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Agricultural Input Use Efficiency in Pakistan: Key Issues and Reform Areas

Naila Afzal[1] *and Dr. Shahid Ahmad*[2]

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[1] *Research Internee, Natural Resources Division, Pakistan Agricultural Research Council, Islamabad.*
[2] *Member Incharge Natural Resources Division, Pakistan Agricultural Research Council, Islamabad*

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Motivation
Agriculture sector in Pakistan provides employment opportunities to more than 60 percent of the country's population. It also provides food to around 162 million people and supports earning of foreign exchange. The profitability of irrigated agriculture is now declining as the input prices are growing at a rapid rate. The good examples are energy and fertilizers, where rise in electric tariff, diesel prices and prices of phosphatic fertilizers is going to have negative impacts on the profitability of irrigated agriculture. Thus, in the present scenario of food security and export of commodities not only output but also input analysis is necessary. This paper is the first approximation of conducting the input-output analysis where unit gross value production was estimated to indirectly analyze the input use efficiency at current factor price. This analysis is based on the past trends of inputs availability and their relationship with the Gross Value Production. In future, more systematic analysis can be made where primary data can be collected on canal command basis using diagnostic studies.

1. Growth of Agricultural Sector in Pakistan

Pakistan's agriculture sector contributes to the economic growth through a variety of channels among which self-reliance in food, provision of raw materials to industry; earning of foreign exchange through agricultural commodities and products; and providing employment to a large portion of population are worth mentioning. Firstly, the sector is very volatile to international conditions in most of the developing countries as well as in Pakistan**.** Highly inelastic demand for agricultural products, product and market concentration along with other tribulations have confined the agriculture sector to play its potential role in the economic development. Secondly, the increase in liberalization and trade in crops further constrain the self-reliance of country's food industry. Cereal crops i.e. wheat, maize and rice are the main source of food reliance and also the major foundation for earning the foreign exchange. The temporal variability in the growth rate of food crops[3] is extremely high i.e. it varies from -9% to15% per annum (**Figure 1**). Increase in the demand of bio-fuel at the world level accelerates the requirement of cereal crops and results in higher prices.

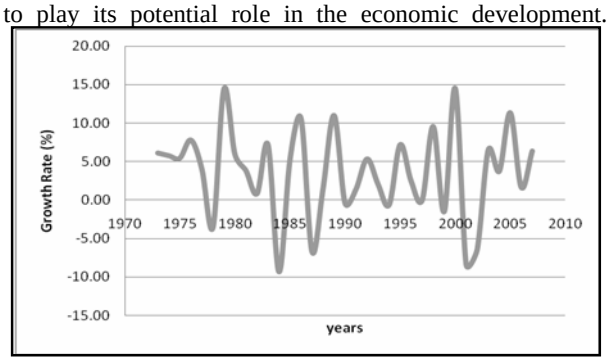

Figure 1. Annual growth rate of food crops

The yield of most crops is almost half of the yield of the developed countries (APO 2002). The main problems faced by the sector are: a) scarcity of freshwater; b) extreme events of droughts and floods; c) salinity and waterlogging; d) use of poor quality groundwater; e) higher prices of inputs; f) low water productivity; and g) ineffective support services and institutions.

The most fundamental constraint in Pakistan is water availability which limits further expansion of irrigated agriculture and creates variations in agricultural growth. The problems associated with productivity of crops include poor quality seeds, in-appropriate production technology, crop varieties with low yield potential, shortage of irrigation water and inadequate credit facilities (Chaudhry and Kayani 1991). With the passage of time energy also gets importance in agriculture. New varieties need to bring an improvement by strengthening the research programmers for the best utilization of the scarce resources.

[3] *Wheat, rice, maize, sorghum, millets and barley are categorized as food crops.*

Agriculture sector is divided into five sub-sectors which are: major crops, minor crops, livestock, fisheries and forestry. At the time of independence, Pakistan was an agricultural economy and 99 % of exports were based on agricultural commodities. Manufacturing sector had very small base. In 1947-1958 the annual growth of agriculture was nearly 1.43 % which was less than half of the population growth rate. The agriculture growth rate during 60s was very higher (5.1%) than population growth rate. During 70s the agriculture growth rate was dropped to 2.4 %. It was increased during 80s to the level of 5.4% and then there is a continuous decline till 2007 (**Table 1**).

Table 1. Agriculture growth rate – temporal trends

Decade/Year	Agriculture Growth Rate (%)
1960s	5.1
1970s	2.4
1980s	5.4
1990s	4.4
2000-07	3.7

Source: GoP. 2007b. State Bank of Pakistan.

