



Impact of Non-linear Analysis of Crude Oil Prices on Domestic Inflation in Pakistan

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Abstract: Post-COVID-19 outbreaks and the Russian-Ukraine war seriously disturb the energy supply chain, which causes massive inflation worldwide. This inflation badly affected developing countries because of the poor population living in these countries. This study explores the different determinants of inflation in Pakistan by considering the global crude oil prices (COP) energy prices by using the annual time series data from 1980 to 2020. This study measured inflation by using CPI as the dependent variable, while COP was the key independent variable by controlling the exchange rate, GDP, and remittances. The empirical results are estimated by using the non-linear ARDL econometric approach. The study proposes the U-shaped relationship of COP with CPI. Furthermore, foreign remittance and GDP per capita also contribute to domestic inflation. The present study suggests that government should take steps to decrease dependence on imported energy resources to make Pakistan prosperous.

Introduction

Globally, energy is inevitable to all economies because all economic activities perform through energy use. Energy is essential for our daily lives and the functioning of modern societies. It is used to power everything from transportation to communication to agriculture to manufacturing (Asghar, Amjad, & Rehman, 2022). Energy is also critical for the provision of basic needs such as heating, lighting, and cooking. Without access to energy, many people around the world would struggle to meet their basic needs and improve their quality of life (Wang et al., 2022). The

development of energy increase the well-being of the economy. Energy plays a significant role in improving the living standard of people (Sial et al., 2022). In the coming years, the massive growth in industrialization will enhance the energy demand (Amjad et al., 2021).

Energy supplies are a key source to get fruitful activities in farming, manufacturing, trade and industries. Due to a decrease in the supply of energy, poverty slows down economic growth (EG) and prosperity (Asghar et al., 2022). In the

period of globalization, the sign of any country's development is energy and also dependency on its resources. Change in energy prices affects the overall economy of a country and leaves significant results because all sectors are interconnected within a country (Avtar et al., 2019).

Price settlement of energy plays a very crucial role in any country as compared to other products. High energy prices can make it more expensive to produce goods and services, which can lead to inflation and slow EG. On the other hand, low energy prices can make a country's industries more competitive in global markets. The way energy prices are determined can also be significant. In some cases, prices are set by a government or regulatory agency, while in other cases, they are determined by market forces (Mittal & Sarkar, 2023). In Pakistan, like other developing countries, energy price settlement is a very difficult task. Proper pricing should increase efficiency to achieve sustainable EG (Kim et al., 2019).

Pakistan is producing high and sustainable growth in the energy supply but is still not able to fulfil the domestic energy demand. The major sources of commercial energy in Pakistan include coal, oil, gas, hydel, thermal power and nuclear power. Coal is considered one of the principal sources of energy in Pakistan. The coal is mostly of low quality (lignite to sub-bitumen) and is mainly used in brick kilns and the ceramic industry.

In Pakistan, there are 185 billion tons of estimated reserves of coal. In this modern age, approximately 90% of coal production is used for burning bricks and about 9% for power generation. Due to government policies, the cement industry is switching the indigenous coal from furnace oil which would help to save 50 present foreign exchanges spent on the import of coal in Pakistan. There are three main coalfields around Quetta. The goal here is of better quality than the coal found in other areas of Pakistan. The coal is washed and mixed with high-grade

imported coal. It is used in our steel mills (Worldometer, 2022).

The present explores the impact of crude oil prices (COP) on domestic inflation. We know that in the international market, COP faces many fluctuations which increase energy prices. The fluctuations in the COP disturb the supply chains, which raises the prices of all goods. Pakistan is considered the major importer of COP from oil-producing countries, and any fluctuations in COP badly affect all economic sectors (Haider et al., 2014).

After World War II, COP shocks were considered one of the major dampeners of industrialized countries. Since 1970 COP shocks have hit each country and affected each sector of the economy (Van de Ven & Fouquet, 2017). The economic depression in the 1970s was due to the oil shocks by OPEC countries. Fluctuation in COP has created many problems for policymakers since the 1970s, and this practice has been continuing at present (Chen et al., 2020). It is observed that the extensive and expansionary financial approaches of the administration and government in the course of the most recent couple of years brought about a change in different macroeconomic factors; it is including total national output (Gross domestic product) development, which stayed above 6% amid 2014-2016 (Oil price, 2022).

