Review Article

Agricultural Productivity Current Scenario, Constraints and Future Prospects in Pakistan

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Abstract | This review paper intends to portray current scenario of agricultural productivity through yields and gaps of five major crops; wheat, cotton, rice, maize and sugarcane. The review discusses major constraints, identifies future prospects and makes policy recommendations for enhanced agricultural productivity in Pakistan. The review revealed that in Pakistan, on average current yield of wheat, cotton, rice, maize and sugarcane is 2.26, 1.87, 2.88, 1.77 and 48.06 tons per hectare, respectively against 6.80, 4.30, 5.20, 9.20 and 300 tons per hectare potential yield of wheat, cotton, rice, maize and sugarcane, respectively, obtained through research. This reflects a yield gap of 67, 57, 45, 81 and 84 % between average and potential yield of wheat, cotton, rice, maize and sugarcane, respectively. The review also informed that current Pakistan's average yield of wheat, cotton, rice, maize and sugarcane is 70, 53, 61, 82 and 60%, respectively lower than the average yields obtained internationally. Major constraints include agronomic, irrigation management, environmental, technological, institutional and socio-economic constraints. Future prospects include upscaling of modern technology, enhanced seed production, improved inputs availability and use, improved irrigation, improved agriculture-education-training-research- extension-nexus, reclamation of salinized lands, improved agricultural credit and support price policies. Recommendations include improving agricultural research and extension systems, accelerating diffusion and adoption of latest agriculture technologies and inputs, enhancing good quality seed production, improving irrigation water management and improving reclamation and drainage.

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Pakistan being located in South Asia is an arid to semi-arid country. The average annual rainfall is about 250 mm (Kahlown and Majeed, 2004). About 67 percent of rainfall occurs in the summer (July-September; monsoon). In Pakistan, approximately 22 million hectares are cultivated for agriculture out of total area of 80 million hectare (Ahmad, 2009).

About 17 and 5 Mha of the total cultivated area of 22 Mha are irrigated and rain-fed, respectively (Qureshi et al., 2010; Kahlown and Majeed, 2004). About 90% of the agricultural produce comes from irrigated land (Qureshi et al., 2010; Kahlown and Majeed, 2004). The Indus Basin Irrigation System provides surface water for irrigation of croplands. Groundwater also plays an important role in meeting about 50% irrigation requirements of irrigated land (Qureshi et al., 2010). Rain-fed agriculture contributes about 10% of the total agricultural production in the country (Kahlown and Majeed, 2004).

Agriculture is the backbone of Pakistan's economy

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and major contributor to food security. It contributes about 20.9% (agricultural GDP) to Pakistan's national GDP (GoP, 2015; MNFSR, 2015; Chandio et al., 2016) and accounts for about 60% of foreign exchange earnings. Agriculture provides food and livelihoods to approximately 68% population living in rural areas. Agriculture has four sub-sectors: **i)** crops sub-sector, **ii)** livestock sub-sector, **iii)** fisheries sub-sector, and **iv)** forestry sub-sector. Crops sub-sector contributes 8.27% to agricultural GDP. Livestock sub-sector contributes 11.77% to agricultural GDP. Fisheries sub-sector contributes 0.43% to agricultural GDP. Forestry sub-sector contributes 0.41% to agricultural GDP (GoP, 2015; MNFSR, 2015; Chandio et al., 2016).

Agriculture through improved productivity could play a crucial role in future economy development, food security, enhanced livelihoods and poverty alleviation. However, agriculture in Pakistan faces most pressing water, land, environmental, agronomic, institutional and socio-economic challenges, which have severe agricultural productivity implications. Comprehensive strategies and actions for improved management of water and non-water elements of agricultural productivity need to be developed and implemented for enhanced agricultural productivity in Pakistan.

The present paper focuses on only crops subsector of agriculture considering the major crops; wheat, cotton, rice, maize and sugarcane. These five major crops cover a large tract of cultivated land in Pakistan. In the paper agricultural productivity refers to major crops' yields per unit land. The present paper deliberates on agricultural cropping systems and measures of agricultural productivity, reviews current scenario of agricultural productivity, highlights current major constraints and identifies future prospects for enhanced agricultural productivity in Pakistan.

Agricultural Cropping Systems

In irrigated areas, major cropping systems include rice-wheat, cotton-wheat, wheat-maize, sugarcane-wheat and mixed cropping based on various combinations of wheat, rice, cotton and sugarcane (Table 1). In rainfed areas, major cropping system includes wheat, pulses and oilseeds.

The cropped area in Pakistan is about 22 Mha. This includes: wheat 9.18 Mha (41.73% of total cropped area); cotton 2.96 Mha (13.45%); rice 2.89 Mha (13.14%); maize 1.13 Mha (5.14%) and sugarcane 1.14 Mha (5.18%). These five major crops cover about 17.30 Mha representing 78.64% of the total cropped area. This reflects that a large tract of cultivated land is under five major crops. Other crops cover about 4.70 Mha, which is about 21.36% of total cropped area in Pakistan (GoP, 2015).

