Science and Technology Based Agriculture Vision of Pakistan and Prospects of Growth

Ahmad, Munir and Iqbal, Muhammad

Pakistan Institute of Development Economics

2004

SCIENCE & TECHNOLOGY BASED AGRICULTURE VISION OF PAKISTAN AND PROSPECTS OF GROWTH

Muhammad Iqbal and Munir Ahmad[1]

1. INTRODUCTION

Agriculture is the largest income and employment-generating sector of Pakistan's economy. About two third population of the country resides in rural areas and directly or indirectly depend on agriculture for their livelihood. The sector provides raw materials to the industrial sector and is an important source of demand for its products. The past experience shows that periods of high/low agricultural growth have generally coincided with periods of robust/poor performance of the national economy [Ali 2000]. The share of agriculture in GDP of the country has though declined overtime as a result of ongoing process of structural adjustment, its performance still have a major impact on the overall performance of the economy because of its linkages with the rest of the economy. Therefore, a higher and sustained growth in agricultural production is imperative for a rapid development of the economy and poverty reduction in the country. A number of researchers including Naqvi et. al. (1992, 1994) and Mellor (1988) believe that agriculture must maintain a growth rate of more than five percent in order to ensure a rapid growth of national income, attaining macroeconomic stability, effective employment of growing labor force, securing improvement in distributive justice and a reduction in rural poverty in Pakistan.

The important factors that may contribute to a higher agricultural growth include expansion in cultivated area, enhanced use of water and other agricultural inputs, increase in cropping intensity, technological change, and technical efficiency. Various studies show a positive growth in total factor productivity for agriculture in Pakistan. However, the estimates differ widely and range from 0.37 [Kemal et. al (2002)] over the period 1964-2001 to 2.3 [Ali (2000)] for the period 1960-1995. Chaudhry et al (1996) estimated a total factor productivity growth of 0.48 for crop sub-sector over the period 1950-1995; the growth in aggregated inputs accounted for about 80 percent of the total increase in crop output growth and the rest was contributed by improvement in agricultural technology.

It is widely maintained that the potential for allocating more land and water resources to agricultural production and/or scope of further increase in cropping intensity is limited in Pakistan. Moreover, use of inputs like fertilizers and pesticides cannot be increased beyond certain limits and also because of national health and environmental concerns. Therefore, the country would have to depend more heavily on technological change and improvement of technical efficiency for the desired rapid agricultural growth.

Technological change is the result of research and development (R&D) efforts, while technical efficiency with which new technology is adopted and used more rationally is affected by the flow of information, better infrastructure, availability of funds and quality inputs, and farmers' managerial capabilities. Empirical evidence shows that R&D through its influence on productivity has been an important source of growth in

[1] The authors are respectively Senior Research Economist and Chief of Research at Pakistan Institute of Development Economics, Islamabad

agricultural production in many of the developed as well as developing countries [Evenson (2002)].

In Pakistan, productivity in various sub-sectors of agriculture continues to be rather low relative to the developed and many developing countries with similar resource base. It is also argued that Pakistan's economy would be more and more integrated into the world economy and it would become increasingly difficult for the agriculture sector to compete in the world market unless higher growth in agricultural productivity is ensured on sustainable basis. This paper reviews the current status of Pakistan's agriculture and discusses the potential of various factors to contribute towards a higher and sustained growth of the sector in future. The study would focus on the role that science and technology can play towards achieving higher growth in agriculture and on prioritizing the future research and development efforts. While R&D activities are absolutely important, these alone cannot be expected to achieve the above goals unless they are supported by favorable policy instruments, human resources development, necessary physical and institutional infrastructure etc. The required supportive actions have also been identified in the paper

The scope of the study is limited to crops, livestock, inland fisheries, and agro processing. The paper is organized into six sections. Section 2 presents a brief introduction of the agriculture sector and mainly deals with issues in crops sub-sector. The livestock and inland fisheries sub-sectors are discussed in section 3. The agro processing is deliberated in section 4. The state of agricultural research is reviewed in section 5. The final section concludes the paper and suggests R&D activities and supportive actions.

