Environmental Science and Pollution Research (2023) 30:116440–116448
https://doi.org/10.1007/s11356-021-18471-6

GIS APPLIED TO SOIL-AGRICULTURAL HEALTH FOR ENVIRONMENTAL SUSTAINABILITY

The effects of Agriculture Productivity, Land Intensification, on Sustainable Economic Growth: A panel analysis from Bangladesh, India, and Pakistan Economies

Nusrat Yaqoob[1] · Syed Ammad Ali[2] · Desti Kannaiah[3] · Nasir Khan[4] · Malik Shahzad Shabbir[5] · Kanwal Bilal[6] · Mosab I. Tabash[7]

Received: 8 November 2021 / Accepted: 29 December 2021 / Published online: 15 February 2022
© The Author(s), under exclusive licence to Springer-Verlag GmbH Germany, part of Springer Nature 2022

Abstract
Population in South Asia is increasing ever than a faster rate, subsequently; food security, climate change, and capital intensive agro farming techniques are the prevailing challenges in this region. This is a tri-country penal analysis, Pakistan, India, and Bangladesh, and the study covers the data throughout (1973–2020). This study has used modern farm input data besides demographic variables in the study. In this study, we use panel data set, ARDL (PMG) approach, autoregressive distributed lag model pooled mean group, which is an extensively dynamic modeling technique for heterogeneous data. The results of the study explore that transition in the demographic pattern in Pakistan, India, and Bangladesh is the real cause of low crop productivity and land intensification. Technology innovation is the only ray of hope to fulfill the food demand of the future ahead and climate agriculture practices can hamper the further deterioration of the small farmlands.

Keywords Demographic changes · ARDL PMG · Agricultural productivity · Land intensification · Population growth

Introduction

The strong agriculture sector always strengthens the economy, because each 1% increase in per-capita agriculture growth leads to 1.5% increases in per-capita nonagricultural growth. The growth of the agriculture sector has a

Responsible Editor: Eyup Dogan

JEL Classification; Q18, J13, J17, J24, Q13, P25, P28, Q01, Q15, Q24, Q33

✉ Malik Shahzad Shabbir
mshahzad786.pk11@gmail.com

Nusrat Yaqoob
nusratbaloch0301@gmail.com

Syed Ammad Ali
ammad.aerc@gmail.com

Desti Kannaiah
destiram2000@yahoo.com

Nasir Khan
nasirkhan14202@gmail.com

Kanwal Bilal
kanwalbilal@cuilahore.edu.pk

Mosab I. Tabash
mosab.tabash@aau.ac.ae

1 Department of Economics, University of Karachi, Karachi, Pakistan

2 Department of Applied Economics Research Centre, University of Karachi, Karachi, Pakistan

3 C. H. Sandage School of Business, Graceland University, Lamoni, IA 50140, USA

4 Institute of Business and Management Sciences, The University of Agriculture Peshawar, Peshawar, Pakistan

5 Department of Management Sciences, University of Lahore, Lahore, Pakistan

6 Department of Management Sciences, Comsat University, Lahore Campus, Lahore, Pakistan

7 College of Business, Al-Ain University, Al Ain, UAE

strong correlation with the population; a high population leads to increases per unit of land use as per the proportional increase in population. Nevertheless, in the contemporary world, the agriculture sector across the globe facing daunting challenges, farmers are being expected to produce adequate output in given resources, therefore, since the second half of the twentieth century farmers are moved from long fallow to short fallow and from annual cropping to multiple cropping cycles per year (Headey et al. 2010). Since the late 1980s and early 1990s, two models of agriculture are now emerging as a result of the integration of this globalization. The first one is an industrial model which advocates the usage of high inputs/output intensive land farming to get high production. Subsequently, the international capital market penetrated in south Asian countries by the elaboration of biotechnology. The alternative model is sustainable agriculture and quality food production (Gilan C Filson 2005, page no: 37).

Currently, the average distribution of per-capita land per hectare in India (0.129) ranked 104th, Pakistan has (0.118) ranked 111th, and Bangladesh (0.0499) ranked 157th in the world. Mainly in India, Bangladesh, and Pakistan, the situation is alarming. In India, 60% land is rainfed; 81% farmers own less than 2-ha land in size, 0.5 ha in Bangladesh; and 9% of its farmers are small farmers. In Pakistan, on average, a farmer owns less than 3 ha of land, more than 55% of the country's farmers own less than 2 ha of land. However, due to an increase in rural and urban population, land intensification has become a major and imminent issue. Subsequently, this is the reason why the annual cropping pattern has turned into a short fallow to long fallow and multiple cropping systems are being practiced intensively on highly fragmented land. This problem is further aggravating because of uneven rural–urban population density, and thereby, it is ensuing food insecurity. The rapid population growth affects the major SDG 1, 2, 3, and 15 indicators in the sampled economies. As in these economies, low literacy rate, high population density, and higher age dependency ratio are on an incessant rise more than ever due to persistent level of rural poverty. Since millions of people from rural areas are landless farmers, besides being on the threshold of poverty, these are the reasons why in South Asia, the agriculture sector is under great stress, specifically on the account of its population growth, high demand for staple crops, increase in temperature, and scarcity of water exerting downward pressure on the available natural resources. It ultimately leads to lower economic profit for small farm holders.[1]