Table 1: *Major cropping systems*

Sr. #	Cropping system
1	Wheat-Maize (Khyber Pakhtunkhwa)
2	Rice-Wheat (Punjab)
3	Mixed-Wheat (Punjab)
4	Cotton-Wheat (Punjab)
5	Sugarcane-Wheat (Punjab)
6	Cotton-Wheat (Northern Sindh)
7	Cotton-Wheat (Southern Sindh)
8	Rice-Wheat(Northern Sindh)
9	Rice-Wheat (Southern Sindh)

Measure of Agricultural Productivity

Agricultural productivity here refers to "*output per unit of input*" as mentioned by Dharmasiri (2012). Two measures of productivity are frequently used: partial measure of productivity and total measure of productivity.

Partial Measures of Productivity

Partial measure of productivity is the output quantity per unit of a single input. Crop yield per unit of land is the generally used partial measure of agricultural productivity. Partial measure of productivity is in common because of easy availability of the required data. In Pakistan, generally partial measure of productivity is used to quantify the agricultural crop productivity, such as wheat production per hectare of land.

Total Measures of Productivity

Total measures of productivity considers all inputs to quantify the agricultural productivity. The economic models, namely; *growth accounting model, Cobb-Douglas econometric model and nonparametric model* are used for measuring agricultural productivity (Dharmasiri, 2012). Ali and Byerlee (2000) applied econometric cost function model to estimate changes in total measures productivity in wheat & rice, wheat & mixed, wheat & cotton, and wheat & mungbean crop production systems of Pakistan's Punjab. Nadeem et al. (2010) estimated total measures productivity of

Pakistan's Punjab agriculture for the period of 1970 to 2005, using the index number approach; Tornqvist Theil Approximation.

Partial measure of productivity also known as Single Factor Productivity (SFP) considers only a single input to the production process and does not consider other inputs used. So SFP can be misleading, as there is no clear indicator of why they change. For example, crop yields could increase simply because of farmers' increased addition of other inputs, such as fertilizers, pesticides, irrigation water, labor, or machinery, to their land base. In order to address this weakness of SFP, a total measure of productivity (called as Total Factor Productivity; TFP) was devised. TFP considers all of the inputs (land, labor, capital, livestock, chemical fertilizers and pesticides) used in production process.

Though compared to SFP, TFP measure is a more vigorous and preferred method to measure agricultural productivity but it requires intensive and extensive agricultural input and output data, which is usually not available easily. So under the situation where quantification of marginal contribution of each input to aggregate production is required and also detailed crop production input and output data is easily available, TFP is preferred. Under the conditions where objective is to quantify the contribution of only a single input to the production process and also less data is available, SFP is suggested.

Current Scenario of Agricultural Productivity

Agricultural productivity here refers to crop yield obtained from a unit land area, *i.e.* one hectare. Pakistan's current scenario of wheat, cotton, rice, maize and sugarcane productivity per unit land area is reviewed below.

Yield Levels and Yield Gaps

Iqbal and Ahmad (2005) discussed the following four yield levels as shown in Figure 1.

- *Average yield (T_0) is the first yield level which is achieved on the average farmer's fields.*
- *Best practice yield ($T1_1$) is the second yield level which is obtained employing the best available technologies. Generally progressive farmers achieve best practice yields by adopting latest technology.*
- *Research potential yield (T_2) is the third yield level which is achieved through applied research.*
- *Science potential yield (T_3) is the fourth yield level which is obtained employing innovative scientific inventions through applied research.*

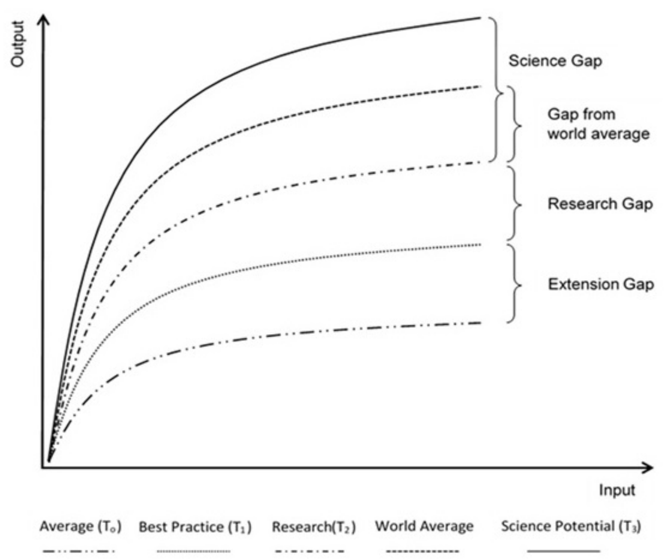

Figure 1: *Crop yield levels and gaps (Adopted & modified from Iqbal and Ahmad, 2005)*

Following three yield gaps linked with abovementioned four yield levels have also been discussed by Iqbal and Ahmad (2005) as shown in Figure 1.

