Economic outlook of food crops in Pakistan: An empirical study

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Abstract: Agriculture is the backbone of Pakistan's economy, highly depends on food crops. There is a huge gap between the products purchased and the actual products, which suffer from inadequate technology, inadequate resource use, inappropriate use of water and land, and inappropriate pests management studies, it's not just negatively affects production but also reduces production. Most farmers use synthetic chemicals to control pests, but they are often used in vain. In order to illustrate the main gaps and actual results of the main upland crops. The study examines the link between food security and GDP growth in Pakistan, including wheat, rice, sugarcane and maize, and water availability in Pakistan from 1999 to 2018. Periodic data are collected from the Pakistan Economic Survey (various sources). Use conventional miniature methods and refine Dickey-Fuller (ADF) testing to analyze crop data, and use Johansen aggregation testing to interpret results. Our research found that wheat, rice, sugarcane, and maize yields were positively correlated with Pakistan's agricultural GDP, while water supply was negatively correlated with Pakistan's agricultural GDP without significant correlation. Water resources related to climate change and the context of climate change will have a devastating effect on Pakistan's water resources. Therefore, the study suggests that the Pakistani government should provide major agricultural inputs on subsidies formulate policies, and launch new funding programs to develop and improve water availability.

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1. Introduction

Pakistan's agricultural sector is playing a vital role in economic development; it contributes about 19% of the gross domestic product (GDP), and employs around 43% of the country's labor force, and has also played a key role in providing raw materials for many cost-added sectors. It is playing an important role in economic development, poverty reduction, and food security. The rapid development of urban areas in Pakistan explains the growing use of widely used items such as vegetables, fruits, dairy products, and meat. The Government is working to expand and expand these products by implementing new policies to increase rural growth through investment in infrastructure, including reliable transport networks and contemporary supply chains (GOP, 2016).

In the wheat production system, Punjab is irrigated in Pakistan, its field and historical center was the Green Revolution. In the 1960s, Pakistan's Green Revolution involved government investment in the development of irrigation canals and markets (Renkow, 2000). Changes in rural society and wheat production. Hunger expectations are low (Hazel, 2010). Despite encouraging improvements, wheat stalks. Production is the priority of the Pakistani population. The government of Pakistan needs to improve the production of different varieties of wheat. Previous crop studies have shown that the growth of alternative crop varieties was slower when farmers introduced new varieties of wheat in Pakistan (Haisi, 1990; Iqbal et al., 2002). In 1997, the area under wheat production was estimated at 1 million hectares, which is 51% of the total area under wheat in Pakistan 4. Pakistan has an important role to play as the world's rice exporter. It exports about 20 million tons each year, accounting for 10% of world trade. Indian rice accounts for about 25% of Pakistan's exports. Rice exports Pakistan's second-largest source of income is rice grains, which meet the nutritional needs of about 60% of Pakistan's population, and in winter rice is a potential source of animal feed worldwide 4; 5. After the 1950s, the use of pesticides increased when 250 tons of pesticides were introduced to further increase production. Its use increased by 2,158.6% from 1952 to 2004 (Khan et al., 2010). Sugarcane is the most valuable sugar cane in Pakistan, the most important source of sugar production. It makes up 3.4% of the agricultural value and 0.7% of GDP. As a sugar plant, sugarcane is the world's largest biofuel plant (Robinson et al., 2011). The slow growth in the introduction of sugarcane provided space and resources for field cultivation. Numerous studies have shown that the combination of sugarcane and other crops (such as peas, watermelon, and onions) can reduce sugar production and significantly increase economic income (Al-Azad and Alam, 2004; Nazir et al., 2002).

Maize is another economical and nutritious crop in Pakistan. Used as feed and silage, it is one of the most profitable grain crops in the world. Maize is the fourth largest grain after wheat, rice, and cotton. It is sown mainly in spring and autumn. Seeds are sown from February to March in the spring and maize from July to August in the fall. The life cycle of maize depends on the availability of water. At any stage of the statement (ie, breeding and maturation) there is some difference in the amount of water that dries and affects grain yield. Previous studies Heisey and Adams, 1999 have shown that drought stressors can also cause drought. Damage to grain production. The reproductive stage of the crop life cycle.

In addition, it is reported that from 1995 to 2020, agricultural water use is expected to decline from 72% to 62%, and it is estimated that globally, agricultural water use in developing countries Consumption will also fall from 87% to 73% (Khan et al., 2006). Because Pakistan is a largely agricultural country, the scarcity of agricultural water will adversely affect its economy, agriculture directly subsidizes its GDP and more than 40% of the labor force (Pakistan, 2008-09). In Pakistan, traditional crops such as wheat, are planted on flat basins and irrigated for direct irrigation. With this type of irrigation, there is a huge loss of water. Steam and deep waterfall losses also lead to crop shortages associated with increased groundwater, leading to finding alternative methods of irrigating crops to meet water demand, such as raised bed (RB) technology.