The first theoretical model is more in practice in this region of South Asia, because small tracts of agricultural land use are increased, and there are very few tracts of virgin land that are left now in south Asian most-populated countries. This is the reason is why in South Asia, an increase in population is the driving factor that resulted in fragmentation and land losses in the agriculture sector due to urbanization, industrialization, and infrastructural development. The proportional decline in the rural population in developed Asian countries has driven agricultural land to be converted for the non-agriculture purpose. Subsequently, it is leading to a decline in a farmer's income and rural markets are countering with numerous imperfections, since continuous tillage is causing land degradation because of poor farm practices; natural hazards due to climate change have driven out many farmers from the farming sector and for this predisposing lands are to be converted away from agriculture purposes.

The distinction of the study is that neither of the study is available concerning south Asian demographic changes' impact on yield kilogram per hectare pertinent to transitional variation in demographic variables and aggravating climate crises. Therefore, the study is an addition to the existing pool of literature which captured the impact of demographic variables on yield kilogram per hectare. Further, how much farm inputs are yielding productivity return in countries Pakistan, India, and Bangladesh by using data over the period from 1973 to 2020. The study investigates the following questions: (1) to which extent transitional demographic variables are causing to affect yield kilogram per hectare in Pakistan, Bangladesh, and India; (2) at present, what are the key factors of land intensification in the sample economies; and (3) how long the current farming system will sustain in these underlying socio-economic conditions on a given massive population pressure. All of these questions are imperative to know, since all of these three economies are the major player of south Asia, and they have a large share in the world population besides being big suppliers of agriculture commodities. The study is organized as follows: the "Theory and existing literature review" section reviews the past literature, Sect. 3 theoretical frameworks; the "Methodological framework" section gives methodology and data description, the "Results and discussion" section is based on empirical results, and finally the conclusion is drawn in the "Conclusion" section.

Theory and existing literature review

It was Malthus (1798) who very first presented the growth theory of population and he warned that soon the world population carrying capacity will reach its limit. Principally, Malthus' theory was based upon the assumption of a

[1] Not balancing the increase in temperature associated with reduced transpiration.

closed economy model. However, in the recent past, Boserup (1965) claimed that by equipping the agriculture sector with modern farm inputs, food insecurity issues can be resolved. The approach was influenced by capitalist industrial farming; resultantly, a green revolution from 1950 to 1960 in the world and particularly in South Asia took place.

It was Glen and Filson (2005) who presented the modern school of thought that those social implications are the real reasons behind intensive agriculture activities and rapid evolution in farming technologies, consequently, increasing the pressure on farming communities globally. Because of this reason, the predominated farming techniques of agriculture production are becoming less efficient in today's world, although these main intensive techniques were ecofriendly and still remain competitive. However, since the agro-based industries got phenomenal development soon after 1990 globally, this has negatively affected the rural population across the globe. Currently, it is putting considerable pressure on them to change their economic, social, and environmental components in response to increasing population. Robust increases in information technology and continuously evolving trade patterns and relationships among the nations are also hitting the rural communities hard especially in countries: India, Pakistan, and Bangladesh. The intensification of industrialization accelerated intensive farming to meet the global food requirements. Now the phenomenon is replacing family farms in Pakistan particularly, and in India and Bangladesh generally.

Since the early 1990s, economists, agriculturalists, and environmentalists forewarned that population growth is a root cause of climate change, and it is harbingering food crisis in transitional economies. Degradation of the environment puts a strong impact on agriculture output; so, when population density and growth vary, it leads to variation in agriculture activities directly. The agriculture sector in South Asia is in an interim stage, and many structural reforms are being taken in the region due to population steadiness Therefore, since the green revolution took place specifically in south Asian fertile lands, the period population growth has been rising steadily. So the high population density demands high food requirements; this is the reason why it has a negative relationship with the average productivity of crops. But farm productivity and incomes tend to rise only when population density is up to 600–650 persons per km^2, and beyond this threshold, rising population density is associated with sharp declines in farm productivity (Jayne et al. 2014).

Some studies tested the Malthusian hypothesis, by using Johnson con-integration technique and ECM (error correction model) for Pakistan in terms of the short-run and long run. The results of the study disclosed that soon the country may fall into the trap of food insecurity and face chronic famine as anticipated by Malthus because the population in Pakistan has reached its steady state.[2] In another estimated agriculture sustainability in south Asia,[3] by using 34 years of data (1980–2013), the objective of the study was to examine the role of capital, in driving TFP total productivity growth; for this study, multi-temporal total factor productivity model was used. Results disclosed that agriculture sector growth in Bangladesh was 1.05%, Pakistan was 0.38%, India was 0.52%, and Nepal was 0.06%. There seem to be no change in technical and scale efficiency variation among the countries, except residual scales which increase in sample economies slightly. It was 0.44 in Bangladesh, 0.12 in Pakistan, and − 0.39 in Nepal and remained unchanged in India as per the 2020 statistics. The only key factor of agriculture TFP growth in these countries is the levels of natural resource abundance, and human and technology capital endowment, whereas financial capital and crop diversification were on the opposite side, (Ahmad and Amjad 2016; Malik and Ali 2015; Anser et al (2021a, b, c, d); Li et al (2021); Khan et al. (2021); Shabbir (2020), Rehman et al. 2015).