The present study covers the two burring issues in Pakistan inflation and crude oil prices. Various studies inspected the impact of COP on inflation in developed and developing countries such as the U.S., Canada, Bangladesh, Nigeria, India etc. In the review of the literature (Qasim et al., 2021; Zakaria et al., 2021), only a few studies covered this problem. This research is very significant because its results played a vital role in the knowledge about COP and inflation in Pakistan. Additionally, this study does not limit itself to the previous literature but extends its knowledge to more time frames. The key objective of this study is to determine the linkage between COP and inflation in Pakistan.

Literature Review

Initially, the crude oil prices (COP) shocks were observed by Hamilton (1996) on macroeconomic factors. Later on, many researchers extended their application to different macroeconomic factors like inflation, exchange rate, and EG. Stuber (2001) connected COP with inflation in Canada and concluded that fluctuations in COP affected commodity prices. The study concluded that the supply shocks motivate increased dependence on coal which decreased with its fractional transition to COP.

Malik (2016) pointed out the empirical estimation of the traditional Phillips curve approach by using quarterly data from 1980 Q₁ to 2014 Q₄ in Pakistan. It suggested that an increase in COP raises inflation. The study concluded that with higher energy prices, a large amount of income compensation is essential to pay for the consumer to achieve the initial energy utility. Varghese (2016) also investigated the COP shocks and inflation in India. The study concluded negative oil price shocks caused inflation in India. Zivkov et al. (2018) carried out their study in eleven Central and Eastern European countries to study COP change the consumer price inflation. Wavelet-based Markov switching test was applied. It was concluded inflation rates were rather flexible to the COP change in these selected countries. Zulfigarov and Neuekirch (2020) conducted their study in Azerbaijan to find the impact of COP on EG from 2002Q1 to 2018Q4. The VAR model established that high prices in the oil and gas sector decline GDP, which leads to higher inflation.

Amjad et al. (2021) examined the pump diesel and gasoline prices on CPI in Pakistan from 1990 to 2020. The NARDL econometric approach concluded that both these prices proposed a U-shaped relation with CPI in Pakistan. Qasim et al. (2021) investigated the impact of COP on inflation during 2004–2019 in Pakistan. The study found that COP increased inflation in Pakistan. Zakaria et al. (2021) conducted their study in South Asian countries from 1980M1 to 2018M12. The study

showed that COP positively contributed to this region.

Kilian and Zhou (2022) studied the effect of gasoline prices on CPI. Rising gasoline prices increased energy expenditures which caused to increase in the prices of the production of the final good. It reduces the consumption of goods, thus harming GDP and the balance of payments.

Numerous previous works of literature explained the different factors of inflation in developed and developing countries. Here few studies are discussed about the determinate of inflation in Pakistan. Hafiz et al. (1995) examined that inflation rose rapidly by the macroeconomic factors in Pakistan. Khan and Schimmelpfening (2006) investigated the major determinants of inflation by taking monthly data (1998–2005). The researcher concluded in their study that monetary variables played a vital role in enhancing inflation.

Ayyoub et al. (2011) examined the effect of inflation on the EG in Pakistan from 1972 to 2010 by using the OLS. The study found that GDP declined CPI. Qureshi et al. (2011) explored the major factors of CPI in Pakistan. The study found CPI enhanced in Pakistan by macroeconomic variables (gross domestic product, Broad money, exports and imports, government expenditure and government revenue).

Asghar et al. (2013) investigated the empirical estimation of different determinant inflation during 1972–2010. The results showed that inflation and lagged inflation played a significant impact on domestic inflation in Pakistan.

Ghumro and Memon (2018) investigated the determinants of inflation evidence from Pakistan. The study concluded that 'broad money supply, the exchange rate, first lags in the domestic price level, GDP, gross national expenditures and total reserves considered the important determents of inflation in Pakistan.

After reviewing the existing literature, it can be summarized that after COP shocks, developed countries faced high inflation rates and

recession, but later, this effect became insignificant (LeBlanc & Chinn, 2004) but in developing countries still, crude oil prices affected GDP and CPI (Zulfigarov & Neuekirch, 2020; Malik, 2016; Saleem & Ahmad, 2015). There is numerous literature examining that COP increases inflation (Qasim et al., 2021; Zakaria et al., 2021; Zulfigarov & Neuekirch, 2020; Zivkov et al., 2018) while there is not any study which examined the non-linear analysis of crude oil prices on inflation. This study will try to fill this research gap by using the non-linear analysis using the environmental Kuznets curve approach.