One of the major reasons for low growth during 90s and later there were droughts and floods in the country which affected the production of major crops. During 2000-07, the agriculture growth rate was 3.7 % (**Table 1**). The major agricultural policies implemented during this era were removal of import barriers on agriculture goods and reduction of interest rate on agriculture credits from 14% to 9% by the Zarai Tarraqiati Bank (GoP 2007b). It can also be noticed that average growth rate of wheat and rice were very low during 2000-06 (2.39% and 1.51 %, respectively) compared to 60s (4.05% and 5.42%, respectively; **Table 2**). However, the yield per ha of food crops is continuously increasing (**Figure 2**) due to increased availability of improved seed, higher use of chemical fertilizers, improved water management and farm mechanization.

Table 2. Average annual growth rate of yield of cereal crops

	Growth Rates (%)		
Decade/Year	Wheat	Rice	Maize
1960s	4.05	5.42	-2.31
1970s	3.55	2.58	2.01
1980s	2.81	-0.19	1.27
1990s	1.65	2.35	2.27
2000-06	2.39	1.51	8.87

Source: GoP. 2007c. Economic Survey of Pakistan

Pakistan's agriculture sector performance is marked by a mixed trend. There have been some years of drab growth and some years of splendid growth. Agriculture's share of total GDP declined from about 31 % to 24 % over the period (Alam and Naqvi 2003). Crop production contributed the largest share of agricultural GDP (62 % in 1996) with livestock contributing 34 % fisheries and forestry contributed 4 %, and that changed to 48% share of crops, 50% share of livestock and 1% share of fisheries and forestry, respectively, during 2006. Yield per ha of rice also has fluctuating trends but on the other hand yield per ha of maize was on the increasing trend. Wheat has decreasing trend till 1990s but after that it increased **(Table 2**). Overall yield per ha has increasing trend and in 2006-07 it is around 2.5 (**Figure 2**).

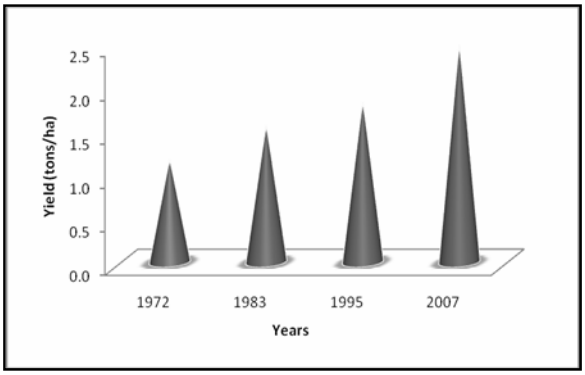

Figure 2. Yield of food crops

2. Inputs Availability

2.1. Availability of Improved Seed of Cereal Crops

Improved seed is a key input in raising agricultural productivity. The improved seeds are not only high yielding but also resistant to droughts, salinity, pests and diseases (LUMS 2004). In Pakistan, both the public- and private sectors are involved in the production, multiplication and distribution of improved seed. Initially the public-sector was dominating in the market but in the last decade the private sector has increased its role. Due to the aggressive marketing strategy adopted by the private sector, the availability of improved seeds for the cereals has shown a tremendous increase in the last decade. Currently, 20% area of rice, wheat and maize crops is under improved seed (**Figure 3).** At the same time, the public-sector also provides regulatory framework for production, registration, certification and distribution of seed.

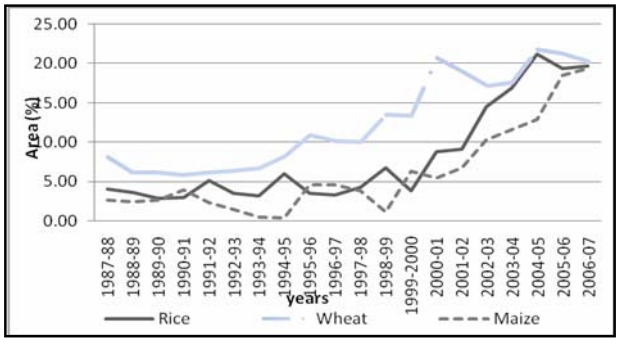

Figure 3. Coverage of improved seed

The distribution of improved seed is still a problem. The seed processing facility is largely concentrated in the province of Punjab. The public-sector provides the seed of major crops like cotton, wheat, grams, oilseeds, etc. at subsidized rates. As public-sector does not provide all the demand for improved seed therefore farmers are fulfilling their rest of the requirement from the private sector. In addition, public-sector is providing seed of few major crops, whereas private sector is providing seeds of all the crops especially the hybrid seeds.

The public-sector Seed Corporations were established in Punjab and Sindh provinces. The seed availability upto 1999-00 was almost stagnant or increasing at a lower growth rate for the cereals. After 1999-00, there was a significant growth in the production of improved seed largely due to the involvement of the private sector (**Figure 3**). The Sindh Corporation closed its operations for many years and in the last year it was revived. Thus, the Punjab Seed Corporation is largely contributing into the distribution of improved seed since the last many years**.** In 2006-07, 20% area under wheat production has the coverage of improved seed, but the overall trend for improved seed availability for wheat remains higher than maize and rice. There is a large demand for improved seed. Efforts are needed to have at least 30-40% coverage of improved seed (synthetic varieties). But 100% coverage is required for hybrid seeds.