2. CROPS SUB-SECTOR

In Pakistan, agricultural output is dominated by crop and livestock production, which respectively accounted for 56.5 and 38.9 percent of the total valued added in agriculture during 2002-03; fisheries and forestry sub-sectors contributed just 3.5 and 1.1 percent respectively. The respective shares of major and minor crops in total value added in agriculture stood at 40.5 and 16 percent. The four major crops namely wheat, rice, cotton, and sugarcane contributed 37 percent to the overall agricultural income and around 9 percent of the GDP. Therefore, performance of these four crops has been crucial for agricultural production and overall performance of the economy. Since there have been wide fluctuations in their performance over time, the GDP growth rates have been quite unstable. Therefore, more diversification in the agriculture sector is crucial both for stability of agricultural income as well as GDP. Though the contribution of minor crops has been small relative to major crops, they have the highest growth potential particularly for vegetables, fruits, and flowers along with livestock and fisheries sub-sectors. The following sub-sections discuss important issues confronting agriculture in general and crops sub-sector in particular and assess the roles that various factors can play toward a rapid growth for the sector.

2.1 Low Yields and Large Unachieved Potentials

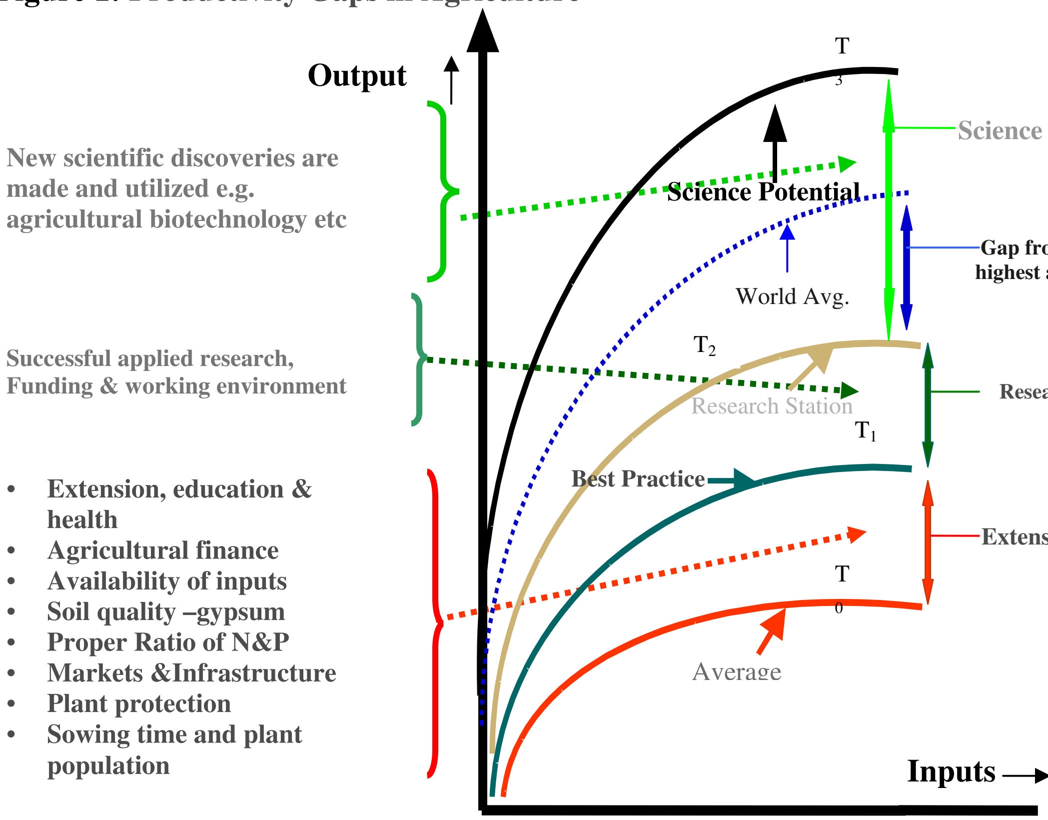
The national average yields of various crops are far below their potential yields realized at the progressive farms and that demonstrated at research stations. Moreover, research potential yields are lower than the potential demonstrated in many of the developed and developing countries. Evenson (2002) discusses four yield levels and three yield gaps associated with them. The first level is actually realized yield on the average farmer's fields (T_0). The second is the "best practice" yield (T_1), which can be realized using the best available technology (Figure 1). It is possible that some farmers obtain best practice yields but the average farmer does not. The third yield level is the "research potential" yield (T_2), i.e., it is the hypothetical best practice yield that would be expected to be attained as a result of a successful applied research program directed toward this crop. The fourth is "science potential" yield (T_3). This is also a hypothetical yield. It is the research potential yield attainable if new scientific discoveries (e.g., in biotechnology) are utilized in applied research programs.