Methodology and Data

In this present study, we will consider the annual data of Pakistan from 1980 to 2020. In this study, CPI is used as the proxy of inflation which is used as the dependent variable. While COP, GDP per capita, Personal foreign remittance (REM) and official exchange rate (OER) are used as the independent variables. An annual time series data of all economic variables such as CPI, GDPPC, REM, and OER is taken from the World Development Indicators of Pakistan 2021, while COP data is taken from the Energy Book 2021 and various editions of the economic survey of Pakistan.

It is observed from the previous literature (Amjad et al., 2021; Qasim et al., 2021; Ghumro & Memon, 2018) that CPI in Pakistan is a serious problem caused by the change in the energy prices in terms of COP. Due to many fluctuations in the COP is behaving non-linear association with CPI. So, following Amjad et al. (2021a), the quadratic term of COP is used. Based on the above discussions, we can present the functional form as follows:

$$\text{Inflation} = f(\text{COP}, \text{COP}^2, \text{GDPPC}, \text{REM}, \text{OER}) \quad (1)$$

From equation 1, inflation depends upon COP, GDPPC, personal remittance and official exchange rate. It is concluded from the previous literature that an increase in the COP, GDPPC,

personal remittance and official exchange rate will increase inflation.

Inflation is measured by the economic variable CPI in terms of annual percentage. It changes the cost of the average consumer of obtaining the basket of services and goods that may be changed or fixed at a specific period, such as yearly. In this study, Crude Oil Prices (COP) are the annual oil price of the OPEC crude oil prices in terms of Pakistani rupees. Exchange Rate (ER) is determined officially by the certified exchange rate market.

Based on the above discussion, the functional form discussed in equation 1 can be converted into multiple regression can be written as follows:

$$LN(CPI)_t = \beta_0 + \beta_1 LN(COP)_t + \beta_2 LN(COP)_t^2 + \beta_3 LN(GDPPC)_t + \beta_4 LN(ER)_t + \varepsilon_t$$

(2)

$LN(CPI)_t$ = Natural logarithm of CPI

$LN(COP)_t$ = Natural logarithm of COP

$LN(COP)_t^2$ = Quadratic term of the natural logarithm of COP

$LN(GDPPC)_t$ = Natural logarithm GDP per capita

$LN(ER)_t$ = Natural logarithm of exchange rate

$LN(REM)_t$ = Natural logarithm of Personal foreign remittance inflow

In this study, we will use the non-linear ARDL methodology. It is a modern co-integration technique to find the long-run association between dependent and independent variables. This approach is suitable for small data set and statistically significant results of co-integration association of the sample, while on the other hand, Johansen Co-integration is suitable for large data set for valid results (Ghatak and Siddiki, 2001). The non-linear ARDL model is always acceptable on the strength of the unit root test if all the selected variables are integrated in a different order, such as $I(0)$ and $I(1)$, which is the basic requirement to analyze the data with the non-linear ARDL approach.

In the equation, the quadratic term of the COP shows the deviation from the constant return to scale and proposes a non-linear curve such as an inverted U-shaped or U-shaped curve. To find the cut-off value of this non-linear curve, the following derivation is required:

$$\frac{LNCPI_t}{LNCOP_t} = \beta_1 + 2\beta_2 COP_t = 0$$

$$LNCOP^* = -\frac{\beta_1}{2\beta_2} \quad \text{--- (3)}$$

Equation (3) shows the cut-off value of the non-linear curve. It helps to find the minimum

value of the U-shaped curve or the maximum value of the inverted U-shaped curve (Sial et al., 2022; Wang et al., 2022; Amjad et al., 2021).

Estimation of the Model and Results

To check the stationarity of the variables, the ADF unit root is applied. The results are evaluated by the ADF test shows except for CPI, all variable stationery at 1st difference. So, it is the pre-condition of applying the non-linear ARDL model.