Demand for improved seed is met jointly from the local production and import, which is regulated under the Seed Act of 1976. The seed certification and registration is the responsibility of MINFA (Ministry of Food and Agriculture) through its Seed Certification and Registration Directorate, whereas Pakistan Agricultural Research Council is responsible for research through National Uniform Yield Trials and Variety Evaluation Committee. In 1994, the Government of Pakistan recognized the importance of private sector in the production and distribution of improved seed and within a decade 400 national and five multinational companies were registered. Many national and multinational companies (Engro Chemicals, Monsanto, Pioneer, ICI and Syngenta) are distributing seed of major crops including hybrid seed of maize, cotton, rice and sunflower. For maximizing the yield and minimizing the use of pesticide, the Monsanto has introduced the pest and disease resistant hybrid seeds of crops. The government of Sindh is now seriously working to privatize the management of Sindh Seed Corporation under the ADB (Asian Development Bank) financed Governance Programme for Sindh Government. However, Punjab has a mixed strategy where both the public- and private-sectors are involved in the seed sub-sector.

Informal sector is also active in the multiplication and distribution of improved seed of synthetic varieties. Enlightened farmers who are using the improved seed are also selling their seed to other farmers after the first harvest. This is the most effective way of diffusion of improved seed to the large number of small-holders in the country. It is much easier for the farmer to get seed from the fellow farmer after visually observing the quality of the seed in the field. The quality of this seed in certain cases is even better than the public-sector seed companies

or extension department. However, support role of public-sector institutions is vital for maintaining the quality of improved seed multiplication and distribution by the informal sector.

2.2. Net Water Availability (Surface and Groundwater)

Water is an essential input in agriculture and it is the largest sub-sector of water use, as it uses around 93% of total water available in the country. Indus basin irrigation system consists of three large storage reservoirs, 23 barrages and headworks, 45 canal commands, 12 inter-river links canals, 90000 kms of watercourses (WCD 200) and around 1.0 million tubewells (GoP 2007a). Surface and groundwater are the two main sources of water availability. Surface water includes rainfall, glaciers- and snowmelt. River flow is less in the Rabi season because of slow melting of glaciers and snow and less rainfall.

Overall water availability[4] at the farm gate is highly variable. It is 94 MAF[5] in 1987-88 but increased up to 98 MAF in 2006-07 because lack of construction of large dams since the completion of Tarbela dam (**Figure 4**). This smaller increase is only due to climatic variability. At present, Mangela and Tarbela are the two main storage reservoirs on the western rivers, which increased the water availability during the early Kharif and Rabi season. These reservoirs are designed to divert water from the Kharif season to the Rabi season. The Indus basin has extensive groundwater resources because of the deep alluvial aquifer. The inefficient canal irrigation system is contributing significantly in recharging the groundwater. Recharge of groundwater from Indus basin is 45.4 MAF (56 billion m^3) from which around 29.2 MAF (36 billion m^3) is in the freshwater zone and the rest in the marginal to brackish zone (Ahmad 2008).

Water availability at farm gate was 90 and 87 MAF in 1997-98 and 2001-02, respectively due to drought (**Figure 4**). The water quality in marginal and brackish zone can be characterized into saline, saline-sodic and sodic (Ahmad 2008).

The inter-river link canals are contributing significantly to the groundwater recharge because of large discharge. The good example is the Chashma Right Bank Canal, where rise in water table has adverse effects on the productivity of surrounding lands. Farmers have lost their source of livelihood. Surface water has freshwater quality having 150-350 ppm. It is safe for irrigation and domestic use but continued use of chemical fertilizers and pesticides in agriculture and entry of agricultural and urban effluents in the freshwater streams is polluting the surface and groundwater (Ahmad 2008). Groundwater quality is varied spatially. In spite of improved irrigation and drainage facilities in the Indus basin, waterlogging and salinity are the problems affecting the productivity and sustainability of irrigated agriculture (Panhwar 1998).