- *Extension gap refers to the difference between best practice yields obtained by using best available technology and average yields (=T_1-T_0).* Agriculture extension services are expected to fill this gap.
- *Research gap refers to the difference between research potential yields and the best practice yields (=T_2-T_1).* Applied research proves helpful to fill this gap.
- *Science gap refers to the difference between science and the research potential yields (=T_3-T_2).* This gap could be filled employing modern scientific inventions through agricultural applied research.

Current Scenario of Pakistan's Various Yield Levels and Gaps

Average Crop Yields

Table 2 provides national average crop yields currently obtained from average farmer's fields in Pakistan (Kamal et al., 2012).

Table 2: *Average crop yields*

Crop	Yield (ton/ha)
Wheat	2.26
Cotton	1.87
Rice	2.88
Maize	1.77
Sugarcane	48.06

Best Practice Crop Yields

Best practice crop yields which are obtained using the best available technology are presented in Table 3 (Kamal et al., 2012). Progressive farmers get best practice yields by adopting modern technology.

Table 3: *Best practice crop yields*

Crop	Yield (ton/ha)
Wheat	4.50
Cotton	2.89
Rice	4.58
Maize	7.46
Sugarcane	106.70

Research Potential Crop Yields

Table 4 reveals research potential crop yields which could be obtained by adopting innovative agriculture and irrigation technologies through applied agriculture research (Iqbal and Ahmad, 2005).

Table 4: *Research potential crop yields*

Crop	Yield (tons/ha)
Wheat	6.80
Cotton	4.30
Rice	5.20
Maize	9.20
Sugarcane	300

Yield Gaps Scenario

Table 5 presents various yield levels and gaps for the major crops of Pakistan. There are huge yield gaps in Pakistan. Average yields are quite low compared to yields obtained by progressive farmers and through applied research. For considered crops; wheat, cotton, rice, maize and sugarcane, the extension and research gaps range from 35 to 76% and 12 to 64%, respectively (Iqbal and Ahmad, 2005) as shown in Table 5. Pakistan's average yields are 53 to 82% lower than the yields obtained internationally (Kamal et al., 2012). The big crop yield gap reflects the potential for increasing crop yield in future.

Table 5: *Various yield Levels (tons/ha) and gaps for major crops in Pakistan*

Crop	World highest average Yield*	Potential Yield	Progressive farm's yield	National average yield	Yield gap (%)		
					Extension	Research	From world avg.
Wheat	7.45 (France)	6.80	4.50	2.26	50	34	70
Cotton	3.98 (China)	4.30	2.89	1.87	35	33	53
Rice	7.37 (USA)	5.20	4.58	2.88	37	12	61
Maize	9.91 (France)	9.20	7.46	1.77	76	19	82
Sugarcane	119.84 (Egypt)	300	106.7	48.06	55	64	60

(Source: Kamal et al., 2012)

Major Constraints to Agricultural Productivity

Environmental Constraints

Land degradation causes huge reduction in land productivity. Soil salinity, waterlogging, soil nutrient deficiency and soil erosion hugely degrade the land's productive capability.

Soil salinity: Soil salinization severely devours the productive capability of land and causes considerably low crop yields. Currently in Pakistan, about 4.5 Mha area is salinized because of saline groundwater lying close to land surface and cropland irrigation with poor quality tube well water (Qureshi et al., 2008).

Secondary salinization is taking place due to use of poor quality groundwater for irrigation. About 70% of tube wells of the Indus Basin pump sodic or saline-sodic water because of which 2.3 Mha of land have become sodic/saline (Qureshi and Barrett-Lennard, 1998; Pakistan Council of Science and Technology, 2003). Estimates of losses due to salinization are 28,000 to 40,000 ha of land and about US$ 230 million of revenue per year because of low crop yield due to salinity/sodicity problems (Aslam and Prathapar, 2006; Haider et al., 1999).

Waterlogging: Waterlogging is another environmental problem which degrades land productive capability. Currently, about 5 Mha (30%) of irrigated area (17 Mha) is potentially waterlogged with water table within 3 m depth from ground surface and 2 Mha (12%) area having water table depth of 1.5 m is seriously waterlogged (Iqbal and Ahmad, 2005; Aslam et al., 2008). Kahlown and Azam (2002) reported that rise in the water table from 1–2 m to less than 1 m resulted in 27 and 33% yield loss for wheat and sugarcane, respectively. For cotton, a rising water table from 2–3m to less than 1 m caused 60% yield loss.