Associated with these four yields levels three "gaps" are defined. Firstly, extension gap, the difference between best practice and average yields. The extension programs are designed to close this gap. Secondly, research gap, the difference between research potential yields and the best practice yields. Applied research programs, if successful, will close this gap (and will thus open up the extension gap). Thirdly, science gap, the difference between science potential and the research potential yields. The agricultural productivity growth would thus require frequently shifting of T_3 and T_2 yields[2] thus widening the "research gap" and continually bridging this gap by enhancing the best practice yield (T_1) through applied research. This in turn would expand the "extension gap" to be continuously bridged through effective extension services; improving access to institutional credit and quality inputs;

[2] This would require adequate funding for the R&D efforts to make new discoveries, human resource development/capacity building, creating working environment, and incorporating new scientific discoveries in agricultural research, e.g. agricultural biotechnology.

markets; health facilities; resource conservation; and promoting the adoption of tested technologies.

Figure 1: **Productivity Gaps in Agriculture**



In Pakistan, all the above discussed yield gaps exist and are quite wide. Due to general inefficiency of our agricultural production system, the national average yields of most of the agricultural crops are far below the demonstrated potentials at the progressive farms and the research stations. The "extension" and "research" gaps range from 31 to 75 and 25 to 57 percent respectively (Table 1). The national level yields of selected crops are 50 to 83 percent lower than the highest averages attained in other countries of the world. The realization of this unachieved potential could offer excellent opportunity for future agricultural growth.

Table 1: Various Levels' Average Yields for Selected Agricultural Commodities and Associated Yield Gaps (Yield in tonnes/hectare)

Commodity	Highest Avg. (world)	Potential Yield	Progressive Farms' Yield	National Average**	Gaps (%)		
					Extension	Research	From world Avg.
Wheat	7.5 (France)	6.8	4.6	2.3	50.0	32.4	69.3
Cotton	4.0 (China)	4.3	2.6	1.8	30.8	39.5	55.0
Sugarcane: Sindh	120 (Egypt)	300	200	60	70.0	33.3	50.0
Punjab		300	130	40	69.0	56.7	66.7
Maize	9.9 (France)	9.2	6.9	1.7	75.4	25.0	82.8
Rice	7.4 (USA)	5.2	3.8	2.0	47.4	26.9	73.0
Rapeseed/ mustard		3.4	1.5	0.8	46.7	55.9	
Cow milk (tonne/Year)	5.5 (USA)	6.5	3.1*	1.2	61.3	52.3	78.2

Source: PCST (2003a); Iqbal and Ahmad (1999)
* Sahiwal Breed Potential ** National average yields in 2000-01

2.2 Degradation of Land and Inefficient Use of Water Resources

Land Resources: The growth in agricultural output in the past is mainly attributed to development of irrigation infrastructure, increased cultivated area, enhanced land use intensity, and augmented use of various inputs and to a lesser extent to improved productivity. Out of 79.61 million hectares of geographical area of Pakistan, 22.11 million hectares were cultivated during 2002-03 as compared to 14.99 million hectares in 1949-50 (Table 2). Considering the extent and severity of different soil related constraints, 26 percent of the arable land is classified as very good, 35 percent good, 24 percent moderate, and 15 percent as marginal (PCST, 2003a).

The cultivated area increased by about 48.6 percent over a period of 52 years at a rate of roughly less than one percent (0.76 %). A major proportion (82 %) of the cultivated area is irrigated, while the rest (18 %) is rainfed. The cultivable wasteland of about 9 million hectares seems to offer a good possibility of crop production if exploited in future through enhanced water availability. Given the limited amount of unexploited water resources coupled with political complications and heavy investments required for development of country's water resources, only a slow and partial exploitation of wasteland is possible.

