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Agriculture Induced Environmental Kuznets Curve: Evidence from South Asia

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ABSTRACT

South Asian countries are facing many environmental changes due to change in economic activities. Carbon Dioxide (CO2) emission is due to the usage of fossil fuels and is the reason for an unsustainable environment. This region is pre-dominantly agrarian part of Asia continent. However, implements of agriculture rely on fossil fuels which may cause environment degradation. Sustainability development goals emphasis on sustainable development, therefore, controlling of carbon emission is how uphill task. Considering this, we explored the linkage of agriculture growth and environmental with the perspective of Environmental Kuznets Curve (EKC) hypothesis. Annual panel secondary data of data five South Asian countries has been taken on the concerned variables over the period 1980 to 2018. To achieve the objectives, we employed tests like cross-sectional dependence (CD, panel unit root and co-integration tests, FMOLS technique and DH causality test. The prevalence of agriculture-induced environmental Kuznets curve in South Asia has also been observed.

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INTRODUCTION

In recent years, economists have increasingly focused on sustainable development. For sustainable development, environmental considerations are very important. Through unsustainable economic activities, nations had gained unprecedented growth, but at the cost of environmental degradation. Bah et al. (2020) explain that policy makers are facing an important issue related to economic growth and sustainable development because these are dual-mode objectives and need careful treatment to achieve them. These identical goals are critical for developing economies. Azam (2016) proposed that there should be no development at the cost of environmental deterioration. Recently, much attention has been given to sustainable economic growth instead of only growth. Keeping in mind the harmful effects of climate change, policymakers are trying to formulate and implement reasonable policies that can attain a sustainable future by encouraging economic growth and changing the environment (Dogan & Lotz, 2020). Khan et al. (2018) found that loss of human life, infrastructure, natural resources, and low agricultural productivity are the result of environmental degradation. Although to compete and to flourish, natural sources are being used by countries but the cost of this development and competition is polluted air, contaminated water, and polluted land (Ulucak & Bilgili, 2018). Murshed (2020) asserts that this situation is alarming for all countries. All countries around the world have been compelled to mitigate their CO2 levels and to make sure that their development goals are not affected by these curative measures.

Agriculture makes a great contribution to any economy. Agricultural expansion not only assists the economy in different aspects by providing raw material, food and fodder but also gives employment to a large population, means of exports and imports, means of foreign exchange earnings, and better the competing ability of a country (Gokmenoglu, 2019). Sustainable development and eradication of poverty are goals that can be achieved through investment in the agriculture sector (FAO, 2017). Problems like unclean groundwater, loss of a variety of living things, depleting resources, and forest deforestation are a problem that needs international attention and demand further investment in agriculture (Aydogan & Vardar, 2020). Due to intense agricultural activities, energy needs and dependence on fossil fuels both are also increasing (FAO, 2009). Moreover, cutting trees, livestock release, burning of bushes, soil use, and fossil fuel-based fertilizers, use of machinery in agriculture, and burning of biofuel are the causes of greenhouse gas emissions (Balsalobre-Lorente et al., 2019). One reason for global warming is the agriculture sector and approximately one-third of world greenhouse gas emissions are due to agro-based activities (FAO, 2016).

South Asia is primarily an agrarian region; the major part of its population is dependent on agriculture for its subsistence. Kumara et al. (2020) argue that agriculture helps to provide food security and employment. Despite fact that South Asia is a farming economy, it belongs to rapidly growing regions (World Bank, 2019). According to WDI (2020), in Pakistan, the contribution of the agriculture value-added in GDP was 23.1% in Pakistan, in India 18.3%, in Bangladesh was 12.9% and in Sri Lanka it was 8.4% and Nepal 23.1%. About 20% of people live in South Asia out of 60% of the world's dwellers, and the majority of those full fill their energy needs by using non-renewable energy and fossil fuel. Both emit a large number of emissions (Hanif et al., 2019). Despite the fact, agriculture in SA gives income to more than 70% of people, provides employment near about 60% working population, and adds 22% of regional GDP. Due to climate change, it is predicted that overall economic losses as an annual percentage of GDP can be 7% in Bhutan, 10% in Bangladesh, 13% in Maldives, 9 % in India, 6.5% in Sri Lanka and 10% in Nepal, (Wang et al., 2017). Worldwide agricultural GHG emissions may increase by 58% until 2050 if no attempt has been made to reduce them (WRI, 2019). According to Ikram et al. (2020), Intergovernmental Panel on Climate Change (IPCC), policymakers are bound to take into account the role of land and agriculture. They can do this by devising some policies regarding climate change at the country level.