Lee and Wang (2015) used quarterly data of 29 countries from 2000 to 2011; for regression analysis, they employed pooled mean group (PMG) method to estimate dynamic heterogeneous data. Alsaleh and Abdul-Rahim (2019) also applied the ARDL (PMG) model to check the causality between the financial development and population growth of Malaysia. Tarique and Sohag (2014) measure the impact of CO_2 emission impact on agricultural output by using the penal data set (PMG) ARDL model to estimate the long- and short-run effects. The data comprises Southeast Asian countries. Ali et al. (2019) investigated the nexus among environmental pollution, economic growth energy use, and foreign direct investment in 6 selected sub-Saharan African countries. He also used (PMG) ARDL model. In a nutshell, in many studies for heterogeneous data analysis, ARDL (PMG) model has been used extensively.[4]

Methodological framework

This study is a revisit of the Boserupion and Malthusian approach from the outlook of Pakistan, India, and Bangladesh agriculture by keeping into account agriculture land use and fragmentation into it due to given transitional changes in demographic variables. Additionally, it has estimated how modern farm inputs are directly interlinked with the food insecurity problem because the study took into account yield kilogram per hectare as its core variable. The study has included variables average

[2] More than carrying capacity of the country as per the proportion of its natural resources (i.e., agriculture land, availability of fresh and safe drinking water, and forest).

[3] Pakistan, India, Bangladesh, and Nepal.

[4] East and West Africa, south Asia and Central America.

yield kilogram per hectare, and the available number of tractors in the economy (a proxy of mechanization and road infrastructure as per ADB, 2006), moreover, water usage per hectare, fertilizer consumption kilogram per hectare, population density, education expenditure as per GDP ratio, per-capital availability of land and agriculture labor force, population density, and rural population growth, to estimate the population pressure on average yield kilogram per hectare (Jayne et al. 2014; Shabbir and Wisdom 2020; Anser et al. (2021a, b, c, d); Mughal et al. (2022); Shabbir and Zeb (2020). All of the prior studies have shown that population pressure affects negatively natural resources, because demand-driven migration towards urban markets plays a central and key role in determining agriculture crop productivity. Rural or urban population growth is an endogenous phenomenon and it depends upon natural resource abundance. So migration decision leads to increase in change in rural population growth, agricultural labor force, and population density, which invigorates economic activities[5] and resultantly food demand increases and it intensifies the depletion of natural resources.

As we know in Pakistan, India, and Bangladesh, the population is higher than that in any other country of the world. Thus, it is imperative to assess why and how demographic variables aside from modern farm inputs affect the average yield kilogram per hectare. Therefore, the study empirically analyzed the dynamic effects of population growth and modern farm inputs' impact on average yield kilogram per hectare by using panel data.

Data sources and estimation technique

This is a tri-country penal analysis: Pakistan, India, and Bangladesh, and data are from throughout (1973–2020). The data of average yield kilogram per hectare, the total area of crop, and no tractors available in the economy are taken from Indian agriculture statistics at a glance, Bangladesh agriculture statistics, Bangladeshi economic survey, Pakistan agriculture statistics, and economic survey of Pakistan. Moreover, the World Bank is a data source for expenditure on education to GDP ratio, population density, child mortality rate, the agriculture labor force (in millions), and rural population growth. Variable of water and fertilizer consumption per-hectare data is taken from FAO statistics.

In this study, we use FAO and UNO definitions for per-capita cropland and its given data on UNO and FAO statistics to check the dynamics of variation in average yield kilogram per hectare due to change in agriculture inputs with transitional demographic indicators. Farm input data is taken from national agriculture statistics (Pakistan, India, Bangladesh), and fertilizer kilogram (consumption per hectare) from FAO. Sources of demographic variable data are taken from the World Bank because the objective of the study is to make balance panel data to use the ARDL PMG approach: autoregressive distributed lag model, which is an extensively dynamic heterogeneous model tool.

Before running the regression, we have checked the stationarity of the variables in the long run by using Levin et al. (2002) unit root test to use panel data ARDL PMG approach, that either variable is stationary on level or at their first order. As in this study, different cross-sectional time series data sets are being used, and in such kind of data heterogeneity problems may occur, but panel data estimation method has the extensive attribute to take such heterogeneity and correlation explicitly into account. But to make our results more authentic, we have employed a two-stage least square method to avoid the endogeneity among the variables. From a wider perspective, multi modeling analysis is required to address the problems of sustainability in the long term by keeping in mind SDG 2030 agenda (Kaytesa and Ayechew 2021).