## 2. Current view of major field crops of Pakistan

2.1. Wheat

For wheat production, Punjab and Sindh are Pakistan's irrigated provinces. In the 1960s, Pakistan's Green Revolution involved public investment in the development of irrigation canals and

markets. Rural society and wheat production have changed. Expect a hanger strike (Hazell, 2010). Wheat is an important crop for many countries and is used as a staple food in these countries. The truth of the matter is nothing more than the needs of the people. The sustainability and reliability of grain products are very important for the sustainability of crop production. Water and threshing are essential for wheat production and will continue to be a major war to ensure agricultural sustainability and confidence in grain production. However, water and energy savings are two major issues for researchers to reduce the cost of these two so that they do not interfere with production. In the 1980s, Pakistan experimented in the Golden Age with the management of water resources in the construction of concurrently developed canals. But as a result of some drought, this system has become impossible. The water shortage that lasted for almost three years from 1999 to 2002 opened my eyes and our country has just recovered. The country is already facing the problem of this product, because it is pumping this water and using too much groundwater and using too much available energy due to lack of water resources. (Pakistan, 2008-09). It is also predicted that agricultural water use will decrease from 72% to 62% from 1995 to 2020, and it is estimated that agricultural water use in developing countries will decrease from 87% to 73% on a global scale (Khan et al., 2006). Since Pakistan is largely an agricultural country, Agriculture directly subsidizes GDP and more than 40% of the workforce are directly or indirectly employed in the sector, so a shortage of agricultural water will adversely affect the economy (Pakistan, 2008-09). In Pakistan, traditional crops (such as wheat) are planted in flat basins and directly watered for irrigation. This type of irrigation can cause large amounts of water loss. The loss of evaporation and deep seepage also led to a serious shortage of crops associated with the overuse of groundwater. Therefore, it is advisable to find other ways to apply water to crops, such as raised bed (RB) technology to meet water demand.

For agricultural workers, meeting the feeding needs of 9 billion people by the middle of the 21st century is a serious challenge (FAO, 2009). In arid and semi-arid regions, producing more food with less water is a challenge in agriculture. Water shortages and droughts have degraded soils along with rain-fed agriculture (Suleimenov et al., 2011) and low food production, especially in the agricultural and semi-agricultural sectors in Africa. (Fraiture et al., 2010). About 80% of the world's agriculture is on rainfed land, accounting for 80% of global food production. (Falkenmark et al., 2001; Valipour, 2013).

In North Africa and West Asia, 95% of the land is drained by the rains, and about 40% of Uzbekistan land is used due to lack of water, causing land degradation (Shaumarov and Birner, 2013; Zakaria et al., 2013). Wheat is an important agricultural crop in Pakistan because it has many food uses (Iqtidar et al., 2006). In Pakistan, freshwater drains drain 6.35 million hectares of land, and 12.53 million hectares contain drainage, while another 3.59 million hectares have no access to water, totaling 224.5 million hectares (GOP, 2012). Restriction of water leads to exposure due to insufficient water, resulting in a reduction of grain biomass in farm grain (Oweis and Hachum, 2004; Tavakkoli and Oweis, 2004; Xie et al., 2005). The scarcity and rarity of rainfall distribution in the remote part of Pakistan have exacerbated this situation. It has been observed that, under the weight of water purification, the loss of grain starts at a very low yield at full completion (Oweis, 1997). Rain collection and use have been used successfully in many weak regions. They use water that flows from the spring and is taken to the drainage area (Qiang et al., 2006; Short and Lantzke, 2006). Rainwater harvesting can be improved through appropriate methods of harvesting water (such as shrubs) (Rogelio et al., 2006; Zakaria et al., 2012). The use of this technology can increase water availability during the growing season and also increase productivity (Oweis and Hachum, 2003; Ramotra and Giakwad, 2012). Pakistan wheat area thousand hectares and annual harvest area measured in tons shown in Figure 1, respectively.