Keeping in views the agricultural production importance and its role in environmental degradation, the present study explores the role of agriculture growth on carbon emission in the perspective of EKC hypothesis. This paper is based on five sections. Literature is discussed in section 2 whereas section 3 is based on econometric methodology, model and data sources. Second last section contains discussion and last section is devoted for conclusion.

LITERATURE REVIEW

The studies that confirm the prevalence of EKC in individual countries are Saboori et al. (2012) in Malaysia; Javid (2016) in Pakistan; Sinha and Shahbaz (2018) in India; Sarkodie and Ozturk (2020) in Kenya; Murshed (2020) in Bangladesh. The EKC prevails in different regions and groups of economies but mostly results are ambiguous or EKC may exist in some countries or not exist others in a particular region. Even though globalization, government spending, institutional quality, financial development, economic growth and energy consumption increased CO2 emission, Dumitrescu and Hurlin causality analysis found causation among these variables. Dogan and Lotz (2020) conducted a study in European countries for the period 1980-2014 and they concluded that taken EKC prevailed Ahmad et al. (2021) confirmed the prevalence of EKC in 11 selected developing nations during 1992 - 2014. Shahbaz et al. (2016) used the variables globalization and energy intensity into economic growth and CO2 relation and tried to check the existence of EKC in 19 African countries during the time 1971–2012. EKC confirmed in the case of Africa, Algeria, Cameroon, Congo Republic, Morocco, Tunisia, and Zambia. Bilgili et al. (2016) found EKC for the panel and pointed out that renewable energy had a adverse relation with CO2. Bah et al. (2020) confirmed the presence of EKC in 10 middle-income countries of Sub-Saharan Africa during 1971–2012. Alsamara et al. (2018) used two alternative indicators of environmental degradation CO2 and SO2 emissions to check the prevalence of EKC in the Gulf Cooperation Council region. They found that in the long- run, EKC existed in both cases by using CO2 and SO2. In short-run when CO2 emission was used for environmental degradation EKC prevailed Dogan et al. (2019) conducted a study in 55 countries during 1971-2014 and confirmed EKC in high income, lower middle and higher middle and high income countries.

Some studies claim the non-prevalence of EKC in individual country cases. One of them is a study on Tunisia for the period 1980-2009. Both graphically and analytically non-existence of EKC was found in long run (Jebli & Ben Youssef, 2015). Jebli and Youssef (2017) observed the non-existence of EKC in Tunisia during 1980–2011. Saboori and Sulaiman (2013) confirmed the non-presence of EKC in Malaysia for the period 1980–2009, when data of aggregated energy consumption was used. However, disaggregated data on energy revealed evidence for the EKC. Xu (2018) revealed when EKC was estimated at the aggregate level disaggregate data did not provide evidence for EKC. CD and slope heterogeneity results showed that Sulfur dioxide EKC estimation faces aggregation bias in China. Katircioglu and Katircioglu (2018) explored EKC did not exist in Turkey and he observed traditional EKC by controlling the urbanization. For the Group country, case it has been already discussed that in most of the cases EKC prevails in some countries and not in others. However, complete non-existence has also been seen. Ozokcua and Ozdemirb (2017) estimated two models for the period 1980-2010 by using panel data. The first model was estimated for 26 OECD countries and the second model was estimated for 52 emerging countries. In both cases, N-shape and an inverted N-shape relationship were observed.

Many researchers used agriculture-induced environmental Kuznets hypothesis the recent studies present in literature are a case study of Pakistan (Ullah et al., 2018), China (Dogan, 2018), Pakistan (Gokmennoglu & Taspina, 2018),. The purpose of all types of studies was to investigate that how agriculture products influence economic growth and its by-product environmental status. Some authors found positive linkage in agriculture and CO2 (Dogan, 2018; Ullah et al., 2018; Eyuboglu & Uzar, 2020; Gokmennoglu & Taspina; 2018. But (Wang et al., 2020; Dogan, 2016) found negative relation between CO2 agriculture.