Description of the variables

Basic model

$$
\begin{aligned}
AYKG =& \alpha + \beta1 AGE\_DEP + \beta2 AGLFM + \beta3 EDU + \beta4 FKG \\
& + \beta6 PCL + \beta7 POPDN + \beta9 RPG \\
& + \beta10 TRACT + + \beta11 W + \varepsilon
\end{aligned}
$$

1. AYKG = average yield kilogram per hectare of crops (wheat, maize, rice, sugarcane, cotton).
2. Tract = no of tractor available in economy (a proxy for mechanization and road transportation)
3. FKG = fertilizer kilogram consumption per hectare.
4. RPG = rural population growth.
5. AGLFM = agriculture labor force in millions.
6. POPDN = number of people living in per km^2 (proxy of urban sprawl)[6]
7. W = available water per hectare
8. AGE_DEP = age dependency
9. PCL = per-capita crop land
10. ε = error term

These are the variables of the study which are major determinants to find agriculture productivity, land intensification, and population growth relationship in the sample countries with yield kilogram/hectare. Many studies like Malik and Ali (2015), Anser et al. (2021a, b, c, d), Kumari et al. (2021), Shabbir et al. (2020), Jun et al. (2021), Shabbir

[5] Higher population growth and density accelerate the expansion of nonfarm industries, which are closely linked with urban markets; resultantly, urban demand increases which leads to higher rural–urban migration.

[6] Urban sprawl, also called sprawl or suburban sprawl, the rapid expansion of the geographic extent of cities and towns, often characterized by low-density residential housing, single-use zoning, and increased reliance on the private automobile for transportation.

Table 1 Unit root test results (Levin-Lin-Chu)

Variable	Level	1st difference	Decision
AYKG	− 1.46(0.07)*	− 9.55(0.00)***	I(0)
AGE_DEP	− 4.24(0.00)***	− 1.53(0.06)*	I(0)
AGLFM	1.55(0.94)	− 2.34(0.01)**	I(I)
FKG	− 0.79(0.21)	− 6.31(0.00)***	I(I)
PERCROPLAND	− 1.52(0.94)	− 6.00(0.00)***	I(I)
RPG	− 2.94(0.00)***	− 2.09(0.02)*	I(0)
TRACT	− 0.13(0.45)	− 3.46(0.00)***	I(I)
W	− 1.63(0.05)*	− 10.02(0.00)***	I(I)

Probability value is in parenthesis, and significant at *10%, (90% significant), **5% (95% significant), ***1% (99% significant).

and Yaqoob (2019), found a very strong relationship between population growth and land intensification.

Results and discussion

Unit root test

In Table 1, unit root test results reveal that some variables are stationary on the level and some are at their first difference. Average yield kilogram per hectare (AYKG), age dependency AGE_DEP, rural population growth (RPG), and water per hectare (W) are overall stationery, at their level, and first difference both, whereas the available number of tractors in the economy for the agriculture sector (TRACT), per-capita cropland (arable land per hectare) (PCL), fertilizer kilogram per hectare (consumption) (FKG), and the agriculture labor force in millions (AGLFM) are stationary at their first difference. It is a prerequisite test to find the long-run relationship among the variables also used the same variable panel data to find the land intensification in Malawi.

Cointegration model

Anser et al. (2021a, b, c, d), Arslan et al. (2021), Arif et al. (2020), Shabbir and Wisdom (2020), Khuong et al. (2021), Shabbir (2016), and Pesaran and Shin (1999) present the autoregressive distributed lag (ARDL) in the error correction form, which was a relatively new form of cointegration test. Although Johansen (1995) and Phillips and Hansen (1990) argued that the long-run relationship that exists only is central to cointegration among integrated variables, such assumptions present several econometric advantages of the PMG and MG compared with other methods. First, the PMG and MG estimators do not require a cointegration test. Moreover, the validity of stationary or integration between the variables to estimate long-run relationship and pre-testing for unit root is no longer required because this methodology allows estimation of different variables with different orders of stationary i-e (it is valid whether the variables of interest are I(1) or I(0)). The model is adequate to deal with N large sample and T dimensions; therefore, the model has no issue dealing with short-run and long-run panel data.

We have regressed two models of regression in the study to get unbiased results. Long-run con-integration asks for the identification of lag structure for a specific variable; therefore, the likelihood ratio (LR), the Akaike information criteria (AIC), the Hannan Quinn Information criteria (HQIC), and Swartz Bayesian Information Criteria (SBIC) have also been checked in this study to determine the optimal lag length criteria. Table 2 depicts the results of the criteria.

The first model (basic model)

$$
\begin{aligned}
AYKG = & \alpha + \beta AGE_{DEP} + \partial AGLFM \\
& + \Omega FKG + \tau PERCROPLAND \\
& + \alpha tract + \sigma w + uit
\end{aligned}
$$

The second model (without per-capita cropland)

$$\mathrm{AYKG} = \alpha + \beta \mathrm{AGE}_{\mathrm{DEP}} + \partial \mathrm{AGLFM} + +\Omega \mathrm{FKG} + \alpha \mathrm{tract} + \sigma \mathrm{w} + \mathrm{uit}$$

Results of the study

We have regressed three models to find the relationship between average yield kilogram per hectare land

Table 2 VAR lag order selection criteria (sample: 1973–2020)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1009.4	NA	613,832.2	16.16511	16.36770	16.24742
1	-964.76	82.19744	307,073.4	15.47238	15.69749	15.56384
2	-961.524	5.908311*	296,395.4	15.43688	15.68449*	15.53748*
3	-960.001	2.754504	293,987.9*	15.42859*	15.69871	15.53833
4	-959.732	0.482734	297,465.2	15.44019	15.73283	15.55908

* indicates lag order selected by the criterion: endogenous variables—AYKG; exogenous variables—C AGE_DEP EDU FERTW MOR PERCROPLAND RPG TRACT WATER.