**Figure 1: Area and yield of wheat crops, 1999-2018**
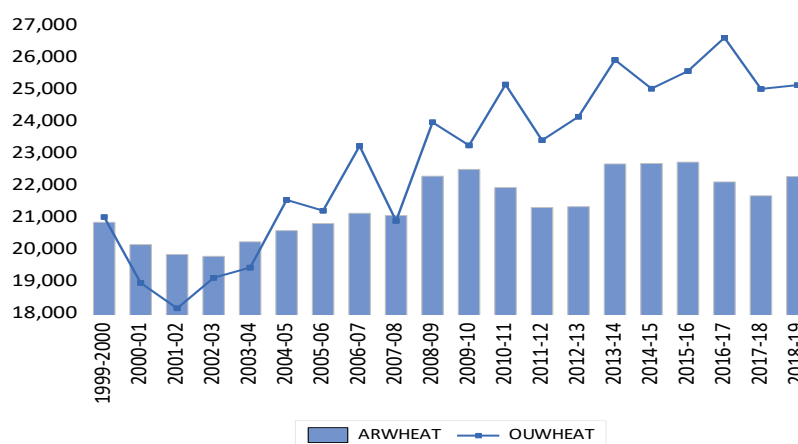
2.2. Rice

Pakistan plays an important role as the world's rice exporter, exporting about two million tons per year. Basmati rice is famous for about 25% of Pakistan's exports. Rice exports are another source of income for Pakistan. Rice, which accounts for 60% of Pakistan's food demand, is a potential food source for livestock in winter (Kahlown et al., 2007; Nguyen et al., 2008). Rice is an important crop in many countries, and its culture is widespread over 2,500 meters of water in humid tropical regions to northeastern China and southeastern Australia and the central regions of Nepal and Bhutan. Most rice is grown in Asia, while large numbers are grown in Oceania and Europe. The broad classification of soils makes it possible to grow rice in different soils at different seasons and with different soil characteristics. Major studies have emphasized the characteristics of rice soil, which is the mainstay of rice production in Asia. However, most studies have focused on the flood-inducing properties of floodwaters (Kirk, 2004; Kogel-Knabner et al., 2010; Wessmann et al., 2000).

Therefore, it is not possible to obtain equivalent quantitative data on the soil quality area of paddy fields and the rice production system. Important questions about soil quality can usually only be addressed qualitatively and are usually answered by local experts. Several goals can achieve a better understanding of soil quality and local representation of barriers. Regional information on environmental barriers to crop production can be used to assess objectives and focus on agricultural research (Singh and Singh, 2010; Hijmans et al., 2003). Factors related to local soil distribution and characteristics, climate, hydrology, and abiotic factors were: subsidence tolerance (Xu et al., 2006), better rice variety tolerance (Huang et al., 2010), phosphorus. Lack of tolerance (Gamuyao et al., 2012) and water stress tolerance (Verulkar et al., 2010). Similarly, such information can be used to investigate and disseminate management options and specific soil issues. The sustainability of traditional rice systems is easily affected by the depletion of water and energy resources. Therefore, Resource Conservation Technology (RCT) has been developed and is widespread to promote global rice production (CGIAR, 2010; IRRI, 2010).

Recently, various types of rice planting technologies have been introduced, such as other dry and wet methods, heart regulation, using rice saline, and aerobic routines. These practices were validated and introduced in Punjab and Sindh. By the Pakistan Research Council (PARC) in collaboration with national and international research organizations (IRRI, 2010; Sharif, 2011). For a brief discussion of these technologies and systems, please see (Bouman et al., 2007). For example, we focus on the performance of the aerobic rice system, in which seeds are sown directly in the field as an alternative to seedling transplantation. The system is very suitable for labor shortage areas, and it also reduces the cost per unit area (Pandey et al., 2002; Pandey and Velasco, 2005). Also, there is a wide variety of weed control chemicals, and they also reduce labor restrictions on seasonal weeding (Farooq et al., 2011). When the soil water drops below the critical water level, it is necessary to supply water to the field to meet the irrigation requirements. The overall performance of aerospace and directly milled rice can be a very efficient and environmentally friendly production system. For this reason, the space shuttle system can be an attractive alternative technology system in a dehydrated environment. (Bouman et al., 2007; Bouman et al., 2005).

During the growing season, there is a tendency to depend on rice crops to prevent water and increase productivity. This exercise leads to ineffective use of water. Many demands in Pakistan indicate that irrigation water use is 13 cm 18 cm, which is much larger than water use between the two irrigation events, such as about 8 cm (Kahlon et al., 2001). In addition, the irrigation efficiency of the farm is between 23% and 70% (Kahlown et al., 1998; Kijne and Kuper, 1995). In addition, rice and wheat were planted in different countries using the pressurized irrigation method (Spanu et al., 1996). Ink-based irrigation, such as the use of a portable rain gun, can be used to irrigate water at a certain depth, and in the main climatic conditions of the subcontinent, sprouted irrigation improves agricultural irrigation efficiency by up to 80 percent. Figure 2 shows the area of rice cultivation in Pakistan per 1000 hectares and the production per hectare.