METHODOLOGY

Model and Data

To better understand the economic growth and environment deterioration linkage, different researchers added different variables and sectors into the EKC framework.

The conventional model of EKC is

$$CO_{2it} = f(GDP_{it}, GDP_{it}^2, TEC_{it}) \quad \text{----------------------------- (1)}$$

The Agriculture-induced EKC hypothesis equation is expressed as

$$CO_{2it} = f(GDP_{it}, GDP_{it}^2, AVA_{it}, TEC_{it}) \quad \text{----------------------------- (2)}$$

The Agriculture-induced EKC hypothesis equation can be expressed in logarithmic form to represent the long-run effect.

$$lnCO_{2it} = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{it}^2 + +\beta_3 lnAVA_{it} + \beta_4 lnTEC_{it} + \mu_{it} \text{------------- (3)}$$

CO2 is for carbon dioxide emission in kilogram (kt), and GDP stands for gross domestic product in constant 2015 US dollars. GDP^2 denotes real income squared, while TEC denotes total energy consumption. Agriculture value added (constant 2015 US$) is denoted by the letter AVA.

CO_2 emission kilo tons (kt) will be used as environmental degradation measure.

GDP at constant U.S. $.will be used as an indicator to measure economic growth.

AVA represents agriculture value-added (constant 2015 US$).

TEC is total energy consumption.

Table 1: Measurement of Variables

Variables	Description	Measurement	Sources
$lnCO_2$	Carbo dioxide emission	Kiloton	WDI
LnGDP	Gross domestic product	Constant 2015 US$	WDI
lnAVA	Agriculture ,fishing ,forestry value added	Constant 2015 US$	WDI
lnTEC	Total energy consumption	Converted into kg of oil equiv. PC.	USEIA

This study is designed for modeling the link in CO_2 emissions, GDP, AVA, and TEC and in South Asian nations by using the panel secondary data for 1980 - 2018. Sources of data is given at Table 1.

Research Methods

To observe the prevalence of agricultural induced EKC in South Asia, the study has employed first and 2nd generation test of unit root and co-integration, and FMOLS methods.

The pooled time series data has the same characteristics as the time series data. Data is often non-stationary and shows a time trend. In this situation panel regression OLS and GLS regression results will be misleading (Yuzbashkandi & Sadi, 2020). To check the stationarity, different panel unit root tests are used.

The countries are interlinked with each other differently like through imports and exports, economic and social relations, and financial integration. In this scenario, cross-sectional dependence (CD) may exist among different countries. The CD statistic of Pesaran (2004) is:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij} \right)$$

N = sample size, T = time, and ρ_{ij} = correlation of errors present in cross-sectional data of country i with country j.

So, to take into account CD, 2nd-generation unit root tests CADF and CIPS are applied. This study also applied panel co-integration tests by Pedroni (1999, 2004). This test is applicable when variables used in the study have a panel unit root. Co-integration takes the form of equation as

$$Y_{it} = \alpha_1 + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots\ldots\ldots \beta_{ki} X_{kit} + \varepsilon_{it}$$

t = 1 ….T is time, i = 1 ….N are countries and j = 1...k shows length of independent variables. It is assumed that X and Y are integrated of order one. α_1 is intercept, $\beta_1, \beta_2 \ldots .. \beta_k$ are the slope of coefficients and ε_{it} is the error term. Seven statistics for co-integration Pedroni (1999) developed 7 statistics for co-integration to analyze the null hypothesis in the panel of heterogeneity, 4 are within-dimension and 3 are between-dimension. In this study, Kao's (1999) co-integration test is also applied.

In the case of CS dependency, the Pedroni approach's findings might be misleading. The Wester-Lund co-integration test is frequently suggested as a solution to this problem. This method is more efficient in terms of avoiding misleading estimations and solving the heterogeneity problem (Haseeb et al., 2018). Wester-Lund (2007) presented an ECM basted to cope with the panel data heterogeneity. Wester-Lund provided four fundamental test statistics, two of which are aimed to test if the panel is co-integrated as a whole (Gt and Ga) and two are tested for the presence of co-integration of at least one cross-section unit (Pt and Pa).