Table 1. Results of Augmented Dickey Fuller Unit Root Test

Variables	I(0)		I(1)	
	Intercept	Trend & Intercept	Intercept	Trend & Intercept
LNCPI	0.2796	-3.6881**	-3.6852*	
LNCOP	-0.2885	-2.3792	-4.5605***	-4.5395***
LNOER	-1.1522	-2.7897	-3.7643***	-3.4986*
LNGDPPC	-0.9865	-2.7093	-3.2902**	-3.2978*
LNREM	-1.2267	-2.9944	-4.2955***	-4.2325***

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

In this step, Optimum Lag Length is selected. If Optimum Lag Length is not suitable, it may lead to unreliable results. In this study, the data set is very small, so an unrestricted VAR model from lag

0 to 3 is applied. In Table 2, SC shows 1 optimum lag while the AIC test shows 3 optimal lags by using Eviews 09.

Table 2. Optimum Lag Length in Unrestricted VAR Model Results

Lag	LR	FPE	AIC	SC	HQ
0	NA	3.75E-	-4.67708	-4.4158	-4.5849
1	477.8975	3.26E-16	-18.6610	-16.8324*	-18.0163
2	70.6398*	1.41e-16*	-19.6584	-16.2624	-18.4611*
3	40.78907	1.62E-16	-19.97855*	-15.0151	-18.2287

The bound test in Table 3 shows the higher value of the F-statistic value, which is 10.1655, which shows evidence of long-run co-integration. These results are the base of the non-linear ARDL approach.

Table 3. Bond test Estimations

F-Stat-	5% significance		10% significance	
	LB I(0)	UB I(1)	LB I(0)	UBI(1)
10.1655	3.0207	4.3857	2.5078	3.7118

The bound test confirmed the long-run relationship of the variables. After this test long, run estimation of non-linear ARDL is applied in Table 4. To determine the long-run coefficients of COP and other determinants are estimated by using the non-linear ARDL approach, which is discussed in Table 4.

The natural logarithm of GDPPC positively increases inflation. It shows a one per cent increase in the LNGDPPC, then an average LNCPI increase of 0.9460 per cent (Ghumro & Memon, 2018). In general, higher GDPPC lead to inflation in Pakistan through several mechanisms. One way is that as incomes rise, consumers can purchase more goods and services, which can lead to increased demand for those products. This can put upward pressure on prices, as businesses may raise prices to keep up with the increased demand. Additionally, as GDPPC increases, businesses may also see the opportunity to charge higher prices for their products due to the increased purchasing power of consumers, leading to inflation.

Another way that higher GDPPC can lead to inflation is through the "cost-push" effect. As incomes rise, businesses may need to pay their workers higher wages to keep up their living standards. Additionally, a higher GDPPC income may also mean that the government has more revenue, which it may use to increase public spending. If this increased spending is not met by an increase in production, it can lead to inflation as the demand outstrips supply, putting upward

pressure on prices. When a country has a high GDPPC income, it also indicates that it has a high level of urbanization, industry and technological advancements. These factors, in turn, may lead to high imports and lead to inflation through the exchange rate and trade deficit dynamics.

The natural logarithm of remittance (LNREM) significantly increases inflation (Qureshi *et al.* 2011). Remittances, or the money sent by overseas workers to their home countries, can have an impact on inflation in Pakistan in several ways. One way is through the increase in aggregate demand. When workers receive remittances, they are likely to spend more on goods and services, which can lead to increased demand for those products. This increased demand can put upward pressure on prices and lead to inflation. When workers receive remittances, they may be able to afford to buy or rent better housing. This increased demand for housing can lead to higher prices, and as housing is a basic need, it can be considered core inflation. Additionally, remittances can also have an impact on inflation by affecting the government's fiscal policy. If the government receives a significant amount of revenue from remittances, it may decide to increase spending on various programs, which could lead to inflation if the demand for goods and services outpaces the supply.

The natural logarithm of the official exchange rate is insignificant and impacts inflation (Asghar *et al.*, 2013).