Figure 2: Area and Yield of Rice crops, 1999 – 2018
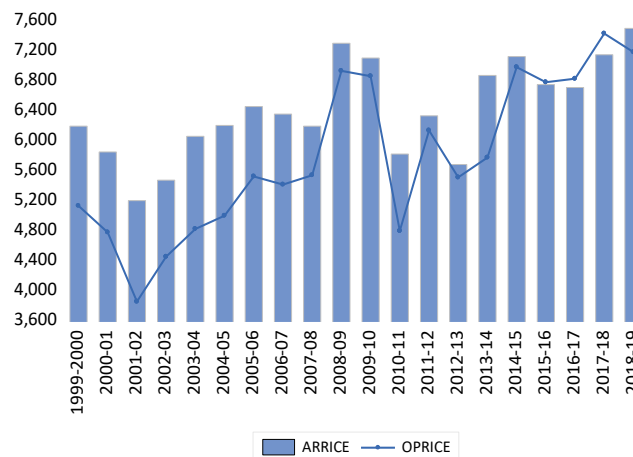
2.3. Sugarcane

Sugar cane is widely cultivated in tropical and subtropical regions of the world and is of great economic importance. According to 2014 estimates, over 100 countries have grown 27 million hectares of sugar cane (FAOSTAT, 2015). In the world, Brazil occupies the top sugarcane production, accounting for 39% of the world's sugarcane production, India second, 19% of sugarcane production, followed by China, Thailand, Pakistan, and productivity respectively. 7%, 5%, 4% (FAOSTAT, 2015). So far, sucrose is commonly used in the sugar cane industry because of its sucrose content and later as a sweetener. The biomass residue (bagasse) remaining after sucrose extraction is used as fuel to supply steam and electricity. We operate a sugar factory. However, people's awareness of by-products (bagasse, molasses, bagasse, filter cake, etc.) continues to grow, and nowadays various industries and products (such as bioethanol and electricity) and chemicals (including various types) of a (Dias et al., 2013). India has become the world's largest producer, consumer, and trader of sugar cane products. Due to its abundance, its production has been highly evaluated by society and the government. Sugarcane (Saccharum officinarum L.) is considered to be the most important industrially important traditional and commercial crop in the world, as it has strategic and commercial uses in almost every industry. In recent years, the sugar cane industry has become increasingly important due to its economic impact on sustainable energy production. Deer Industries is another basic agricultural raw material following textiles. It is the basis of one of the largest desserts produced in the country. Brazil, India, and Cuba also use unrefined sugar as human food and animal feed. These countries make up the world's largest sugar production world, accounting for more than half of all sugar production in the world (Girei and Giroh, 2012).

In another study, sugarcane production was increased only by planting sugarcane and rotating with potato (Solanum tuberosum cv. Kufri Bahar), and net income in the intercropping system was also significantly higher. Control of plant pests in sugar cane crop rotation has also been studied (Berry et al., 2009; Chen et al., 2011; Li et al., 2009). However, so far there is insufficient information on the evaluation of the interspecific competition in sugarcane cropping systems. A key element of the intercropping system is competition, which directly affects crop yield (Li et al., 2011). Vandermeer (1990) Found that yields were increased in these cultivation systems when intraspecific competition in intercropping systems was greater than interspecific competition.

The cereal legume intercropping system can increase the efficiency of yield and land use (Ghosh, 2004) and the efficiency of the use of natural resources (such as water, light, and nutrients) with several important (Xu et al., 2008). It can also increase pest and disease control (Chen et al., 2011). In addition, the system of intercropping grains and beans has become a system of popular cultivation throughout the world (Eskanddari, 2012). The area of sugar cane in Pakistan, 1,000 hectares and the area of annual production are measured in tons, are shown in Figure 3.