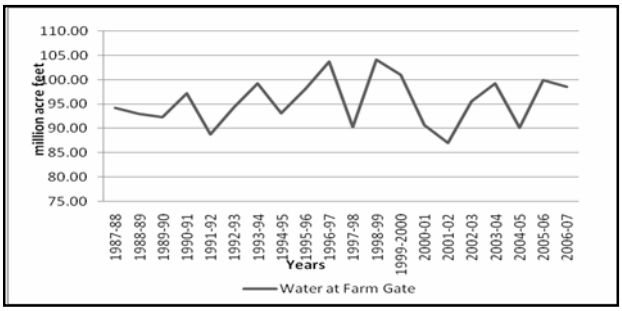

Figure 4. Net water availability at farm gate

The use of tubewell has been increased tremendously in agriculture during the last four decades. The innovative and low cost tubewell technology development also encouraged the farmers to exploit groundwater. It is now contributing one-third of water availability at the farm level. In spite of extensive development of groundwater, the water availability was extremely variable during the last decade largely due to the variability in canal diversions (**Figure 4**). The variability in river flows is due to climatic variability, sedimentation in large reservoirs and lack of development of new storage facility.

[4] *Water efficiency is measured by incorporating water losses into the surface and groundwater*
[5] *MAF is million acre feet*

The use of groundwater has been increasing since 1970s after the completion of Mangla dam and the power policy introduced by the government which encouraged the farmers to use electric power for pumping groundwater. The persistent drought and enhanced use of groundwater helped to lower down the water table in the Indus basin, but 2-3 wet years can bring the water table on the rise. The problem of waterlogging and salinity is still there due to water conveyance losses in the canal network. From 1987-88 to 2006-07, groundwater contribution to total water availability in the Indus basin increased from 25% to 33% (**Figure 5**).

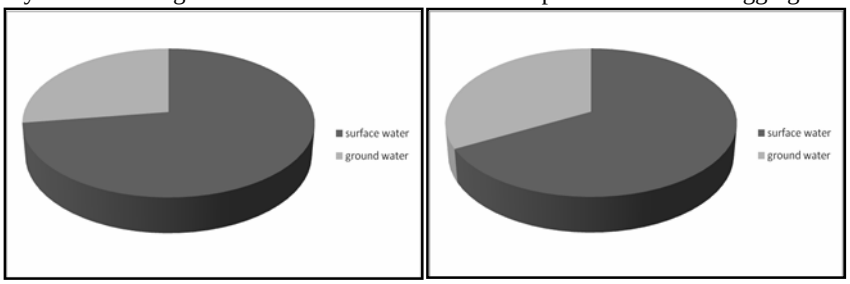

Figure 5. Surface and groundwater share in water availability at farm gate
1987-88 **2006-07**

2.3. Energy Use in Agriculture

Electricity is a key input in the economic growth of the country. Like other sectors, the use of energy in agriculture is vital for number of activities like pumping of groundwater and processing of food. Currently, the country is facing shortage of electricity and the only option available for the electric power companies is the load shedding to manage the peak demand. Agriculture sub-sector uses around 14.3 % of total electricity available in the country. Due to the rise in tariff of electricity and unreliable power supply resulted in less use of electricity in agriculture.

In agriculture, the use of electricity has increased from 1988 to 1998 and then it was decreased up to 2000 and after that had an increasing trend till 2007. The load shedding (exceeding 8 hrs per day), power failures and poor quality of power are the reasons for lower demand in agriculture (**Figure 6**). These problems also forced the farmers to use diesel fuel although its operational cost is higher than electricity even than the number of diesel tubewells are around 84% of the total tubewells. The government of Pakistan has recently decided to reduce the subsidy on diesel and now diesel and petrol prices are almost same. In the past, diesel prices were kept less to provide benefits to the farmers and urban poor to provide relief to the transport sub-sector. The consumption of diesel is going to further increase as there is shortage of electric power and tariff is also increasing, whereas the quality of power is deteriorating[6]. In the last two decades (1988 to 2007), the diesel consumption in agriculture has continuously increased (**Figure 7**). The rise in electric tariff and diesel prices is now a major issue in agriculture, as it is going to increase the cost of production and reduce the profitability of irrigated agriculture.

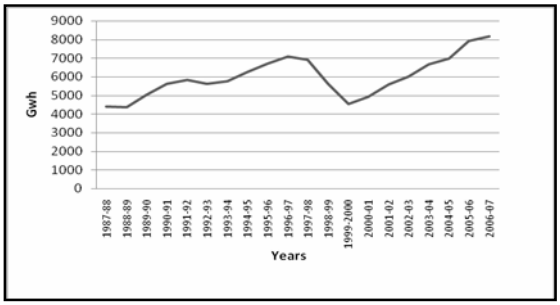

Figure 6. electricity consumption in agriculture

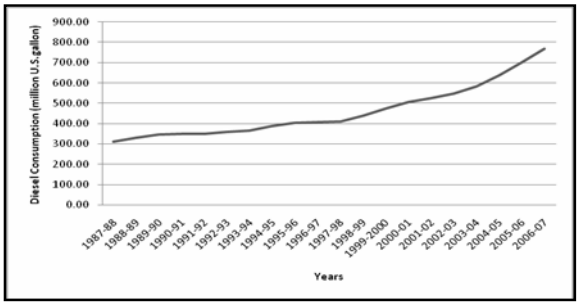

Figure 7. Diesel consumption in agriculture

[6] *Diesel consumption is estimated for tractors and tubewells, as these two are the major user of energy in Pakistan's agriculture.*

2.4. Fertilizers Use in Agriculture

Fertilizers play a vital role for increasing productivity. One of the major factors in reduction of productivity is poor soil fertility and less use of organic and mineral fertilizers. There is net depletion of nutrients due to higher uptake by the plants compared to addition of fertilizers. Thus, the soil health (macro- and micro-organisms) is deteriorating and affecting the efficiency of mineral fertilizers. Nitrogenous, phosphatic and potassic fertilizers[7] are essentially needed to maintain soil fertility for most crops.