Table 3 Long-term co-integration result (dependent variable is AYKG)

Variable	Model 1	Model 2
AGE_DEP	−480.6(−4.1) 0.0***	−87.1(−2.2) 0.0*
AGLFM	−4.7(−0.1) 0.9	3.1(0.4) 0.7
FKG	93.5(3.2) 0.0***	9.7(4.0) 0.0***
PERCROPLAND	−488.3(−0.6) 0.6	
RPG	−4526.4(−3.6) 0.0***	−226.2(−1.3) 0.2
TRACT	0.0(−2.9) 0.0**	0.0(8.7) 0.0***
W	166.2(2.4)0.0*	−190.0(−2.3) 0.04*
COINTEQ01	−0.9(−2.0) 0.1	−0.8(−3.0) 0.0**

T-statistics is in parenthesis, whereas probability is without parenthesis. Probability values are significant at *10% (90% significant), **5% (95% significant), and ***1% (99% significant).

intensification and population growth impact on it besides modern farm inputs. (Table 3)

We have applied the panel ARDL model to check the long-run cointegration among the variables. The average yield kilogram per hectare is the dependent variable in this study. Variables of the study are age dependency agriculture labor force in millions, fertilizer kilogram per hectare, and per-capita cropland; rural population growth, tractor (a proxy for mechanization), and water consumption per hectare are the explanatory variables. In the first model which is our basic model, we regress all the explanatory variables on dependent average yield kilogram per hectare. The results indicate that age dependency (−480.6, −87.1), agriculture labor force (−4.7, 3.1), and rural population growth (−4526.4, −226.2) all have a negative relationship with average yield kilogram per hectare. It shows every 1% increase in these variables leads to a decrease in the average level of crop output that much. This is a clear indication of low return from given cultivated land per capita. However, fertilizer kilogram per hectare (93.5, 9.7), the total number of available tractors (0.01, 0.003) in the country, and water availability (166.2, 190.0) have shown a positive relationship with the average yield kilogram per hectare. Since all these variables are the proxies of technological advancement, it means natural return has decreased; now, technology is the variable that determines the output in today's world. The rate of adjustment (cointeq) from the short run to the long run is highly significant and appropriate; in the first model, it is −0.9, and in the second model, it is −0.8.

Table 4 shows the results of short-run cointegration of the variables. *T* values are in parenthesis; the steric values are showing the level of significance. The results of the coefficient values explore that the current value of average yield kilogram per hectare depends upon its own leg values. Fertilizer kilogram per hectare and rural population growth current period values also affect the productivity of the agriculture sector in short run.

Table 4 Short-run error correction model results

Variable	Model 1	Model 2
D(AYKG(−1))	−0.4(−0.9) 0.4	
D(AYKG(−2))	−0.5(−1.6) 0.1	
D(AYKG(−3))	−0.3(−5.4)0.0***	
D(AGE_DEP)	6321.0(1.6) 0.1	−84.5(−0.4)0.7
D(AGE_DEP(−1))	−10,228.9(−0.9) 0.4	
D(AGE_DEP(−2))	7394.1(0.8) 0.4	
D(AGLFM)	48.1(1.6)0.1	86.1(1.5)0.1
D(AGLFM(−1))	−132.3(−1.9)0.1	
D(AGLFM(−2))	−229.9(−1.7)0.1	
D(FKG)	−58.3(−2.6)0.0	−5.7(−1.2) 0.2
D(FKG(−1))	−43.0(−1.9)0.1	
D(FKG(−2))	−43.0(−2.5)0.0***	
D(PERCROPLAND)	1033.3(1.2)0.2	
D(PERCROPLAND(−1))	107.9(0.1)0.9	
D(PERCROPLAND(−2))	−1030.7(−0.5)0.6	
D(RPG)	5876.0(2.1)0.0***	752.1(1.0)0.3
D(RPG(−1))	6152.2(1.7)0.1	
D(RPG(−2))	5923.4(1.8)0.1	
D(TRACT)	0.2(1.1)0.3	0.0(1.3) 0.2
D(TRACT(−1))	−0.2(−0.9)0.4	
D(W)	−257.2(−2.0)0.1	−31.3(−0.2)0.8
D(W(−1))	−296.7(−1.7) 0.1	
D(W(−2))	−109.0(−0.4)0.7	
C	20,322.0(1.5)0.1	

T-statistics is in parenthesis, whereas probability is without parenthesis. Probability value are significant at *10% (90% significant), **5% (95% significant), and ***1% (99% significant).

Robustness analysis

In order to endorse the ARDL model result in this study, the 2SLS technique is also applied for the robustness of the analysis by using the sample throughout (1973–2020). The regression included 4 cross-sections and 3 total panel (balanced) countries data set.