**Figure 3: Area and Yield of Sugarcane crops, 1999 – 2018**
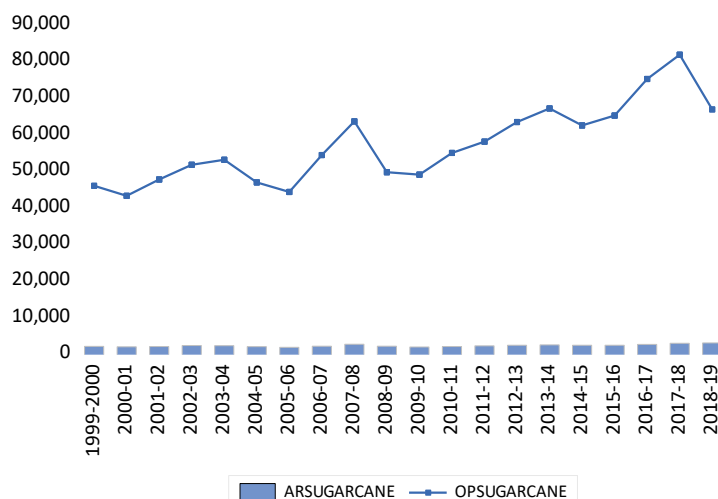
2.4. Maize

Maize is another cash crop and food source in Pakistan, is the world's fodder crop, including manure and sugarcane. After wheat, rice, cotton. Maize is the fourth largest crop in Pakistan, mostly grown in two seasons: spring and autumn. In spring, it is planted from February to March, while in the fall, maize is planted from July to August. The life cycle of maize depends on water availability; Water disputes are present at every stage of voting. In other words, there is a lot of fluctuation between the production process and the maturation process, which can ruin the grain yield. However, studies by Li *et al.* (2021) drought stress is one of the main environmental factors limiting maize yield. Under severe drought stress, the expression of the photosynthetic system and protein synthesis-related proteins are down-regulated, indicating that severe drought damaged photosynthetic organs. Under drought stress, plant biomass also decreased sharply. Maize is an important food grain, a source of many commodities, and adds value to an individual commodity. Inorganic fertilizers play an important role in high yields of the earth, but nitrogen (N) is one of the nutrients absorbed by maize. Moreover, the cost of nitrogen fertilizer is very high, which will cause great losses to the agricultural environment (da Rocha Dias *et al.*, 2020). Currently, about 50% of the population is dependent on nitrogen fertilizer for food, and 60% of nitrogen is used to produce three major crops: rice, maize, and wheat (Ladha et al., 2005). Nitrogen has been developed to increase food production for population growth, and most agricultural nitrogen is fixed by energy-intensive Haber Bosch processes (35 – 50 MJ/kgN (Yan *et al.*, 2018) or 28 – 30 GJ / T) (Kirova-Yordanova, 2004), although only 17% is consumed by humans through crops or livestock. The remaining nitrogen is lost to fresh water and the atmosphere (Beckinghausen *et al.*, 2020). Unfortunately, it is clear that plants cannot use the nitrogen fertilizer used efficiently and that it is lost due to evaporation and leakage, causing serious damage to the aquatic and terrestrial environments, and this nitrogen recovery requires nitrogen to be used, Only 50%. Same for China, Global nitrogen recovery is only 40 percent (Fageria and Baligar, 2005; Ruan et al., 2002). Fageria and Baligar (2005) Nitrogen fertilizer recovery were reported to be low due to its volatility. This is associated with spillage, deforestation, and soil erosion. In addition, the active properties of nitrogen, its mobility in plants, and its transformation in the soil make an unused element. In addition, Ruan and Johnson (1999) estimated that 67% of total nitrogen consumption is lost, with an annual loss of $ 15.9 billion. Even a 1% increase in nitrogen replenishment could save the world $ 234 million (Glass, 2003). Therefore, the effectiveness of nitrogen application (NUE) in nitrogen fixation is of great concern to nitrogen cycle researchers. To improve the efficiency of nitrogen application in crop production, nitrogen control strategies should include fertilizer efficiency and soil and crop management practices. In these management methods, the amount and application of fertilizer and the timing of fertilization play an important role in the plant growth cycle (Abbasi et al., 2012; Fageria et al., 2006). This strategy can not only increase the volume of production but also reduce production costs and environmental risks.

Continuous cropping systems should include rice plants to overcome nitrogen deficiency. These plants play an important role in maintaining soil fertility and crop production. Legumes can convert nitrogen in the atmosphere into nitrogen by root control. Therefore, they have proven to be a valuable source of nitrogen (Giller, 2001).

As a valuable management tool, farmers and researchers are increasingly interested in crop rotation and plant waste management. Studies have shown that the addition of suitable organic matter is necessary to control wind and water erosion by maintaining arable land and preventing food loss from floods and spills (Bukert et al., 2000). Despite these favorable conditions, farmers still need to remove crops from the land and use them as firewood for livestock feed and construction. Unlike sustainable farming systems, farmers use these trees to cover improving physical and chemical properties of the soil, thus increasing the amount of organic matter in the soil. Soil organic matter plays an important role in enhancing the chemical and physical properties of the soil, so beans must be included in the crop rotation to preserve plant residues. Figure 4 shows the area of 1000 hectares of maize in Pakistan and the annual yield area measured in tons.

### Figure 4: Area and Yield of Maize crops, 1999 – 2018
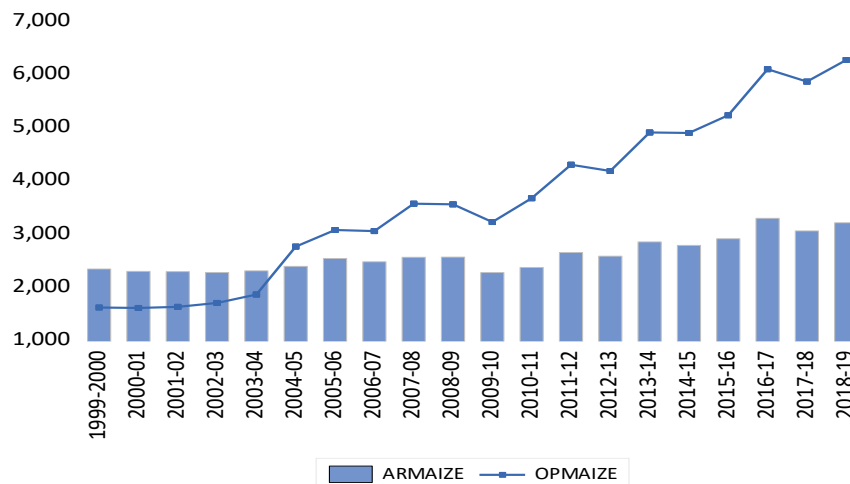
2.5. Water availability