When the order of integration of all variable is known, FMOLS method presented by Pedroni (2001) is applied. Pre-condition for applying FMOLS are fulfilled such as all variables are non-stationary at level but their first differences are stationary and co-integration is confirmed among all variables by using Pedroni co-integration method. To find long-run equilibrium among the variables and to control for endogeneity and serial correlation FMOLS is used (Uddin, 2020). FMOLS is not only provide reliable estimators for small sample size but also, it overcome the serial correlation and endogeneity problems.

RESULTS AND DISCUSSION

All tests' result presented in Table 2 confirm that unit root prevails at level but variables are stationary at first difference. Hence, possibility of cointegration may exist in the model, therefore, cointegration tests are applied.

Table 2: Penal Unit Root

Test Name		lnCO2	lnGDP	$lnGDP^2$	lnAVA	lnTEC
Levin, Lin & Chu t*	Level intercept	-0.37	6.66	7.11	0.41	0.33
	1st difference intercept	-4.85*	-3.73*	-3.39*	-9.2*	-7.36*
Im, Pesaran & S. W-stat	Level intercept	2.91	8.19	8.82	3.52	3.29
	1st difference intercept	-5.92*	-5.83*	-5.53*	-9.19*	-8.4*
ADF - Fisher Chi-square	Level intercept	1.54	0.71	0.49	2.61	1.1
	1st difference intercept	53.71*	57.43*	55.2*	90.24*	81.55*
PP - Fisher Chi-square	Level intercept	2.05	2.65	1.71	14.1	1.69
	1st difference intercept	117.29*	87.17*	82.68*	112.2*	119.74*

Table 3: Pedroni co-integration (Dependent Variable: $lnCO_2$)

Within Dimension	Without Trend		With intercept & Trend	
	T-Stat	Prob	T-stat	Prob.
Panel v-stat	0.50	0.30	-0.20	0.58
Panel rho-stat	-1.87	0.03	-1.06	0.14
Panel PP-stat	-3.88	0.00	-2.44	0.00
Panel ADF-stat	-4.11	0.00	-2.48	0.00
Between Dimension				
Group rho-stat	-0.83	0.20		
Group PP-stat	-3.23	0.00		
Group ADF-stat	-4.53	0.00		

Table 4: Kao Residual Co-integration Test

ADF	t-stat	P. Value
	-4.57	0.00
Resid. Var.		0.00
HAC var.		0.00

In Table 3 results of Pedroni panel co-integration indicate that there exists long-run co-integrating relation among $lnCO_2$, lnGDP, $lnGDP_2$, lnAVA, and lnTEC. Four out of eight statistics within-dimension reject the null hypothesis of no co-integration at 1% significance level and one statistic rejects the null hypothesis at 5% significance level, while in between-dimension the null hypothesis is rejected by two out of three statistics at 1% significance level. Hence, seven out of eleven statistics have confirmed the rejection of the null hypothesis. Results confirmed that long-run association is present among the variables for South Asian countries.

Kao test findings are present in Table 4, the null hypothesis of no co-integration is rejected at a 1% significance level. Overall findings show that there is a long-term relationship between the all considered measures.

Table 5:Cross-Section Dependence Test

Var.		Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
$lnCO_2$	Statistic	362.60*	78.84*	78.79*	19.04*
lnGDP	Statistic	384.94*	83.84*	83.77*	19.62*
$lnGDP^2$	Statistic	384.92*	83.84*	83.77*	19.62*
lnAVA	Statistic	372.37*	81.03*	80.96*	19.29*
LnTEC	Statistic	359.22*	78.09*	78.02*	18.94*

Residual Cross-Section Dependence Test

Null hypothesis	Breusch-Pagan LM	Pesaran scaled LM	Pesaran CD
No cross-section dependence Statistic (correlation) in residuals	77.79*	15.16*	2.15**