Table 6: *Province-wise distribution of salt-affected area*

	P	S	KP	B	Pak
Cultivated area (Mha)	12.27	5.65	2.11	1.84	21.87
Salt-affected area (Mha)	1.234	3.04	0.11	0.12	4.5

P: *Punjab;* **S:** *Sindh;* **KP:** *Khyber Pakhtunkhwa;* **B:** *Baluchistan;* **Pak:** *Pakistan*

Soil fertility depletion: In Pakistan, low fertilizer use efficiency causes low soil fertility which results in low land productivity. Every crop harvest results in depletion of more nutrients from soils compared to addition of nutrients to soils due to imbalanced use of fertilizers (Hamid and Ahmad, 2001).

Soil Erosion: In rain-fed and mountainous areas soil erosion results in huge soil nutrients depletion causing low soil fertility which results in low agricultural productivity (Iqbal and Ahmed, 2005; Ali, 2010).

Climate impacts: Unfavourable climatic conditions such as heavy rains, floods and droughts adversely affects agricultural productivity. About 20% reduction in crop productivity occurs due to adverse climatic situations in Pakistan (Sattar, 2012).

Irrigation Water Management Constraints

Inequitable canal water distribution: The water distribution irregularities within a watercourse along with variability of outlet discharge results in low irrigation application efficiencies which cause significant reduction in crop yields. Adequate and reliable water supplies with equitable water distribution are vital for improved agricultural productivity. Research has shown that unreliable and inadequate canal water supplies along with inequitable water distribution cause low crop yields (Hussain et al., 2003).

Improper conjunctive use of canal and groundwater: About 8.4 MAF of public tube wells water and 37 MAF of private tube wells water are being used for irrigation by Pakistani farmers (Aslam and Prathapar, 2006). Direct use of saline-sodic tube well water cannot be made for crop productivity without having a proper soil, water and crop management system in place (Rashid et al., 1997; Ghafoor et al., 1998). Majority of the farmers do not follow proper conjunctive use patterns and also use poor quality groundwater for irrigation without considering a proper soil, water and crop management. This results in secondary salinization which causes low land productivity.

Low water use efficiency: Watto and Mugera (2016) reported that in Pakistan, water use efficiency of wheat is 0.76 kg/m^3 which is 24% lower than the world average of 1.0 kg/m^3 and water use efficiency of rice is 0.45 kg/m^3 which is 55% less than the Asian average of 1.0 kg/m^3. Water use efficiency for cereal crops is 0.13 kg/m^3 which is very low compared to India's 0.39 kg/m^3 of India and 0.82 kg/m^3 of China. It reflects that in Pakistan, potential water productivity is not realized, and this is largely due to poor irrigation management and low irrigation water quality (Hussain et al., 2003).

Agronomic Constraints

Traditional methods of cultivation: Small poor farmers use traditional methods of cultivation (Ali, 2010). This results in low crop yield, despite investing more on inputs and increased application of fertilizers (Khan, 2012; Sattar, 2012). Lack of awareness about modern farming practices and technologies, poverty and high prices of modern technologies are the main reasons for using traditional methods of cultivation (Jehangir et al., 2007).

Inadequate availability of improved quality seed: In Pakistan, inadequate supply of improved quality seed (high yielding variety seed) is also a big constraint for enhanced agricultural productivity. As shown in Table 7, during 2012-13, only 24, 24, 81 and 39% of wheat, cotton, rice and maize seed requirement, respectively was made available to farmers (Planning Commission, 2012). Clearly, there is a huge gap between requirement and supply of good quality crop seed which results in low crop productivity.

Table 7: *Improved seed requirement and distribution ('000' Tons) in 2012-13*

Crop	Requirement	Distribution
Wheat	1,085.4	260.0
Cotton	40.0	9.74
Rice	42.5	34.5
Maize	31.9	12.5

Improper use of fertilizers: Poor economic condition of farmers and high prices of fertilizers cause the imbalanced use of fertilizers (Planning Commission, 2012; Iqbal and Ahmad, 2005). Intensive cultivation and imbalanced use of fertilizers are depleting essential plant nutrients which consequently results in low land productivity (Hussain et al, 2003).

Plant diseases: Pests and plant diseases also cause low crop yields (Khan, 2012). Rice, wheat, cotton and sugarcane are often attacked by pests and insects and lack of proper use (doze and timing) of good quality pesticides results in low crop yields (Planning Commission, 2012).

Technological Constraints

Application of traditional agricultural technology: The term technology means *application of knowledge and tools accurately for achieving the desired goals and economic objectives* (Masood et al., 2012). Here desired goal refers to the achievement of enhanced agricultural productivity, which requires application of innovative and modern agricultural technology. In Pakistan, majority of the farmers use old traditional agricultural technology which results in low land productivity (Sattar, 2012).

Lack of awareness and poverty of farmers: Famers are unaware of the modern agriculture technology that can increase land productivity. Poverty also hinders the access of farmers to modern technology (Ayalneh and Hagedorn, 2002; Phillip et al., 2009; Sattar, 2012). Small land holdings are also a big impediment for adoption of modern technology (Sattar, 2012).