Table 2: Distribution of Land Use in Pakistan (area in million hectares)

Area Categories	Land Use in 1949-50	Percentage of Geographical area	Land Use in 2002-03	Percentage of Geographical area
Geographical Area	79.61	100.00	79.61	100.00
Cultivated Area	14.99	26.33	22.11	27.77
Culturable Waste	9.32	11.12	9.00	11.31
Cropped Area	12.21	27.41	21.85	27.45
Forest Area	1.37	4.35	4.04	5.07

The cropped area increased from 12.21 million hectares in 1949-50 to 21.85 million hectares in 2002-03, an increase of about 80 percent at a growth rate of about one percent per annum. The national average cropping intensity increased from about 122 percent in 1980 to 142 percent in 2000 (see Agriculture Census). The provincial average cropping intensity stood at 154, 130, 142 and 78 percent respectively in Punjab, Sindh, NWFP, and Balochistan respectively (Annexure I). The cropping intensities increased over time in all the provinces except Balochistan (where it was highest in 1990) but are declining with increase in farm sizes. The national average cropping intensity on marginal and small farms was 162 and 151 percent respectively during 2000. The average cropping intensity in irrigated area is expected to be even higher and in certain areas may be in the vicinity of 200 percent. This implies that the pressure on land resources is mounting overtime and especially on small and marginal farms (5hectares or less). Such a high cropping intensity along with low use of farmyard manure and unbalanced use of chemical fertilizers have serious implications for soil health and especially for sustainability of marginal and small farms. Keeping this in view, further increase in agricultural production through enhancing cropping intensity would have a slim chance.

Most of the soils in Pakistan are deficient in macro nutrients like nitrogen and phosphorus. Increasing deficiencies of potassium and micro nutrients like zinc, boron and iron etc have also been noted. The imbalanced use of fertilizer nutrients, lack of its integration with organic sources along with poor management are the main factors affecting fertilizer use efficiency. The other factors like salinity/sodicity, water logging, and soil moister stress also affect the fertilizer use efficiency adversely but to a smaller extent. Most of the farmers lack information regarding soils nutrients of their farm lands and with every harvest more nutrients are being mined out than being added resulting in negative balance [Hamid and Ahmad (2001)]. The strategy for a higher agricultural growth on sustainable basis must address the issue of mismanagement of soil nutrients along with other complementary measures like cross subsidy on DAP fertilizers to make it cheaper relative to nitrogenous fertilizers (urea).

The other important issues that affect productivity of land resources in Pakistan include water logging, salinity/sodicity, and soil erosion. Seepage from canals, distributaries, watercourses and unleveled fields and poor drainage has created the problems of waterlogging and salinity in the irrigated areas of the Indus plains. Presently, almost 30 percent of the irrigation water at the farm gate is derived from groundwater, whose quality is far inferior to canal water. Out of over 562,000 private and 16,000 public tubewells in Pakistan, 70 percent are pumping brackish water [PCST (2003)]. The salinity in root zone is expected to increase with the application of marginal quality groundwater. According to recent estimates, approximately 16 percent (2.4 million hectares) of irrigated land is underlain by watertable that is within 5 feet of the surface and is thus classified as disaster area. Out of this only 0.6 million hectares (1.6 million acres) are under various Salinity Control and Reclamation Projects (SCARPs).

With regard to surface salinity, 14 percent of the land is affected at the surface. This percentage, increases to approximately 20 percent if the salinity in the soil profile (in depth) is also considered. There are 6.17 million hectares of lands affected with salinity and sodicity. Out of this about 3.37 million hectares are uncultivated and are severely affected with salinity/sodicity. About 2.80 million hectares of saline/saline-sodic lands are cultivated out of which 0.97 million hectares are severely saline/saline-sodic and about 1.83 million hectares are affected with slight to moderate salinity/sodicity (Table 3). Assuming the rates of 20 and 35 percent lower productivity respectively on cultivated soils affected with slight and moderate salinity/sodicity, it is estimated that nation is losing about 21.5 billion rupees each year. Being under the canal commands, these lands offer very good potential for agricultural production if they are reclaimed through provision of drainage facilities and use of chemical and biological amendments.