The Indus River Basin in Pakistan is one of the major water resources laboratories in the world (Akhter, 2017; Gilmartin, 2015; Mustafa, 2013). It belongs to a type of complex river basin that has been thoroughly studied, with multiple scales of nested water management (Molle & Wester, 2009; Pulwarty, 2015). According to estimates, in the 2011-2012 fiscal year (1 July to 30 June), the water available for irrigation of canals is about 10% of the long-term average water consumption of 128 billion cubic meters (GOP, 2012). It has decreased. Groundwater level decreased at a rate of about 0.3 m per year due to more than 7 m of groundwater extraction and use (Hussain, 2002) (Kahlown et al., 2007; Rehman et al., 2016). Higher fuel prices have also resulted in higher costs for pumping groundwater, leading to lower net economic benefits. When manual evacuation or transplantation is required, lack of manpower also affects rice planting, hinders yield, and leads to seedling transplantation. The existing limited workforce consists primarily of unskilled contracted women and young people. In addition to uneven planting and lower economic density than agronomically optimal levels, quality assurance is also lacking (Baloch et al., 2005; Farooq et al., 2011).

Pakistan is expected to soon run out of water for irrigation, Farmers often use flooding systems for irrigation in clustered units, resulting in poor water unity, long-term irrigation, and excessive irrigation (Kahlown and Kemper, 2004; Rehman et al., 2016).

Water utilization efficiency is low due to the tendency to rely on still water to produce rice yields during the growing season. According to many studies in Pakistan, the amount of water used for each irrigation is 13-18 cm, which is much more than about 8 cm of water consumed during two irrigation events (Kahlown et al. al., 2001). In addition, farm irrigation efficiency is 23% to 70% (Kahlown et al., 1998; Kijne and Kuper, 1995). In addition, the use of pressurized irrigation methods has made it possible to grow rice and wheat in different countries. Sprinklers can be used to increase depth for irrigation of portable rainwater, spray guns, etc. Sprinklers are also used in the major climatic conditions of the Indian subcontinent, increasing farm irrigation efficiency by up to 80%. The Actual Surface Water Availability (Million Acre Feet) in Pakistan is shown in Figure 5, respectively.

Figure 5: Water availability (million acre feet)

WATER AVAILABILITY (MAF)
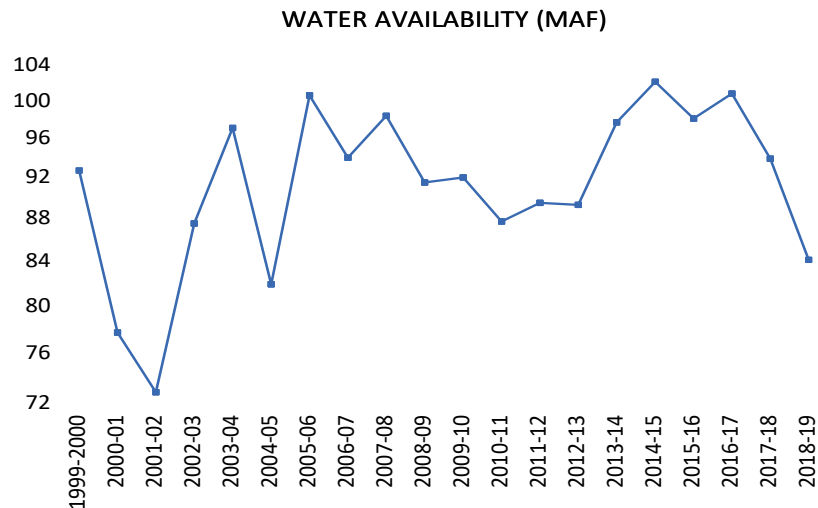
3. Materials and methods

This study is based on time-series data. From 1999 to 2018, annual time series data on Gross Domestic Product (GDP), Wheat Yield, Rice Yield, Sugar Cane Yield, Maize Yield, and Water Availability are available from National Foods. Security Studies, Pakistan Economic Survey, and Bureau of Statistics collected from Pakistan (various publications).