Lack of upscaling of modern agriculture technologies: Though some modern agriculture technologies like laser land leveling (LLL), zero tillage, bed-furrow, high efficiency irrigation technologies (sprinkler & drip), precision surface irrigation, etc. have shown considerable increase in land productivity (for example LLL results in 20% increase in crop yield (Gill and Awan, 2009) and zero tillage causes 12-15% increase in crop yield (Gill et al., 2002; Ahmad, 2009), but still these technologies could not be up-scaled. The lack of financial resources & high costs, lack of access & timely availability, lack of machinery, small landholdings, lack of familiarity, lack of adequate advice and preference for traditional practices are the major constraints to accelerate the adoption of new technologies especially among small farmers. Farmers also do not have comprehensive knowledge and training on selection and use of modern agriculture technologies (Jehangir et al., 2007).

Socio-economic Constraints

Fragmented/small land holdings: As a result of population increase and land division, land holdings are becoming very small. About 81% of Pakistani farmers own less than 5 hectares of land (FAO, 2000). About 58% of the total farms in Pakistan are 2 hectares or less in size (Iqbal and Ahmad, 2005). The small land holdings cause inefficient and uneconomical use of land resulting in low crop yields. Small land holdings are also a big impediment for adoption of modern agriculture technology (Sattar, 2012).

Large Land Holdings: In Pakistan, a large area of land is owned by big landlords (feudal-lords) having more than 10 ha land and the farmers who work on their lands, are just tenants. The tenants have no or less incentive for their hard work and also have no interest in capital investment (World Bank, 2006). It has been reported that large landholdings barely result in high agricultural productivity rather they are very unproductive (Haider, 2013).

Lack of access to improved quality inputs and services: In Pakistan, small farmers having 2 ha of land generally do not get credit facilities (Iqbal and Ahmed, 2005; Phillip et al., 2009) thereby they do not have access to improved quality inputs like seeds, pesticides, fertilizers *etc.* (Sattar, 2012; Planning commission, 2012). They also do not have access to extension services (Iqbal and Ahmed, 2005). All this results in low crop productivity.

Illiteracy and poverty: Illiteracy and poverty of the farmers also lead to low agricultural productivity (Phillip et al., 2009; Masood et al., 2012). In Pakistan, farmers are mostly poor and un-educated about high productivity farming. They are untrained and inefficient to enhance agricultural productivity (Khan, 2012).

Institutional Constraints

Inadequate institutional seed production capacity: In Pakistan, the public sector seed production institutes have inadequate seed production capacity due to financial, human resource and infrastructural problems. Though public and private institutes are busy in producing seed, but their current seed production meets only 40% of yearly seed requirement (Iqbal and Ahmad, 2005; Planning Commission, 2012).

Inadequate agricultural research and extension: There has been very modest pace in technological change in yields per hectare during past two decades compared to 1960s and 1970s resulting in low agricultural productivity. Though a large number of federal and provincial agriculture research institutes conduct research, but their output did not help develop new varieties, improving water utilization practices (Husain, 2012). Research projects are not need, demand and economic benefit based. In order to raise agricultural productivity, agricultural research needs to be improved continuously (Khan, 2012). Lack of coordination between research and extension organizations is also a major constraint to increasing agricultural productivity. Consequently, improved quality inputs, new agriculture and irrigation technologies, practices and strategies do not reach farmers and they just continue to apply inefficient old traditional technologies which result in low crop yield.

Ineffective agricultural education and training: Lack of education and training of farmers also causes low agricultural productivity (Masood et al., 2012). Presently, farming community in many areas of Pakistan due to inactive and ineffective agriculture extension services, does not get any guidance and messages on modern and improved agriculture, irrigation and waterlogging and salinity management practices and technologies to enhance agricultural productivity. Farmers do not get any kind of training and education on modern and innovative techniques (Laser land levelling, zero tillage, bed planting, sprinkler and trickle irrigation methods, leaching) and strategies to manage their water, soils and crops properly for enhanced land productivity. The progressive farmers could not prove helpful to effectively transfer their experiences to the nearby farmers (Husain, 2012).

Inadequate credit facilities: Inadequate loan, high interest rate and untimely availability impact adversely crop productivity in Pakistan (Ministry of Finance, 2009). The informal loans are also not dependable due to their non-availability on time (Bashir et al., 2010). Generally poor farmers do not get credit to buy good quality agricultural inputs and consequently, they get low crop yields. Lack of access to credit and its improper use result in low agricultural productivity (Planning Commission, 2012).