Table 3: Extent of Saline/Sodic Soils in Pakistan and Associated Productivity Losses

Area and Loss Categories	Slightly affected	Moderately affected	Severely affected	Total
Cultivated (000 Ha)	598.7	1229.8	975.3	2803.8
Uncultivated (000 Ha)	-	-	3369.7	3369.7
Total land affected	**598.7**	**1229.8**	**4345.0**	**6173.5**
Rate of agricultural GDP loss	@ 20 %	@ 35 %	Cultivated: @ 60 % Uncultivated@ 100 %	
GDP loss from cultivated area (million Rs)	4679.4	16821.0	22868.5	44368.8
GDP loss from uncultivated (million Rs)	-	-	131686.0	131686.0
Total GDP loss (million Rs)	**4679.4**	**16821.0**	**154554.5**	**176054.8**

A significant amount of arable land resources are being lost due to rapid expanding urban centers and dumping of urban solid waste and untreated toxic industrial waste on arable lands. There is an urgent need to devise and implement a proper land use policy to arrest the rapid loss of fertile arable lands. Soil erosion is relatively a more serious problem in rainfed and hilly areas. Rapid deforestation and increasing crop production along steep hillsides result in heavy losses of soil and its nutrients. The problem is even more serious where soil depth is shallow. The chemical runoff is polluting the water bodies and soil erosion is creating silting problem in water reservoirs and canals.

Water Resources: Pakistan's agriculture is mostly dependent on irrigation from surface and ground water resources. The surface water supplies to Indus plain include rainfall and flows from Indus river system. According to recent estimates, the Indus river system accounts for 60 percent of the annual water supply while rainfall accounts for only 15 percent of the total water requirements for crop production (Table 4).

Table 4: Average annual water supplies for irrigation of the Indus Plain

Source	Volume (billion cubic meter)	Volume (million acre feet)	Proportion (%)
Rainfall	31.98	26	14.8
Diversion to canal irrigation systems	129.15	105	59.6
Groundwater	55.35	45	25.6
Total	**216.48**	**176**	**100**

Source: PCST (2003a)

The surface irrigation system relies on water availability in the rivers and of the total water available for irrigation annually about 84 percent flows during *kharif* season and only 16 percent flows in *rabi* season [IWMI (1999)]. Ground water development has played an important role in agricultural growth in Pakistan. Ground water supplies account for over $1/4^{th}$ of the annual water supplies for agricultural production. Three million hectares are currently being irrigated by tubewells with about 70 percent of them pumping out hazardous irrigation water.

Originally, the system was designed to fulfill irrigation water requirement for 75 percent cropping intensity, which has now exceeded 142 percent (Annexure I). The water losses due to poor maintenance of the irrigation system, seepage, evaporation, and inefficient use of water at the farm level are as high as 60 percent. The canal and watercourse conveyance losses respectively account for 33 and 50 percent of the total water losses. The overall irrigation efficiency is very low compared to other countries, e.g. Israel has quite high efficiency under desert conditions.

The growth rate in overall farm gate water availability has declined after 1980 (Table 5). The capacity of existing storage reservoirs is reducing due to sedimentation. According to the historical records, the 27 years average rim-station inflow of water was 138.7 million acre feet (MAF). The average water outflow to sea amounted to 36 MAF. A certain amount of water is essential to flow continuously into the sea to preserve ecology of deltaic area and prevent seawater intrusion into inland fresh water areas. However, exact quantification of this amount of water need to be determined by conducting impartial comprehensive study. There is a need to conserve every drop of water in excess of the optimal outflow to the sea by developing required storage capacity in future. The main problems of water sector include reduced water availability, water losses both due to inefficient use at the farms and institutional problems, rigid *warabandi* and poor performance of public sector tubewells [MINFAL, PARC & FAO (2000)].