Table 6: Second-generation CADF test

Var.	C			C & T		
	t bar	Z[T-bar]	P-value	t bar	Z[T-bar]	P-value
$lnCO_2$	-1.79	-0.03	0.49	-2.13	0.53	0.70
lnGDP	-1.73	0.10	0.21	-1.87	1.195	0.92
$lnGDP^2$	-3.81	-4.83	0.29	-4.41	-5.27	0.96
lnAVA	-1.97	-0.46	0.32	-2.77	-1.09	0.14
lnTEC	-1.95	-0.40	0.35	-2.83	-1.24	0.11
$\Delta lnCO_2$	-3.87	-4.97	0.00	-3.84	-3.81	0.00
ΔlnGDP	-3.66	-4.48	0.00	-4.39	-5.22	0.00
$\Delta lnGDP^2$	-1.74	-4.35	0.00	-3.98	-4.16	0.00
ΔlnAVA	-5.34	-8.46	0.00	-5.72	-8.58	0.00
ΔlnTEC	-3.06	-3.04	0.00	-3.05	-1.80	0.04

Table 7: Wester-Lund ECM panel co-integration tests

Stat	Value	Z-stat	Prob
Gt	-3.84	-3.25	0.00
Ga	-10.56	0.70	0.76
Pt	-7.31	-2.31	0.01
Pa	-12.24	0.97	0.19

Cross-sectional dependence test results given in Table 5, show a strong dependence has been observed in both cases like between cross-section units and error terms obtained from the model. For all variables and error terms derived from the model, the null hypothesis of no cross-sectional dependency is rejected at 1%. Now, we cannot rely only on first-generation unit root and co-integration, as these conventional tests do not incorporate cross-section dependence. We have to move towards a second-generation test of unit root and co-integration.

The results of second generation CADF unit root test depicts in Table 6, we included both constant and constant and trend at a level and first differences. CADF test results indicate that lnCO_2 emission and lnGDP, lnGDP^2, lnAVA, and TEC all variables are non-stationary at level but their first differences are stationary at 1% level of significance except lnTEC that is stationary at 5%. Now as the order of integration is (1) of all variables so, we can go for Wester- Lund panel co-integration and results of this test are show in Table 7. As one value of Gt and one value from pt is significant at a 1% level of significance. Therefore, results of the Wester-Lund test presented in the table confirm that co-integration exists among all the variables.

Table 8: Results of FMOLS

Variable	Coef.	S.E.	t-Stat.	Prob.
LnGDP	1.95	0.55	3.51	0.00
lnGDP^2	-0.03	0.01	-3.35	0.00
lnTEC	0.74	0.08	9.14	0.00
lnAVA	0.43	0.17	2.57	0.01

Table 8 results show that 1% increase in lnGDP will increase pollution for panel of five countries of South Asia by 1.95 percentage. So, increase in GDP increases the CO_2 emission and the reason is initially, in the way of economic progress production techniques in South Asia were not such that can reduce CO_2. That is why CO_2 increases with the increase in output. The result is consistent with the recent studies of Le and Ozturk (2020), Dogan and Lotz (2020), and Ahmad et al. (2021).

Results also reveal a negative and significant relation between lnCO_2 and lnGDP^2 growth at a 1% level of significance. The reason of this negative relation is improved production methods that indicate along with economic growth South Asian people are well aware of environment issues and use improved technology. These results are a lined with the above-mentioned studies that confirm, the negative and significant coefficient of lnGDP^2 assure the existence of the environmental Kuznets curve in any country and countries or regions.

FMOLS results depict that 1% rise in agricultural activities will increase CO_2 by 0.43% in the panel of five countries. Elasticity of agriculture is positive and inelastic. There are various explanations for the long-term positive relationship between AVA and CO_2 in south Asian countries. The findings show that in these countries agriculture uses lots of fossil fuels. Heating, dehydration, processing, water pumping, packaging, and transport of agricultural goods are all heavily reliant on fossil fuels which contributes to increase CO2 emissions. These results consistent with Ullah et al. (2018), Zang et al. (2019) and Eyuboglu and Uzar (2020).

Results of panel estimation in the case lnTEC show that elasticity of lnCO_2 emission concerning lnTEC is less elastic, which means 1% increase in lnTEC, will increase lnCO_2 about 0.74 %. LnTEC is highly significant to lnCO_2 emission at a one percent level of significance and its positive sign indicates that an increase in TEC increases the CO_2 emission in the same direction. These results are a lined with Usman et al. (2020) in South Africa (Usman et al., 2019) in India; (Pablo-Romero & De Jesus, 2016) in Caribbean and Latin America; (Solarin et al., 2017) in Ghana; (Zaman et al., 2016).