(a) Model Specification

The following models were used to investigate the relationship between agricultural GDP and wheat crop yield, rice yield, sugar cane yield, maize yield, and water availability.

$$Y = AX_1{}^{\beta 1} X_2{}^{\beta 2} X_3{}^{\beta 3} X_4{}^{\beta 4} X_5{}^{\beta 5} \tag{1}$$

Taking the natural logarithm of Eq. (1) and considering five explanatory variables,
Eq. (1) was converted to:

$$LnY = \beta 0 + \beta 1 LnX1 + \beta 2 LnX2 + \beta 3 LnX3 + \beta 4 LnX4 + \beta 5 LnX5 + \mu \tag{2}$$

Where.
$\beta 0 =$ Natural logarithm of A (intercept);
$ln\ Y =$ Natural logarithm of the agricultural GDP per year (in millions PKR);
$ln\ X1 =$ Natural logarithm of the output of wheat (in thousand tons);
$ln\ X2 =$ Natural logarithm of the output of rice (in thousand tons);
$ln\ X3 =$ Natural logarithm of the output of sugarcane (in thousand tons);
ln X4 = Natural logarithm of the output of maize (in thousand tons);
ln X5= Natural logarithm of water availability (in million acre-feet);
μ = error term.

As such, Eq. (2) can also be written as follows:

$$ln\ (AGRGDP) = \beta 0 + \beta 1\ ln\ (OPWHEAT) + \beta 2\ ln\ (OPRICE) + \beta 3\ ln\ (OPSUGARCANE) + \beta 4\ ln\ (OPMAIZE)\ + \beta 5\ ln\ (WR) + \mu \tag{3}$$

Current Study 1999 - 2018 is based on the entire period. To test for the stability of the study variable, we first used the Dickey and Fuller (1981) unit root test. After checking for stability, Long-term relationships between dependent and independent variables were tested using Johansen Coordination Test. Finally, the ordinary least square (OLS) was used to examine the impact of wheat, rice, sugarcane, maize production, and water availability on Pakistan's agricultural GDP.

4. Results and discussion

Results of unit root test

This study uses the enhanced Dickey-Fuller (ADF) unit root test to evaluate the stationarity of each variable. The estimated results of the ADF test shown in Table 1 show that the variables that reach a stationary state are not obtained in their horizontal form, and all variables remain unchanged after the first difference I (1) is taken, as shown by the value of ADF The statistical test is greater than the critical value when the significance level is 5%.

(a) **Unit root test**

Table 1: Results of ADF unit root test including (trend and intercept)				
Variables	**At level**		**First difference**	
	t-statistic	**Critical values:**	**t-statistic**	**Critical values:**
Ln(AGRGDP)	0.072243 (0.9544)	1% level-3.831511 5% level-3.029970 10% level-2.655194	-5.131470* (0.0008)	1% level-3.857386 5% level-3.040391 10% level -2.660551
Ln(OPWHEAT)	-0.965295 (0.7421)	1% level-3.857386 5% level-3.040391 10%level-2.660551-	-7.835223* (0.0000)	1% level-3.857386 5% level-3.0403*91 10% level-2.660551
Ln(OPRICE)	-1.531632 (0.4965)	1% level-3.831511 5% level-3.029970 10%level-2.655194	-5.336323* (0.0006)	1% level-3.886751 5% level-3.052169 10% level-2.666593
Ln(OPSUGARCANE)	-0.196685 (0.9219)	1% level-3.886751 5% level-3.052169 10% level -2.666593	-5.991360* (0.0002)	1% level-3.886751 5% level-3.052169 10% level-2.666593
Ln(OPMAIZE)	0.470267 (0.9799)	1% level-3.886751 5% level-3.052169 10% level-2.666593	-4.414849* (0.0035)	1% level-3.886751 5% level-3.052169 10% level-2.666593
Ln(WA)	-3.593551 (0.0163)	1% level-3.831511 5% level-3.029970 10% level-2.655194	-3.579467 (0.0183)	1% level-3.886751 5% level-3.052169 10% level-2.666593

Note: *, **, *** indicates 1%, 5%, 10% level of significance respectively
Source: Author's calculation using Eviews 11.

(b) **Result of co-integration test**

For co-integration examine the long-run relationship between the dependent variable (Agricultural GDP) and independent variables (OPWHEAT, OPRICE, OPSUGARCANE, OPMAIZE) throughout 1999-2018 based on Johansen, two tests are applied include trace statistics and maximum eigenvalue. The estimated results of Johansen Co-integration tests are presented in Tables 2 and 3. The values of Trace statistic (98.49233) and the values of Max-Eigen statistic (49.19455) which are higher than their critical values (60.06141) and (30.43961), shows that there exists a long-term relationship between agricultural GDP and output of major food crops (Wheat, Rice, Sugarcane and Maize). This means rejects the null hypothesis of no co-integration. In both tests, Trace statistic and Max-Eigen statistic expose that 2 co-integrating equations at the 5% level.

Following the ADF unit root test analysis, we analyzed the long-term relationship between agricultural GDP and output of wheat, rice, sugarcane, maize, and water availability using the Johansen cointegration test, including trace and Max– Eigen statistics. Tables 2 and 3 show the results of the cointegration analysis, values of trace statistics (102.9060), and Max–Eigen statistics (50.76533), which are above their critical values of (69.81889) and (33.87687), indicating a long-term relationship between the dependent and independent variables. This means rejecting the null hypothesis of no cointegration. Both trace and Max–Eigen statistics reveal one cointegrating equation at the 5% level.