Table 4. Long run coefficients results

Dependent variable: LNCPI, ARDL(1,0,2,2,1,2)				
Regressor	Coefficient	Standard Error	T-Ratio	Probability
Constant	2.3433	3.4855	-2.1197	0.0450
LNCOP	-0.6840	0.0737	6.3540	0.0000
LNCOP ²	0.1238	0.0275	2.6304	0.0150
LNGDPPC	0.9460	0.3439	2.7509	0.0110
LNOER	-0.1700	0.2298	-0.7399	0.4670
LNREM	0.5399	0.3050	1.7701	0.0890

In this study, COP is used as the key independent variable. The level coefficient of the natural logarithm of crude oil prices (LNCOP) negatively impacts inflation. It shows a lower level of LNCOP decline in inflation. The quadratic coefficient of LNCOP significantly increases inflation means higher prices of crude oil prices increase inflation in Pakistan (Amjad et al., 2021a; Qasim et al., 2021; Ghumro & Memon, 2018). When we trace the linear and quadratic terms of LNCOP, we trace the U-shaped curve, which is presented in figure 1. This shows lower COP decline inflation while higher COP increases inflation in Pakistan. COP

can influence inflation in Pakistan for several reasons. One of the main reasons is that Pakistan is a net importer of COP, which means that it imports more oil than it exports. When the price of COP increases, it leads to the transportation and production of goods costs because COP is used as a source of fuel for many industries.

The cut-off value of crude oil price is presented in Table 6. The cut-off value is 2.7625, which is within the range of the minimum and maximum value of crude oil value which shows the existence of the U-shaped curve.

Table 6. Cut-off value of LNAEP

	LNAEP
Level coefficients	-0.6840
Squared coefficients	0.1238
Cut off	2.7625
Antilog	17.5316

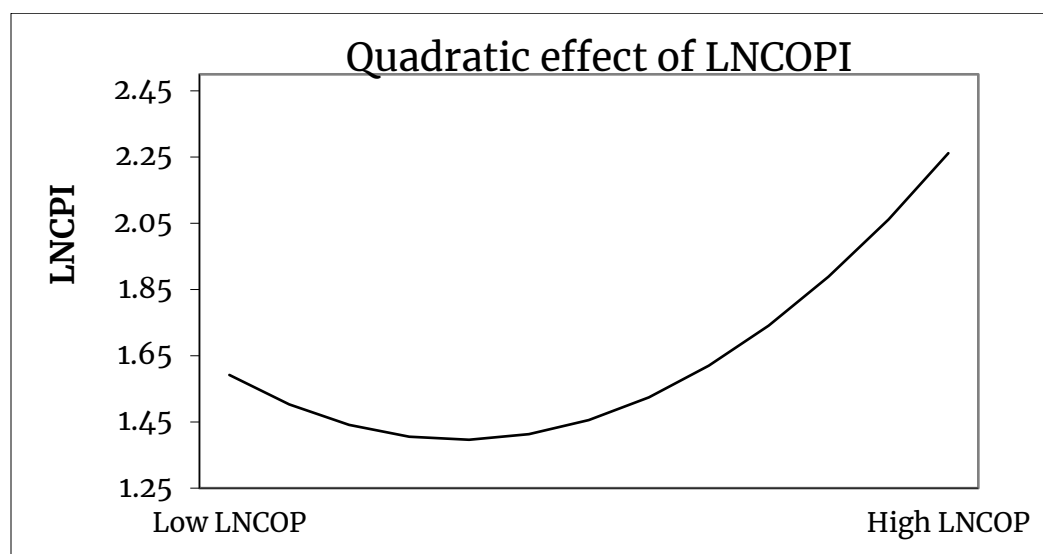


Figure 1: Trace effect of LNCOP on Inflation

In Table 6, VECM measures the short-run to long-run dynamics of the variables. It presents the short-run dynamic speed of adjustment of the model. In VECM, error correction is used, which shows the time to correct the disequilibrium of

the model. If ECM values are a negative sign and significant t values, it shows that there is an existing long-run relationship between the variables.

Table 6. Short-term coefficients results

Variable	Co-efficient	Std.Error	t-Statistic	Prob.
d.LNCPI(-1)	0.0624	0.0051	12.2614	0.000
d.LNCOP	-0.8217	0.0056	-0.14546	0.885
d.LNCOP1	-0.0103	0.0057	-1.7993	0.083
d.LNGDPPC	-0.1300	0.1022	-1.2718	0.214
d.LNGDPPC1	-0.2037	0.1112	-1.8320	0.078
d.LNOER	-0.0773	0.0456	-1.6933	0.101
d.LNREM	0.1600	0.0490	3.2633	0.003
d.LNREM1	-0.0618	0.0279	-2.2162	0.035
ECM(-1)	-0.7333	0.0216	-6.1472	0.000
R-Squared= 0.9730 Adjusted R-Square = 0.9585				

Table 7 shows the insignificant p-value of all the diagnostics showing that there is no issue of serial correlation, normality, and Heteroscedasticity.