Table No 9: D-H Causal linkage

Hypo.	W-Statistics	Z -Statistics	P-Value
$\Delta lnGDP \rightarrow \Delta lnCO_2$	3.24	3.09	0.00
$\Delta lnCO_2 \rightarrow \Delta ln\ GDP$	1.94	1.25	0.21
$\Delta lnAVA \rightarrow \Delta lnCO_2$	2.33	1.80	0.07
$\Delta lnCO_2 \rightarrow \Delta lnAVA$	0.35	-1.01	0.31
$\Delta lnTEC \rightarrow \Delta lnCO_2$	2.17	1.57	0.12
$\Delta lnCO_2 \rightarrow \Delta lnTEC$	3.91	4.04	0.00
$\Delta lnAVA \rightarrow \Delta lnGDP$	2.93	2.65	0.01
$\Delta lnGDP \rightarrow \Delta lnAVA$	1.28	0.31	0.75
$\Delta lnTEC \rightarrow \Delta lnGDP$	0.73	-0.47	0.64
$\Delta lnGDP \rightarrow \Delta lnTEC$	1.85	1.12	0.26
$\Delta lnTEC \rightarrow \Delta lnAVA$	0.86	-0.29	0.77
$\Delta lnAVA \rightarrow \Delta lnTEC$	0.40	-0.94	0.35

Dumitrescu Hurlin causality method gives more reliable results in both case for CD and for unbalanced panel. Finally, the result of DH causality test in Table 9 which indicates that changes in GDP, GDP^2, and AVA granger cause CO_2 emission in five South Asian economies. These results are a lined with (Gokmennoglu et al., 2019) but contradictory in case of total energy consumption. Any policy change to target variables changes CO_2 but, no policy to protect environment will effect these variables. Change in total energy consumption does not cause CO2 emission. No causal relation between CO_2 emissions and GDP, and TEC and GDP is observed,

Uni-directional causality is found between AVA and CO_2, These findings similar to those of Ben Jebli and Ben Youssef (2019), Balsalobre-Lorente et al. (2019), Gokmenoglu et al. (2019), and Udemba (2020). Both casual relation and positive sign from FMOLS confirm that in South Asia agriculture value-added activities contribute toward environment pollution. There is no evidence that CO_2 emission cause agriculture value-addition activities. Unidirectional causality is found between AVA and GDP that points out any change in South Asian agriculture will significantly change GDP. TEC does not homogenously cause CO_2 but CO_2 homogenously cause, TEC. Bidirectional non-causality exists among TEC to GDP, and AVA and vice versa.

CONCLUSIONS

Untired efforts have been done to achieve sustainable development by the policymakers, Governments, and researchers. The present study explores the environmental Kuznets curve in South Asia during the period 1980 to 2018 by including agricultural value-added into the model as an explanatory variable. Pedroni co-integration confirmed that co-integration is present among CO_2 emissions, income growth, agriculture development and energy usage. According to FMOLS results, GDP contain positive and elastic impact on CO_2 and GDP^2 has negative and inelastic, and AVA and total energy usage has a positive but inelastic impact on CO_2 significant. Results of FMOLS confirmed the prevalence of agricultural-induced EKC hypothesis in this region, and GDP^2 is negative and statistically significant which confirmed that the environmental Kuznets curve prevails in South Asia. Furthermore, the coefficient of agriculture value- added is positive and significant that means the agricultural-induced environmental Kuznets curve also existed in this region. This means agricultural activities contribute towards poor environmental quality. The burning of fossil fuels is the biggest contributor to poor environmental quality. Our results indicate that the agriculture sector is the main contributor towards environment deterioration and in South Asia agriculture practices are such type that are increasing environment degradation. The government of these concerned economies must consider this sector as a pollution indicator. Governments, policymakers, and researchers need to know which type of practices are needed to change and which type of policies should be adopted to make the agriculture sector a sustainable sector for economic growth.

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