Table 2: Johansen co-integration test using trace statistic

Hypothesized No. of CE(s)	Trace Statistic			
	Eigenvalue	Trace Statistic	5 Percent critical value	Prob.**
None *	0.940412	102.9060	69.81889	0.0000
At most 1 *	0.832620	52.14068	47.85613	0.0187
At most 2	0.562047	19.96590	29.79707	0.4252
At most 3	0.200665	5.104316	15.49471	0.7976
At most 4	0.057857	1.072773	3.841465	0.3003
At most 5	0.024741	0.450937	3.841465	0.5019

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
Source: Author's calculation using Eviews 11.

Table 3: Johansen co-integration test using Max-Eigen Statistic

Hypothesized No. of CE(s)	Maximum Eigenvalue Statistic			
	Eigenvalue	Max-Eigen Statistic	5 % Critical Value	Prob.**
None *	0.940412	50.76533	33.87687	0.0002
At most 1 *	0.832620	32.17478	27.58434	0.0119
At most 2	0.562047	14.86159	21.13162	0.2987
At most 3	0.200665	4.031542	14.26460	0.8560
At most 4	0.057857	1.072773	3.841465	0.3003
At most 5	0.024741	0.450937	3.841465	0.5019

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
Source: Author's own calculation using Eviews 11.

(c) Regression analysis

To examine the relationship between wheat production, rice, sugarcane, maize production, and water availability with Pakistan agricultural GDP, which the OLS conducted. The results of the regression analysis are presented in Table 4, which shows a high value of R2 of 0.977 or 97.7 percent and adjusted- R2 0.969 or 96.9 percent. This can explain 97.7% of the total difference in agricultural GDP by five independent variables. The calculated value of F-statistics is 122.2787, with a probability value of 0.00000000, which indicates the fitness of the overall model.

Table 4: Regression analysis

Dependent Variable: ARGDP
Method: Least Squares
Sample: 1999 – 2018
Included observations: 20

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.870447	2.304891	3.414672	0.0042
OUWHEAT	1.201538	1.130172	1.859485	0.0000
OPRICE	0.287360	0.233371	1.075731	0.3002
OPSUGARCANE	0.108771	2.616873	0.805836	0.4338
OPMAIZE	0.218412	1.385891	3.824470	0.0019
WA	-2.410954	2.861156	-0.226255	0.8243
R-squared	0.977614			
Adjusted R-squared	0.969619			
F-statistic	122.2787		Durbin-Watson stat	1.522630
Prob(F-statistic)	0.000000			

The results of regression analysis show that the production coefficient of wheat is very significant at the significance level of 1% and 5%, indicating that there is a strong positive correlation between agricultural GDP and wheat yield. These findings suggest that for every 1% increase in wheat production, agricultural GDP will increase by 1.20%. The results further show that the maize yield coefficient is also very significant at the significance level of 1% and 5%, indicating that there is a strong and positive relationship between maize yield and agricultural GDP. This finding shows that for every 1% increase in maize production, agricultural GDP will increase by 0.21%. According to (Ananwu et al. 2010), there is a positive correlation between maize output and agricultural GDP, while the output of rice and sugarcane is not statistically significant, with coefficients of 0.287360 and 0.108771, indicating a 1% increase in rice production. Will cause agricultural GDP to grow by

nearly 0.28% and 0.10%, while wheat production is statistically insignificant, with a coefficient of 1.201538, indicating that a 1% increase in wheat production will lead to a 1.20% increase in agricultural GDP. The agricultural sector is currently facing many challenges, such as a lack of irrigation. Underdeveloped infrastructure, poor sales of agricultural products, insufficient funding, and rising prices for basic agricultural products (Chandio et al., 2016). In addition, the results show that there is a negative correlation between water supply and agricultural GDP. In Pakistan, due to a lack of water resources, agricultural productivity is much lower than in developed countries.

5. Conclusion and recommendations

This research studied the link between Pakistan's gross domestic product and the output of major food crops, including wheat, rice, sugarcane as well as maize and water from 1999 to 2018. Investigated Time series data are obtained from various publications and Pakistan Economic Survey. For analyzing results, the ADF unit root test, the Johansen co-integration test and the ordinary least squares method. The findings of this co-integration indicate that Pakistan's major food crops are related to agricultural GDP over a long period of time. The results of regression analysis also demonstrate a positive correlation to Pakistan's agricultural GDP, wheat output, rice production, sugarcane and maize production, although water is adversely related to Pakistan's GDP and has negative relations. Agricultural GDP in Pakistan. This report therefore proposes and recommends that the government of Pakistan should consider new regulations and financing mechanisms for water resource growth and enhancement.

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