Future Prospects for Increasing Agricultural Productivity

Upscaling of Modern Technology

Agriculture productivity can be increased by the use of modern technology and improvement in the existing technology (Rehman et al., 2012). The evaluation of laser land technology revealed 20% increase in crop yield (Gill and Awan, 2009). The zero tillage technology results in 12-15% increase in crop yield (Gill et al., 2002; Ahmad, 2009). The impact evaluation of bed and furrow irrigation technology also revealed better crop yield and water use efficiency compared to traditional method (Gill et al., 2002; Ahmad, 2009). In Pakistan, pace of adoption of these technologies by farmers is very slow. In order to enhance land productivity these technologies need to be up-scaled. In order to accelerate rate of adoption of modern technology, practical policy measures of enhanced supply of equipment and field demonstration of their use would be needed. Arrangements need to be made for financial support and easy access of the farmers to these technologies. Private sector should be encouraged and given technical and financial support to manufacture modern agricultural and irrigation technologies locally for upscaling of adoption of these technologies.

Modern Agricultural Biotechnology

Modern agricultural biotechnology could play a key role in increasing crop productivity by developing higher yielding, resilient to plant pests and diseases and environmental stresses crop varieties. Thus, modernization of agricultural biotechnology is vital for future improvement in agricultural productivity (Zafar and Malik, 2003; Iqbal and Ahmad, 2005).

Drainage and Reclamation

Water logging and salinity devour productive capability of lands (Aslam and Prathapar, 2006). Soil salinization is causing 25% reduction in the production potential of major crops in Pakistan (Qureshi, 2011). Research revealed that rise in the water table from 1–2 m to less than 1 m resulted in 27 and 33% yield loss for wheat and sugarcane, respectively. A rising water table from 2–3 m to less than 1 m resulted in 60% yield loss of cotton. Rice yield loss was 7% at 1–2 m water table depth. Soil salinity (more than 4 dS/m) reduced the wheat, cotton, rice and sugarcane yields considerably (Kahlown and Azam, 2002).

WAPDA have completed 61 salinity control and reclamation projects (SCARPs) in 7.35 Mha irrigated area of the Indus Basin during 1960 to 2001. The SCARP tube wells lowered groundwater level below 1.5 m in 2 Mha area and below 3 m in 4 Mha area. Salt-affected area was reduced from 7 to 4.5 Mha (Qureshi et al, 2008). Though SCARPs have controlled water logging and salinity considerably, but these problems are still there. Government of Pakistan should continue to strengthen drainage and reclamation efforts by providing adequate drainage infrastructure and bio-chemical amendments.

Land Reforms

As both the small and large land holdings are inefficient and unproductive, there is a dire need to determine the optimal farm size through research and to implement the land reforms intervention to have majority of farms of optimal size (Iqbal and Ahmad, 2005). Land reforms will cause incentive for cultivators/tenants to invest in land and adopt new technologies thereby increased land productivity. Thus, effective land reforms are vital to increase land productivity. Political will, sincere and serious government's commitment and proper laws are essential for successful implementation of land reforms (Haider, 2013).

Improved Agricultural Credit Facilities

Improved availability of agricultural credit to farmers enhances agricultural productivity (Bashir et al., 2010; Saleem and Jan, 2011; Rehman et al., 2014). Financial resources are needed to use improved variety seeds, fertilizers, pesticides, insecticides, and modern agricultural and irrigation technologies. Small farmers generally lack in adequate financial resources. Increasing the volume and outreach of formal banking network for timely and easy access to credit by farming community is vital for accelerating the adoption of latest agro-irrigation technologies and better agricultural inputs (Shah et al., 2008; Raja, 2013). Revolving credits which make disbursement and repayment convenient for farmers should be promoted by the banks of Pakistan (Husain, 2012).

Effective Communication

The information and communication technologies like internet, mobile phones, radio and television are the most important and effective communication tools to provide agriculture information and knowledge to farmers (Chhachhar et al., 2014). The use of these technologies in different countries like Iran and Nigeria impacted positively on agricultural productivity (Ani and Baba, 2009; Nazari and Hassan, 2011; Age et al., 2012). To make radio and television more effective in dissemination of agriculture information to farmers: **i)** agricultural programs presenters must be competent and knowledgeable in agriculture, **ii)** agricultural programs should be broadcasted in local languages, and **iii)** the airing times of these programs must be suitable from farmers' point of view (Ariyo et al., 2013).

In Pakistan, proper & effective dissemination of latest information and assistance on modern technology and improved soil, crop and water management practices to farmers through improved TV, radio and print media agriculture programs broadcasted in regional or local languages at proper times could also play a key role in enhancing agricultural productivity. Currently, there is a big communication gap between agriculture and irrigation professionals and farmers (Ali, 2010). This gap must be bridged through ensured availability of agriculture and irrigation professionals in the rural areas.

Enhanced Good Quality Seed Production

Good quality crop seeds are vital for enhancing agricultural productivity (SAHEL, 2014). In Pakistan, currently seed production meets only 40% of yearly seed requirement (Iqbal and Ahmad, 2005; Planning Commission, 2012). Agricultural research systems and private sector are the main sources of seeds. The private sector can play a vital role to meet the demand of improved quality seeds. To enhance production of good quality seeds: **i)** private sector should be provided with appropriate legal cover, technical and financial support, **ii)** a strong partnership should be developed between agricultural biotechnology research institutes and private sector seed producing firms and **iii)** farmers should be encouraged to adopt good practices to enhance effectiveness of crop seeds produced by them (Iqbal and Ahmad, 2005).