Table 7. Details of diagnostic tests

	P-value
Serial Correlation	0.455
Functional Form	0.598
Normality	0.184
Heteroscedasticity	0.887

To check the stability of the model, Stability Tests have been used, which are CUSUM and CUSUMQ in the NARDL approach. This model is stable because the CUSUM residuals graph is within the limits of 5 per cent significance. Figure 2 shows

that the speed of adjustment from the short run to the long run is stable at a 5% level of significance, and no fluctuation is found from the critical bound.

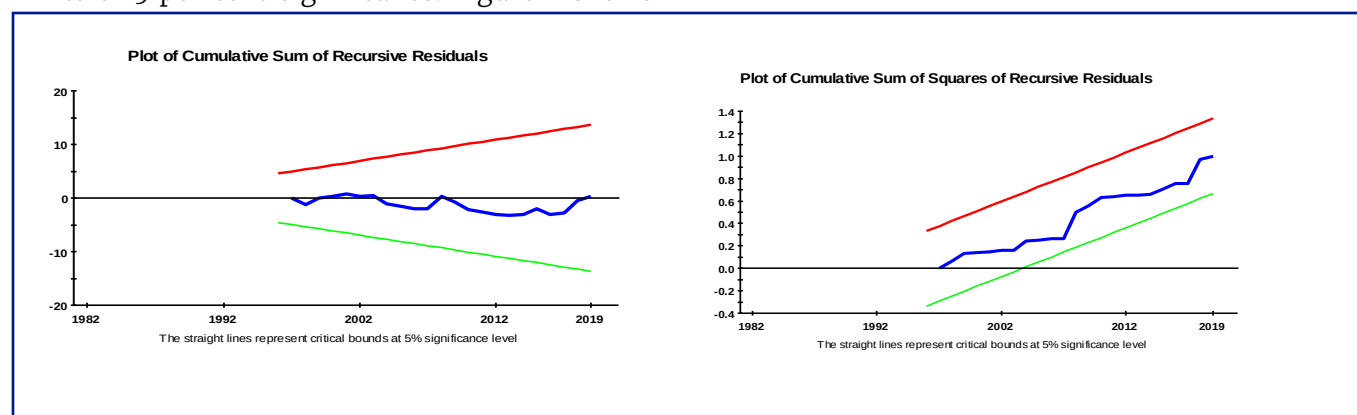


Figure 2: Stability Tests

Conclusion and Policy Recommendations

This study estimates the impact of COP on inflation by applying the NARDL method for the annual time series data during 1980–2020. The

ADF unit root test shows the mixed order of integration. This is considered the pre-requisite condition of the NARDL. In this study, the CPI is used as the proxy of inflation which is used as the

dependent variable. The COP is used as the key independent variable by controlling the exchange rate, remittances, and GDP per capita. COP faces many fluctuations, which motivates the researchers to treat it as non-linear by using the quadratic term. To check the long-run impact of non-linear COP on inflation bond test is used, which revealed that there exists a long-run association between the concerned variables. The long-run coefficients are estimated by using the NARDL approach. The coefficient of error correction term (ECM_{t-1}) is negative and statistically significant, showing that disequilibrium is covered within 1.36 years. The negative level coefficient and positive quadratic coefficients of crude oil prices propose the U-shaped relationship. This study also shows that higher COP encourages inflation in Pakistan. Furthermore, this study also explores that foreign remittance and GDP per capita are major contributors to inflation in Pakistan.

Pakistani economy depends upon petroleum products. Pakistan does not have so much domestic production to fulfil domestic needs. So, it's imported from the international market. In the international market price of petroleum, goods are not stable and fluctuates regularly. These fluctuations always critically affect the domestic economy and cause inflation. An increase in crude oil prices usually raises the cost of production because it directly affects the industrial sector. It relies upon electricity which is usually produced by oil and gas. Pakistan should pay special attention to the alternative energy resources which are domestically available. It should raise the hydel electricity production. Pakistan should try to promote renewable energy resources. These are cheaper and environmentally friendly.

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