The results of the 2SLS analysis which are mentioned in Table 5 show that land availability has a significant positive effect on yield kilogram per hectare, whereas age dependency has a significant negative effect on yield productivity. Dependent variable: AYKG. The objective of the regression was to validate the results, by using the instrument of rural population growth, fertilizer kilogram per hectare, no tractors available on the farmlands, and water availability. The outcomes of the 2sls are aligned with PMG (ARDL) long-run cointegration results. None of the study to date

Table 5 2SLS model instrument specification: C, TRACT, WATER, FKG, RPG.

Constantly added to the instrument list				
Variable	Coefficient	Std. error	t-statistic	Prob
AGE_DEP	−528.921	113.2187	−4.67168	0
PERCROPLAND	−1506.15	198.634	−7.58255	0
C	41,907.76	4574.822	9.160524	0
Effect specification				
Cross-section fixed (dummy variables)				
R-squared	0.444583	Mean dependent var		11,551.02
Adjusted R-squared	0.419144	S.D. dependent var		2343.196
S.E. of regression	1785.842	Sum squared resid		4.18E+08
F-statistic	221.9623	Durbin-Watson stat		0.200057
Prob(F-statistic)	0	Second-Stage SSR		67,364,645
Instrument rank	7			

(Jeyasri et al. 2021; Billings et al. 2021; Juju et al. 2020) available has ever used dynamic modeling tools or technique with addition to the estimation of robust analysis to measure jointly true outcomes of the demographic and farm inputs.

Conclusion

This study tried to synthesize the impact of demographic changes, besides modern farm inputs, on average yield kilogram per hectare, and land-use intensification in Pakistan, India, and Bangladesh. It is widespread truth that unused fertile land availability has been decreasing every passing day, and low-quality land demands more inputs than a fertile piece of land. Especially, when low-quality lands are brought into cultivation, this is the major reason for the decrease in crop productivity in sample economies. Agriculture inputs (non-fixed), i.e., fertilizer consumption, water (irrigation water), the agriculture labor force (in millions), and machinery, captured the positive effects of growth in the agriculture sector in terms of panel data of Pakistan, India, and Bangladesh. Population pressure is completely apprehended by demographic variables resulting in terms of land intensification and growth in yield kilogram per hectare.

Policy suggestions on the basis of study outcomes: high crop rotation is an effective practice but it must include mixed cropping choices, since it demands a multidimensional approach to cure the problem. Thereby, the multi-sectorial investment in research and development is required for a thorough and deep analysis of the problem because the issue involves several mediating factors that are not in their place. Innovative strategies that integrate agriculture and nutrition programs by owing given small farm holdings can enable us to get rid of the vicious circle of malnutrition. The results of the study particularly suggest that the government of the countries needs to begin intra-regional cooperation and joint initiatives that improve the access of the farmers to good quality water; improvement in the practices of the farm used the land to increase sustainable agriculture growth. Consequently, the introduction of new climate-smart agriculture practices is imperative because of given rural and urban uneven population pressure, related food demands, and climate change phenomenon.

Limitations of the study: The topic requires extensive data set of all the crops either minor or major to measure true effects of demographic variables on agricultural output. However, due to less availability of data across the countries, it is not possible to make the comprehensive analysis by combining all crops together. In this regard, more investment on experimental modeling designs and research is required to get vivid picture of true outcomes on small farmers' income due to increase in population pressure and ultimate climate crises.

Author contribution Miss Nusrat has completed the data analysis part, Dr. Desti completed the Introduction section, Dr. Ammad Ali completed the Literature review section, Mr. Nasir wrote the Methodology section, Mr. Malik Shahzad interpreted the data analysis section, Miss Kanwal wrote the conclusion, and Dr. Mosab wrote abstract parts and format the paper as per journal requirements.

Data availability The data is available on request from corresponding author.

Declarations

Ethical approval and consent to participate. This study did not use any kind of human participants or human data, which require any kind of approval.

Consent to publish Our study did not use any kind of individual data such as video and images etc.

Competing interests The authors declare no competing interests.

References

Ahmad K, Amjad A (2016) Rising population and food insecurity linkages in Pakistan: testing malthusian population growth theory Online at https://mpra.ub.uni-muenchen.de/71131/, MPRA Paper No. 71131, posted 11 May 2016 09:29 UTC

Ali HS, Zeqiraj V, Lin WL, Law SH, Yusop Z, Bare UAA, Chin L (2019) Does quality institutions promote environmental quality? Environ Sci Pollut Res 26(11):10446–10456

Alsaleh AM, Abdul-Rahim S (2019) Financial development and bio energy consumption in the EU28 Region: evidence from panel auto-regressive distributed lag bound approach. Resources 8(1):44. https://doi.org/10.3390/resources8010044

Anser MK, Usman M, Sharif M, Bashir S, Shabbir MS, Yahya Khan G, Lopez LB (2021) The dynamic impact of renewable energy sources on environmental economic growth: evidence from selected Asian economies. Environ Sci Pol, 1–13

Anser MK, Usman M, Godil DI, Shabbir MS, Tabash M, Ahmad M, Lopez LB (2021) Does air pollution affect clean production of sustainable environmental agenda through low carbon energy financing? evidence from ASEAN countries. Energy Environ, 0958305X211007854