The demand of fertilizers is increasing because of enhanced demand of food crops due to the rise in population. In 1988, the fertilizer consumption was more than 1.7 million N tones that reaches to 3.6 million N tones in 2007 (**Figure 8**). Urea and DAP are the two major fertilizers that are used in Pakistan. Their demand is increasing at an average rate of 6 and 8% for Urea and DAP, respectively. The country is producing major portion of the nitrogenous fertilizers, whereas rock phosphate is being imported to produce phosphatic fertilizers. The major fertilizers companies are producing 82% of fertilizers within the country, whereas rest is imported. Individually, FFC (Fauji Fertilczer Company) has 51.5% share, whereas Engro Chemicals has 20% and FFBL has 10.5% share in the total production of urea in the country. The country is not producing the major portion of phosphatic and all of the potassic fertilizers and thus these are being imported.

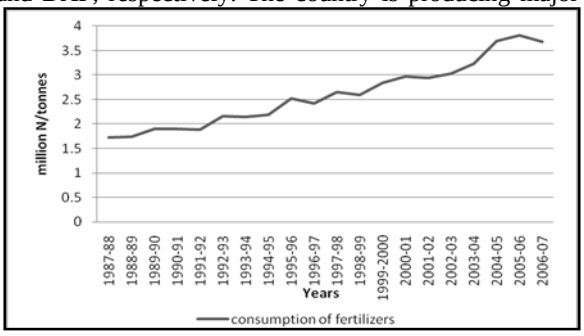

Figure 8. Fertilizers consumption in agriculture

The recent hike in price of fertilizer to the extent of Rs. 5500 per bag of DAP forced the government to provide subsidy on phosphatic fertilizers. This has raised the issue of searching options for alternate sources of fertilizers (organic and bio-fertilizers), where not only cost can be reduced but also huge resources of wastes (agricultural, urban and agro-industrial) can be utilized for converting to compost and at the same time environmental pollution can be reduced. Fertilizer use for different crops is different. Around 50% fertilizers are used for wheat, whereas rice, cotton, maize and sugarcane have used 14, 15, 7 and 8% of fertilizer, respectively (**Figure 9**).

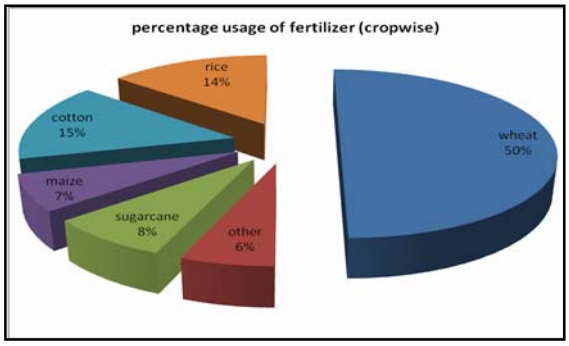

Figure 9. Crop wise usage of fertilizers

Wheat occupies that largest area because of food security, whereas cotton is a cash crop having less area and using smaller amount of fertilizers with large consumption of pesticides. Returns on wheat and rice per unit area are not very high because of low water productivity and nutrient use efficiency is low (FAO 2004).

According to Krauss (1997), USA was producing more than double food grain per ha than Pakistan by applying the same amount of nutrients per ha. Unfortunately Pakistan's soils are deficient in nitrogen (100 %), phosphorus (90%), zinc (70%) and boron (55%). Potassium is generally adequate in irrigated areas but its deficiency is emerging. Hardly 1-2% of farmers apply potash to fruits, vegetables and sugarcane (APO 2002). This is not the precise analysis, the difference between USA and Pakistan is that in USA lot of organic materials are ploughed back into the soil, whereas in Pakistan all the straw is used for animal feed and while animals grazing the harvested fields can even take the stubbles.

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[7] *Common nitrogen based fertilizers are ammonium nitrate, ammonium sulfate and urea]*

Balanced fertilization not only include the supply of nitrogen, phosphorus, potash or other nutrients, but also the available nutrients in the soil, crop requirement and other factors. Balanced fertilization enhances crop yield, crop quality and farm income; corrects soil nutrient deficiencies and maintains soil fertility. But it can also be seen that in spite of increased use of fertilizers, productivity could not be increased.