Improved Availability and Use of Inputs

The backbone of any agricultural revolution is access of farmers to modern agricultural inputs. These agricultural inputs range from improved seeds, fertilizers and crop protection chemicals to machinery, irrigation and knowledge (SAHEL, 2014). Research in Nigeria revealed that, adoption of improved agricultural inputs and technology to rice farming resulted in 358.89 kg/ha (9%) more yield compared to that obtained by the farmers who neither adopted improved inputs nor technology (Awotide et al., 2012).

In Pakistan, crop productivity can be enhanced significantly by improving availability of good quality agriculture inputs like seed, fertilizers, pesticides, herbicides, water and their efficient, judicious and balanced use. Improvement in farmers' access (timely & doorstep availability at reasonable price & subsidy) to these inputs and services through improved agriculture credit would improve land productivity tremendously (Dorward et al., 2014).

Support Price Policies

In the past, government support price policies resulted in higher crop yields (Khan et al., 2003; Ullah et al., 2012). Research has revealed that farmers are very responsive to support prices (Mushtaq and Dawson, 2003; Niamatullah et al., 2010). Also, the increases in prices do induce higher land productivity through use of improved and new agriculture inputs. So, for enhanced agricultural productivity, a proper price policy of government is vital. Thus, keeping the prices aligned with international prices provides the right incentives to the farmers to increase their land productivity (Husain, 2012).

Farmers' Education and Training

Farmers' education and training results in improved agricultural productivity (Okpachu et al., 2014). Education opens the mind of farmers to knowledge, provides hands-on training and better methods of farming and keeps the farmer well informed about innovations and allows farmers to share their experiences (Eric et al., 2014; Okpachu et al., 2014). Investment in education, its planning, expansion, location and delivery need to be integrated in rural areas with its thrust for raising agricultural productivity (Das and Sahoo, 2012).

As education of farmers can lead towards considerable increases in agricultural productivity, there is a dire need to expand educational and training facilities in rural areas of Pakistan to provide education and training to farmers regarding productive agriculture (Husain, 2012). Farmers' days, field visits and awareness campaigns should also be launched to educate and train the farmers about seeds of high-yielding varieties, modern cultivation and irrigation technologies and efficient and judicious inputs use.

Improved Irrigation Water Management

Water shortage is becoming a major constraint for agricultural productivity. GoP (2005) reported that Pakistan has moved from reasonable per capita water availability (>1700 m^3/capita) to the current situation of becoming a water stress country (< 1700 m^3/capita) and fast heading towards water scarce country (< 1000 m^3/capita). Growing shortfall in water availability compared to demand will continuously increase in future. According to estimates, water shortage would increase from 28 MAF in 2015 to 41 MAF in 2025 (GoP, 2010). The major causes of an increasing water scarcity are cited as reduced storage capacity of existing dams due to silting, slow development of new dams and an inefficient irrigation systems. This situation needs the urgent attention of the planners and decision makers regarding immediate water storage development, conservation and efficient utilization of water.

In Pakistan, estimated overall average irrigation efficiency ranges from 38.7 to 42.6%, which is quite low and is largely due to poor operation and maintenance of the irrigation infrastructure (Punjab Irrigation Department, 2009). Based on completely lined canal systems, watercourses and high efficiency irrigation system (sprinkler & drip) at farm could result in an overall irrigation efficiency of about 81.2% (Ahmad, 2009).

In Pakistan, distribution of surface water along the main canals (between distributaries) and along the distributaries (between the outlets) is substantially inequitable (Vander Velde, 1990; Kuper and Kijne, 1992; Bandaragoda and Rehman, 1994; Arif et al., 2014). Inequitable water distribution contributes to declining agricultural productivity. Innovative measures are needed to improve operation of irrigation canals thereby improved water distribution required for enhancing agricultural productivity.

In Pakistan water use efficiency (WUE) is not realized (Watto and Mugera, 2016). Low WUE is mainly due to poor irrigation management (lack of adequate and timely availability of irrigation water, inefficient irrigation practices and technologies, lack of adoption of irrigation scheduling, improper conjunctive use of surface and groundwater for irrigation) and low irrigation water quality (Hussain et al., 2003). WUE could be increased through innovative improvements in agronomic and water management practices which would require shifts in agricultural practices, policies and effective institutions.

Effective Research and Extension Services

Various studies have evidenced a positive impact of research and extension on agricultural productivity (Ahmad et al., 2007; Hasan and Imai, 2013). So, investment in research, extension and education and support services for new agricultural technologies is vital to increase agricultural productivity. Bravo-Ureta (2002) and Nadeem et al. (2013) reported that in order to realize full potential of agricultural productivity: **i)** public sector should design and implement a research program to develop technologies for farmers, and **ii)** also public sector should involve private sector in the research program.