Anser MK, Shabbir MS, Tabash MI, Shah SHA, Ahmad M, Peng MYP, Lopez LB (2021) Do renewable energy sources improve clean environmental-economic growth? Empirical investigation from South Asian economies. Energy Explor Exploitation, 01445987211002278

Anser MK, Usman M, Godil DI, Shabbir MS, Sharif A, Tabash MI, Lopez LB (2021) Does globalization affect the green economy and environment? The relationship between energy consumption, carbon dioxide emissions, and economic growth. Environ Sci Pol, 1–14

Arslan Z, Kausar S, Kannaiah D, Shabbir MS, Khan GY, Zamir A (2021) The mediating role of green creativity and the moderating role of green mindfulness in the relationship among clean environment, clean production, and sustainable growth. Environ Sci Pol, 1–15

Arif A, Sadiq M, Shabbir MS, Yahya G, Zamir A, Bares Lopez L (2020) The role of globalization in financial development, trade openness and sustainable environmental-economic growth: evidence from selected South Asian economies. J Sustain Financ Invest, 1–18

Billings L, Pradeilles R, Gillespie S, Vanderkooy A, Diatta D, Toure M, Diatta AD, Verstraeten R (2021) Coherence for nutrition: insights from nutrition-relevant policies and programmes in Burkina Faso and Nigeria. Health Policy Plan 36(10):1574–1592. https://doi.org/10.1093/heapol/czab108

Evenson RE, Pray C, Rosegrant MW (1998) Agricultural research and productivity growth in India (Vol. 109). Intl Food Policy Res Inst. Experience Food Policy 25:445–462

Filson GC (ed) (2005) Intensive agriculture and sustainability: a farming systems analysis. UBC Press

Headey D, Bezemer D, Hazell PB (2010) Agricultural employment trendsinAsiaand Africa: too fast or too slow? Downloaded from http://wbro.oxfordjournals.org at International Monetary Fund on March 10, 2010

Jayne TS, Chamberlin J, Headey DD (2014) “Land pressures, the evolution of farming systems, and development strategies in Africa: a synthesis”. Food Policy 48:1–17. Science Direct, www.elsevier.com/locate/foodpolicy

Jeyasri R, Muthuramalingam P, Satish L, Pandian SK, Chen JT, Ahmar S, Wang X, Mora-Poblete F, Ramesh M (2021) An Overview of Abiotic Stress in Cereal Crops: Negative Impacts, Regulation, Biotechnology and Integrated Omics. Plants (Basel) 10(7):1472. https://doi.org/10.3390/plants10071472

Johansen S (1995) A stastistical analysis of cointegration for I(2) variables. Econ Theory 11(1):25–59

Juju D, Baffoe G, Lam RD, Karanja A, Naidoo M, Ahmed A, Gasparatos A (2020) Sustainability challenges in sub-Saharan Africa in the context of the sustainable development goals (SDGs). In Sustainability Challenges in Sub-Saharan Africa I (pp 3–50). Springer, Singapore

Jun W, Mughal N, Zhao J, Shabbir MS, Niedbała G, Jain V, Anwar A (2021) Does globalization matter for environmental degradation? Nexus among energy consumption, economic growth, and carbon dioxide emission. Energy Policy 153:112230

Kaytesa S, Ayechew B (2021) The impact of population pressure on agricultural land use in Dirashe special district, Segen Area People’s Zone, Southern Nations, Nationalities and People’s Region, Ethiopia. Eur J Sci Innov Technol 1(1):10–15

Khan I, Lei H, Khan A, Muhammad I, Javeed T, Khan A, Huo X (2021) Yield gap analysis of major food crops in Pakistan: prospects for food security. Environ Sci Pollut Res 28(7):7994–8011

Khan MB, Saleem H, Shabbir MS, Huobao X (2021) The effects of globalization, energy consumption and economic growth on carbon dioxide emissions in South Asian countries. Energy Environ, 0958305X20986896

Khuong NV, Shabbir MS, Sial MS, Khanh THT (2021) Does informal economy impede economic growth? Evidence from an emerging economy. J Sustain Financ Invest 11(2):103–122

Kumari R, Shabbir MS, Saleem S, Khan GY, Abbasi BA, Lopez LB (2021) An empirical analysis among foreign direct investment, trade openness and economic growth: evidence from the Indian economy. South Asian J Bus Stud

Leal Filho W, Azeiteiro UM, Setti AFF (2021) Sustainability in natural resources management and land planning

Lee Y-M, Wang K-M (2015) Dynamic heterogeneous panel analysis of the correlation between stock prices and exchange rates. https://doi.org/10.1080/1331677X.2015.1084889

Levin A et al (2002) Unit root tests in panel data: asymptotic and finite-sample properties. J Econom 108:1–24

Li Q, Cherian J, Shabbir MS, Sial MS, Li J, Mester I, Badulescu A (2021) Exploring the relationship between renewable energy sources and economic growth. The Case of SAARC Countries Energies 14(3):520