3. Gross Value Production of Agriculture

Gross Value Production (GVP) is a rough estimate for the output of crops based on the market prices. The GVA can be estimated by subtracting the input costs from the GVP. It is a bit different concept from that of the Gross Domestic Product (GDP) and normally considered by agricultural economists. The difference is that GVA doesn't include subsidies and taxes on the products and services produced. GVP per ha can be used to compare productivity. In Pakistan, unit GVP of crops is continuously increasing since 1987-07 (**Figure 10**). This shows the increase in output at the market prices. In 2006-07, unit GVP is more than Rs. 40000/ha, which is 5 times from that of GVP in 1987-88. On the other hand, yield has increased 20% from 1987 to 2007. This higher value of GVP is due to higher inflation resulting in rise in output prices.

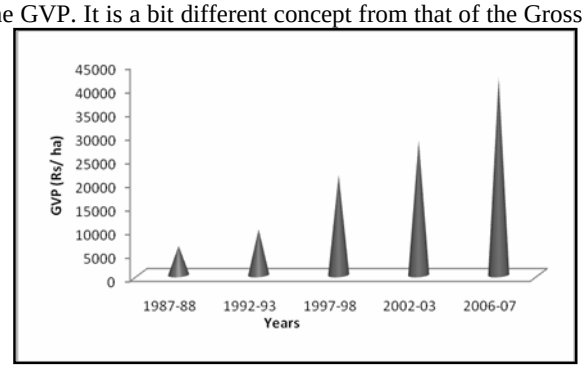

Figure 10. Unit Gross Value Production of Crops

4. Gross Value Production per Unit of Input

4-1. Water Productivity per Unit of GVP

Water productivity is important phenomenon in agriculture because water is a finite and a limiting resource. Although globally there are enough water resources to meet the needs of the world's population, but locally many areas are experiencing water scarcity due to higher demand. There are many barriers on demand side like physical water scarcity, economic water scarcity, managerial water scarcity, institutional water scarcity and political water scarcity (Cook *et al*. 2006). In Pakistan, water productivity with nominal GVP reaches on 8 Rs/m^3 relative to the 7.3 Rs/m^3 in real terms. Water productivity is 8 times higher in 2006-07 from that of 1987-88 (**Figure 11**). This increase is largely due to increased productivity and efficient use of water for raising crops. Water use includes the amount of water used or applied to the crop through rainfall and/or irrigation. Maximizing crop productivity may not be economical therefore it has to be seen in the context of economic efficiency. It is important to note that water productivity and water efficiency are synonymous concepts.

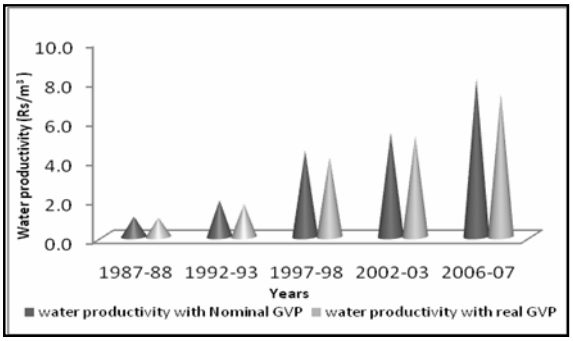

Figure 11. GVP per unit of water.

4.2. Energy Use per Unit of GVP

The data of energy use in agriculture and GVP was used to estimate GVP per unit of energy used. GVP of Rs. 25 million was achieved per unit of GWH[8] of electricity consumed in agriculture (**Figure 12**). The GVP on per unit of GWH of electricity consumed in agriculture is continuously increasing since 1987-88. The major user of

[8] *GWH – Giga watt hours*

electricity is tubewells and the number is growing to either enhance cultivated area, cropped area or cropping intensity.

The major source of energy in agriculture is diesel fuel, as there is shortage of electricity and its availability is limited due to shortfall in supply. The diesel-fuel is used for operation of tubewells, tillage, farm operations, harvesting, threshing, haulage and transportation of agricultural commodities. The GVP per unit of diesel fuel started increasing since 1987-88 (**Figure 13**). In 2007, GVP of Rs. 1200 per gallon of diesel fuel used was obtained. The rise in GVP per gallon of diesel fuel is due to rapid increase in the prices of agricultural commodities. There has been a shift in the government policy of subsidizing diesel fuel to provide relief to agriculture and public-transport sectors. Now the prices of petrol and diesel fuel are almost same thus government is taxing agriculture and public transport sectors.