In Pakistan, in order to make research more effective, a comprehensive research and development policy, well developed human resource and essential institutional and physical setup are vital (Iqbal and Ahmad, 2005). Efforts should also be made to make extension services more effective for dissemination of information, knowledge guidance and training of farmers required for rapid adoption of modern technologies and practices by farmers.

Improved Agriculture-Education-Training-Research-Extension-Nexus

The strong linkages in the agricultural research-extension-education nexus are vital to realize improved and sustainable agricultural productivity (Tenywa et al., 2008). A model was proposed to integrate information and communication technologies in agricultural education, research and outreach for improving coordination across the agricultural nexus, bridging the information gap, sharing information and generating knowledge (Tenywa et al., 2008).

Currently, Pakistan lacks in an improved nexus between agriculture, education and training, research and extension. A strong private-public partnership (PPP) is vital for fostering this nexus and delivering a set of inputs, services and guidance. Internationally PPP has performed well thereby contributed to enhanced agricultural productivity (Husain, 2012). Thus, an effective and improved nexus between agriculture, education and training, research and extension could contribute significantly to increase agricultural productivity in Pakistan.

Conclusions and Policy Implications

In Pakistan, crops sub-sector of agriculture is not performing well because the national average yields of major crops (wheat, cotton, rice, maize and sugarcane) are far below their research potential yields. This reflects that potential agricultural productivity is not being realized, and this is largely due to agronomic, irrigation, environmental, technological, institutional and socio-economic constraints. The gap between current average and potential crop yields offers a huge opportunity to enhance agricultural productivity in future. The goal of enhanced agricultural productivity could be achieved by making huge investments to improve agricultural research and extensions systems, accelerate diffusion and adoption of latest agricultural and irrigation technologies and improved inputs use, irrigation water management, and reclamation and drainage.

Following policy implications are suggested for implementation to enhance agricultural productivity in Pakistan.

Improving Agricultural Research and Extension Systems

The Government of Pakistan should invest considerable financial resources for improving agricultural research and extension systems. The required actions would include: strengthening of national research systems by: developing human resources through higher education, improving physical (labs with latest equipment and digital libraries, *etc*.) infrastructure, improving institutional structure, improving inter and intra institutional coordination among education, research and extension institutions; establishing an effective collaboration with reputable foreign universities and research institutes, enhancing public-private partnerships, and developing capacity of extension professionals of the provincial agricultural departments.

Accelerating Diffusion and Adoption of Latest Agriculture Technologies and Inputs

For this purpose, Government of Pakistan needs to make arrangements for: **i)** dissemination of information and knowledge on latest technologies and improved inputs to farmers through Agricultural Extension Directorates of the provincial Agriculture Departments, **ii)** easily available agricultural credit to farmers so that they may buy and adopt latest technologies. Pakistan's banks should promote revolving credits which make disbursement and repayment easy for farmers, and **iii)** provision of subsidies on latest technologies.

Enhancing Good Quality Seed Production

The Government of Pakistan should encourage private sector seed producing firms by providing a legal cover and technical and financial support for seed production and also help develop a strong partnership between agricultural biotechnology research organizations and private sector seed producing firms.

Improving Irrigation Water Management

Improved availability, reliability and equity of irrigation water and enhanced water use efficiency are vital for enhancing agricultural productivity in Pakistan. Currently, the scenario of water shortage, inefficient irrigation systems and low water use efficiency does not match water supply with water demands for enhancing agricultural productivity. This situation demands an urgent and immediate water storage development, conservation and efficient utilization of water. So Federal and Provincial Governments must consider and invest in development of small, medium and large dams through WAPDA and Provincial Irrigation Departments. Provincial Governments through Provincial Irrigation Departments must invest in rehabilitation and improvement of operation & maintenance of irrigation canal systems. Provincial Governments through Provincial Agriculture Departments (OFWM & Agri. Extension) must continue to upscale resource conservation technologies (watercourse improvement, bed-furrow irrigation, laser land levelling, zero tillage and high efficiency irrigation technologies (sprinkler & drip) to improve water use efficiency.

Improving Reclamation and Drainage

Waterlogged and salinized lands offer great potential for agricultural production if they are reclaimed by providing drainage infrastructure and using chemical and biological amendments. These lands need urgent attention for drainage and reclamation on priority basis for productive and sustained agricultural productivity. Though SCARPs launched by WAPDA have played an important role in controlling the water logging and salinity to a great extent, but these problems are not yet solved completely and effectively. The Government of Pakistan must continue to improve performance of on-going drainage and reclamation projects by strengthening the institutional, technical and financial capacity in the drainage sector. New drainage and reclamation projects should also be launched in critical areas.

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