΔlnOIL	0.05***	3.45	<0.01
ΔlnPC	−6.64	−0.54	>0.10
ΔlnPCS	0.56	0.60	>0.10
ΔlnRP	−48.26***	−4.32	<0.01
ΔlnUP	3.21***	1.77	<0.01
ECT	−1.03	−8.33	<0.01

*** and ** shows significance at 1 and 5% level respectively

of fossil fuel in energy mix as comparatively natural gas emits less emission than oil and coal and fortunately the share of natural gas in electricity production is more than coal in Pakistan. However, government initiated different coal projects to overcome energy crisis that will further worsen environmental degradation. Thus; it is recommended to increase share of alternative energy resources in electricity production for sustainable development of the country.

This study found that EKC hypothesis exists in Pakistan as coefficient of income per capita is positive and its squares coefficient is negative and both these coefficients are significant. This result implies that increase in income is followed by increase in environmental degradation however, when income level is increased to certain level (threshold) after that increase in income is not accompanying by increase in environmental degradation in Pakistan. This is what EKC hypothesis postulates. Moreover, this study found that the threshold income level that is turning point on EKC curve is 897.85 USD for Pakistan whereas highest real per capita income during study period is 1054.23 USD. Besides, this study documented that rural population is inversely related with carbon emissions whereas urban population is positively related to carbon emissions hence; Pakistan is achieving urbanization at cost of environmental degradation. Therefore, government has to decrease migration from rural to urban population by providing basic health and education facilities like urban areas. Similarly, an important source of migrating from rural to urban areas is because of income opportunities. So, government has to take steps to generate income opportunities in rural areas related to agriculture, fisheries and commerce. In order to have less pressure of urbanization on environmental degradation government of Pakistan has to ensure sustainable urban development by encouraging such building structure that suits weather conditions and needs less energy to light up and to encourage houses and buildings designs that need less energy for warming and cooling. Besides, it will be really helpful to control environmental degradation if government provides incentives to firms to make home appliances energy efficient. These incentives maybe in form of tax incentives (lower taxes or tax exemptions).

5. CONCLUSION

This study is designed to examine effect of sources of electricity production on environmental degradation in Pakistan. Besides, this study distinguish itself from other related studies as it examines environmental Kuznets curve (EKC) hypothesis for carbon emissions from electricity and heat for Pakistan. Additionally, this study also examines effect of population distribution on environmental degradation as it introduces rural and urban population as control variables. For this purpose, time series data has been analyzed. Once order of integration is determined though unit root tests, bounds testing approach is used to determine long run relationship between variables. This study finds that hydroelectricity, nuclear electricity along with electricity from natural gas confines environmental degradation in Pakistan as these sources of electricity production have negative and significant effect on environmental degradation in long run as well as in short run. Electricity production from oil sources is aggravating environmental degradation in both time spans whereas electricity from coal has insignificant effect on environmental degradation but it carries positive sign. The reason for insignificant effect of electricity from coal is that its share in electricity is minute so, it implies that if its share increases in electricity production in future this will lead to environmental degradation in Pakistan. Besides, this study confirms EKC hypothesis for carbon emissions from electricity and heat. Moreover, results of the study indicate negative effect of rural population on environmental degradation whereas urbanization leads to environmental degradation in Pakistan.

This study suggests that policy makers should emphasize on renewable energy resources than conventional energy to tackle energy crisis in the country. Moreover, the ongoing coal projects to tackle energy crisis will further aggravate environmental degradation in the country in future. The government can assure sustainable environment and can lessen the effects of climate change by switching from conventional sources of energy to renewable energy. Besides, the policy makers must look into wind and solar energy potential of the country to meet the energy demand of the country. The northern areas and coastal areas of the country has great potential for wind energy whereas plain areas of the country have great potential for solar energy. This study finds that hydroelectricity is curtailing environmental degradation so it is advised to increase share of hydroelectricity in electricity production and this can be possible by constructing big dams like Tarbela and Mangla dams which capacity is 3478 megawatts and 1000 megawatts respectively. Most importantly government of Pakistan has to revise its policy regarding IPPs as its electricity is not only expensive but also aggravating environmental degradations. Moreover, Mohmand Dam and Patan Dam which capacity is 800 MW and 2400 MW needs to be expedite and other hydro projects has to be initiated to tackle energy crisis on one hand and to mitigate environmental degradation on other hand.

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