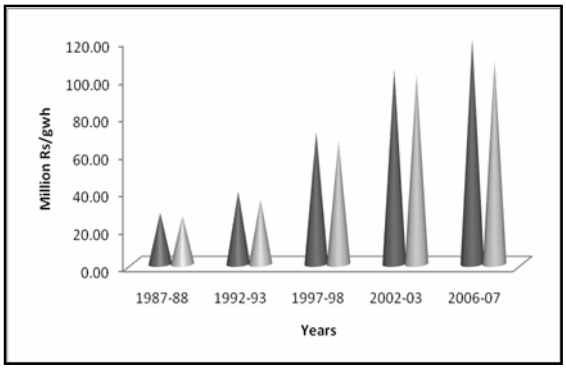

Figure 12. GVP per unit of electricity use

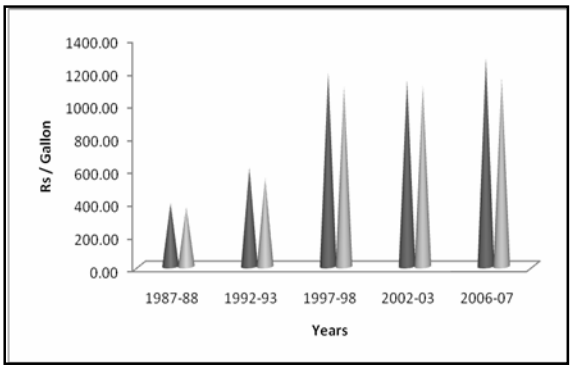

Figure 13. GVP per unit of diesel consumption

4.3. Fertilizer Use per Unit of GVP

Borlaug and Dowswell (1994) stated that as much as 50% global increase in crop yields during the current century is largely due to adoption of chemical fertilizers and irrigation. Many studies highlighted that fertilizers with irrigation can increase the productivity. These estimates can vary between 15 to 50 % due to associated inputs. Same is the case in Pakistan. The GVP of Rs. 250 per nutrient kg was obtained in 2006-07 (**Figure 14**), which is 5 times more than its efficiency during 1987-88. There is a steady increase in fertilizers use efficiency in the last two decades (**Figure 14**). The increase in the GVP per unit of nutrient kg is largely due to the rise in price of agricultural commodities or enhanced productivity and productions. The balance use of fertilizer is still a constraint. The use of phosphatic and potassic fertilizer is lower than the recommended doses of PK in relation to N.

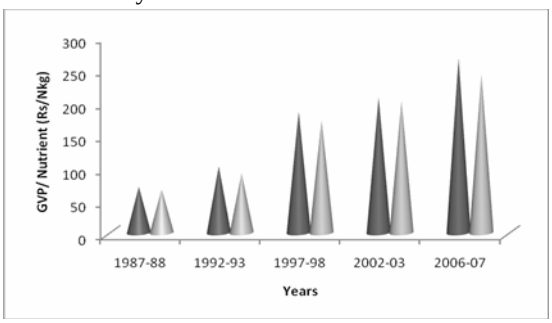

Figure 14. GVP per unit of fertilizer

5. Relationship of Agricultural Inputs

All the inputs used in the analysis are correlated with each other. In any situation one or two inputs can not work. An optimal combination of inputs gives higher productivity. The improved seed has higher relation with fertilizer (83%) and water (72%) than electricity (49%). This means that water and fertilizers are essential to harvest the benefits of improved seed. However, the rise in the price of fertilizers and energy in future might have adverse impacts on the productivity and relation between the inputs (**Table 3**). Furthermore, the arid environments of Pakistan are now experiencing stagnant productivity because the continued use of chemical fertilizers and reduced use of organic manures had adverse affects on the soil health in terms of macro- and micro-organisms. The water and energy use efficiency have to be increased in future because water is a finite resource and there is acute shortage of electricty in Pakistan.

Table 3. Correlation between agricultural inputs

	Seed	Water	Fertilizer	Electricity
Seed	1	0.73	0.83	0.49
Water	0.73	1	0.95	0.68
Fertilizer	0.83	0.95	1	0.72
Electricity	0.49	0.68	0.72	1

Fertilizer has the strongest relationship with water (95%), followed by seed (83%) and electricity (72%). This means that water is essential to harvest the benefits of fertilizer and electricity is also directly related to the pumping of groundwater. This aspect is hardly understood by the scientists that the use of chemical fertilizers and improved seed demand higher amounts of water for enhanced productivity.

For sustainable development, it is important to efficiently use water, energy and fertilizers to attain and sustain crop productivity. Water is a finite and a limiting resource and there is acute shortage of electricity.

6. Projections for Food Crops

With the average annual growth rate of 3.66%, the production of food crops can reach to 43.1 million tons in 2015 with population of 188.2 million (**Table 4**). The per capita production might increase but it is possible if country maintains the annual growth rate. But the global circumstances indicated that the food prices are going to increase globally and it might result into deficiency of food. Furthermore, agriculture sector policies are not that effective in Pakistan, as there are number of policy issues still to be addressed. Political and seasonal factors (climate, water availability, etc.) are also having direct impacts on the production of agriculture sector. The inequity is increasing in the agriculture sector, as farmers are not getting fair prices of their produce due to exploitative marketing system prevailing in the country. Therefore, sustaining the higher growth rate in agriculture sector is a gigantic task as the seasonal variations in climate and water availability can hamper the growth rate adversely.