Mardi E, Montazar A, Nazari Far MH, Bari: CIHEAM (2007) Optimal water productivity of irrigation systems in a semi-arid region. Water-saving in Mediterranean agriculture and future research needs [Vol. 3], pages 87–98, Article available online

Mishra R, Singh E, Kumar A, Kumar S (2021) Application of remote sensing for assessment of change in vegetation cover and the subsequent impact on climatic variables. Environ Sci Pollut Res, 1–13

Mughal N, Arif A, Jain V, Chupradit S, Shabbir MS, Ramos-Meza CS, Zhanbayev R (2022) The role of technological innovation in environmental pollution, energy consumption and sustainable economic growth: evidence from South Asian economies. Energy Strategy Rev 39:100745

Muhammad I, Shabbir MS, Saleem S, Bilal K, Ulucak R (2020) Nexus between willingness to pay for renewable energy sources: evidence from Turkey. Environ Sci Pollut Res Int 28(3):2972–2986

Malik R, Ali M (2015) “The Impact of Urbanization on Agriculture A Case Study of Peshawar, Pakistan**”** Email: rabiamalik.00@gmail.com, maisamali2482@gmail.com**,** of Resources Development and Management www.iiste.org ISSN 2422-8397 An International Peer-reviewed Journal, Vol.8, 2015, 79

Mitra A, Rao N (2021) Contract farming, ecological change and the transformations of reciprocal gendered social relations in Eastern India. J Peasant Stud 48(2):436–457

Mogues T, Yu B, Fan S, McBride L (2012) The impacts of public investment in and for agricultureSynthesis of the existing evidence ESA Working paper No. 12–07 October 2012 Agricultural Development Economics Division Food and Agriculture Organization of the United Nations www.fao.org/economic/esa

Mondal S, Palit D (2021) Ecological intensification for sustainable agriculture and environment in India. Ecol Intensif Nat Res Sustain Agric, 215

Mugizi FM, Matsumoto T (2021) A curse or a blessing? Population pressure and soil quality in Sub-Saharan Africa: evidence from rural Uganda. Ecol Econ 179(106):851

Murshed M, Ferdaus J, Rashid S, Tanha MM, Islam MJ (2021) The Environmental Kuznets curve hypothesis for deforestation in Bangladesh: an ARDL analysis with multiple structural breaks. Energy, Ecology and Environment 6(2):111–132

Pesaran MH, Shin Y (1999) An autoregressive distributed lag modelling approach to cointegration analysis. In: Strom S, Holly A, Diamond P (eds) *Centennial Volume of Ragnar Frisch*. Cambridge University Press, Cambridge

Phillips PCB, Hansen BE (1990) Statistical inference in instrumental variable regression with I(1) Processes. Rev Econ Stud 57:99–125

Rehman A et al (2015) Economic perspectives of major field crops of Pakistan: an empirical study. Science review Humanities and Social Sciences issues 1:145–158

Sadiq M, Usman M, Zamir A, Shabbir MS, Arif A (2021) Nexus between economic growth and foreign private investment: evidence from Pakistan economy. Cogent Economics & Finance 9(1):1956067

Shabbir MS, Bashir M, Abbasi HM, Yahya G, Abbasi BA (2020) Effect of domestic and foreign private investment on economic growth of Pakistan. Transl Corp Rev, 1–13

Shabbir MS, Wisdom O (2020) The relationship between corporate social responsibility, environmental investments and financial performance: evidence from manufacturing companies. Environ Sci Pollut Res 27(32):39946–39957. https://doi.org/10.1007/s11356-020-10217-0

Shabbir MS (2020) Attributes ensuring positive consumer evaluation in brand extension of Pakistan. (IJABIM) 11(4):71–84

Shabbir MS, Zeb A (2020) Nexus and perception of customers toward conventional banking systems: does the islamic banking system exist as a competitor? International Journal of Asian Business and Information Management (IJABIM) 11(4):54–70

Shabbir MS, Yaqoob N (2019) The impact of technological advancement on total factor productivity of cotton: a comparative analysis between Pakistan and India. J. Econ. Struct 8(1):27

Shabbir MS (2016) Contributing factors of inland investment. J Econ Stud 1(10):1–27

Ssali MW, Du J, Mensah IA, Hongo DO (2019) Investigating the nexus among environmental pollution, economic growth, energy use, and foreign direct investment in 6 selected sub-Saharan African countries. Environ Sci Pollut Res 26:11245–11260. https://doi.org/10.1007/s11356-019-04455-0

Tarique KMD, Sohag K (2014) Co emission and agricultural productivity 2 in southeast asian region: a pooled mean group estimation. www.researchgate.net

Tefera B, Ayele G, Atnafe Y, Jabbar MA, Dubale P (2002) Nature and causes of land degradation in the Oromiya Region: a review. Socio-economic and Policy Research Working Paper 36. ILRI (International Livestock Research Institute), Nairobi, Kenya, pp 82

Warsame AA, Sheik-Ali IA, Ali AO, Sarkodie SA (2021) Climate change and crop production nexus in Somalia: an empirical evidence from ARDL technique. Environ Sci Pollut Res Int 28(16):19838–19850. https://doi.org/10.1007/s11356-020-11739-3

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.