Table 4. Projection of per capita availability of food grains in Pakistan

Years	Production (million tones)	Population (million)	Per capita availability per annum (kg)
2008	33.51	161.66	207.3
2009	34.74	165.2	210.3
2010	36.01	168.82	213.3
2011	37.33	172.52	216.4
2012	38.69	176.3	219.5
2013	40.11	180.2	222.6
2014	41.58	184.15	225.8
2015	43.10	188.18	229.1

Major resources that lead to un-sustainability are rapid population growth and wide spread poverty. Per capita availability of cultivated land and freshwater resources are declining at a rapid rate. The degradation of land and water resources with time is also going to be a serious concern due to environmental degradation.

7. Key issues

The input-output analysis revealed that per unit GVP is increasing with the increasing use of fertilizers, electricity, diesel, water and improved seed. The analysis and review of secondary information indicated the following key issues related to the improvement of input use efficiency in agriculture:

- ***Water Security*:** Reduction in per capita water availability is a serious concern for agriculture due to

lack of construction of hydro-power dams, rise in population and decline in storage of existing reservoirs due to sedimentation in the Indus basin. Most of the freshwater resources have already been abstracted and further development of irrigated agriculture would be largely based on the abstraction of marginal to brackish groundwater and/or wastewater from agricultural and urban effluents. Trans-boundary water issues with India would also have serious implications on the availability of water in Chenab and Jhelum Rivers. Similarly, activities in Tibet are also going to have some negative impacts on the availability of water in the Indus River. Thus, water security for agriculture is going to be a key issue in the near future.

- ***Availability of Improved Seed*:** Availability of improved seed, coverage and quality is much less than the optimum levels as less than 20% of the cropped area of wheat, rice and maize crops is covered by improved seed.
- ***Imbalance Use of Fertilizers***: Imbalance use of fertilizers (organic manures, NPK, micro-nutrients) is a major concern affecting the fertilizer use efficiency. The fertilizer use efficiency is low because of low organic matter contents in soils, use of poor quality groundwater and decline in the use of organic manures. The fertilizer use efficiency is quite low (<20%).
- ***Rise in Energy Prices***: Rise in diesel prices and electricity tariff is going to have adverse impacts on the profitability of irrigated agriculture where groundwater is used extensively like the Northern Punjab and Balochistan.
- ***Water-Nutrient-Seed Nexus***: The potential benefits of improved seed and chemical fertilizers can only be achieved if water availability is ensured because these two inputs require almost double the amount of water compared to Desi varieties of crops under organic farming.
- ***Institutions and Service Delivery***: Lack of integrated planning for future agriculture restricts the optimal use of inputs (water, energy and nutrient) and result in sub-optimal productivity of food crops. The required institutions are not in place which can provide timely services to farmers.

8. Policy reforms

Six key issues were identified based on the input-output analysis, which were further analyzed to evaluate the potential policy reforms to ensure sustainable agriculture in the next decade and are listed as under:

- **Investment in water sector** should be made at two levels: a) augmenting the existing water resources through development of new infrastructure; and b) saving of existing water losses in the Indus basin and minor irrigation schemes.
- **Ensure that future investments** in water management should be focussed in improving farm productivity through integrated efforts by linking water and agriculture extension services in the country. There is a need to re-orient the current extension services to provide support to the farmers in improving input use efficiency and farm productivity.
- **Create Public-private partnership** (both for research and development) in multiplication, certification, registration and distribution of improved seed to farmers to cover 40% area under synthetic varieties and 100% area under crops where hybrids are being used.
- **Undertake research** for optimizing the use of inputs to maximize the farm productivity and disseminate the research results using mass media awareness campaigns and trainings.
- **Develop low-cost energy sources** at the farm level (biogas, etc.) so that farmers can use it for agricultural purposes like operation of tubewells and the slurry can be used for bio-fertigation of crops.
- **Undertake research** on water-nutrient-seed nexus to ensure that while using input (water, nutrient and energy) optimally the objective should be to maximize the farm productivity
- **Develop new institutional mechanisms** so that outputs of research institutions and the private sector are provided to farmers in a way that it help them to raise productivity and farmers are not cheated through provision of sub-optimal quality of products like seed, chemicals, etc.

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Email: dr_shahidahmad2001@yahoo.com
Phone No. Office: 92-51-9220385;
Cell Numbers: 0321-9561517/0300-9561517
Address: Pakistan Agricultural Research Council, P.O. Box 1031, Islamabad.

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