Table 5: Water Availability at the Farm Gate (in million acre feet)

Decade	Surface water	Change (%)	Ground water	Change (%)	Total	Change (%)
1964-65	62.94		9.25		72.19	
1969-70	59.51	-5.45	15.59	68.54	75.10	4.03
1974-75	51.86	-12.85	25.16	61.39	77.02	2.56
1979-80	61.64	18.86	31.00	23.21	92.64	20.28
1984-85	65.21	5.79	38.15	23.06	103.36	11.57
1989-90	74.16	13.72	42.98	12.66	117.14	13.33
1994-95	81.23	9.53	48.42	12.66	129.65	10.68
1999-00	83.37	2.63	49.91	3.08	133.28	2.80

Source: Pakistan 2003 and Previous Issues

A national water quality management program to monitor water quality and enforce standards on effluent discharge into rivers and streams is extremely important. Sustainable water use requires an integrated approach involving conjunctive use of surface and ground water with appropriate price mechanisms reflecting scarcity of resource.

2.3 Faulty Post Harvest Handling

The use of poor harvesting and post harvesting technologies for handling agricultural production result in significant income losses in terms of quantity lost as well as reduction in value due to lower prices on account of quality fading. The post harvest losses in different fruits range from 12 to 40 percent (Table 6). In most of the fruits losses are high due to external and internal injuries occurred during harvest. The fruits are usually packed in jute sacks, used fertilizer bags, and in wooden crates. Due to extreme heat, high humidity, and improper packaging conditions, produce quality deteriorates rapidly resulting in high losses. Most of the losses occur during transportation and marketing especially in case of banana, jujube, and mango. Lack of adequate storage and cold storage facilities in wholesale markets is the major factor causing high market level losses.

Table 6: Estimated Post Harvest Losses for Different Fruits in Sindh (Percent)

Horticultural Crop	Harvesting	Packing	Transport	Ripening	Marketing	Total
Mango	10	3	2	5	10	30
Banana	2	5	10	2	20	39
Jujube	10	5	10	5	10	40
Chiku	10	5	5	5	5	30
Guava	15	3	2	-	5	25
Papaya	5	2	-	5	5	17
Dates	5	5	-	-	2	12

Source: Bukhari (2000)

The post harvest losses in fruits are estimated at Rs. 31 billion and in vegetables Rs. 18 billion per annum [MINFAL (2001)]. The value of wasted quantity in case of just three fruits (mango, banana, and dates) amounts to over 4 billion rupees per year. The shelf life and desired quality of horticultural crops need to be improved to meet the international standards and preference of the foreign consumers especially for potential export crops. Take the example of *kinno*, we have varieties which are best in taste, however, the consumers in foreign countries prefer seedless citrus.

A combination of research efforts for evolving suitable varieties and developing improved harvesting, transporting, storage, and packaging technologies in this regard would save us a significant amount of otherwise lost agricultural income. The export of high quality fruits and vegetables needs to be supported by cold chain infrastructure and reefer containers.

2.4 Low Use and Unbalanced Doze of Fertilizer

The present average consumption of fertilizers in Pakistan is about 138 kilograms per cultivated hectare, which is higher than India, USA, and USSR, but it is lower than many developing and developed countries like Egypt, France, Japan, Germany, and Netherlands. The historical data on fertilizer consumption depicts that per hectare fertilizer use declined in Netherlands, Germany, and France respectively from 805, 479, 312 Kgs in 1970-71 to 470, 232 and 225 Kgs per hectare in 2000-01 (Annexure II). In Pakistan, probably at this stage quantity of fertilizer nutrients used is relatively less important (at least in certain area and/or on certain crops) than the balanced use of nutrients. Presently, the use of fertilizer nutrients is in the N: P ratio of 3.4:1 as against the recommended ratio of 2:1. Significant increase in crop output can be achieved by moving fertilizer applications towards a more balanced doze.

Relatively high cost of phosphatic fertilizers is the main driving force for the imbalance use of fertilizer nutrients. Government may exercise cross subsidy to encourage a move towards the balanced doze. Many soils are also deficient in micronutrients due to continuous mining of these nutrients resulting from continuous same crop rotations. It is recommended that testing of farm soils and tubewell water should be made mandatory and the testing results be used for determination of proper nutrient mix and water treatment.

2.5 Unjust Use of Pesticides and Increasing Production Costs

The use of biocides and chemical fertilizers per cropped hectare has declined in a number of countries and a few of them are returning to organic farming. However, in Pakistan the use of chemicals and fertilizer nutrients are increasing and some of the chemicals being used are banned in other countries. The residual effect of pesticides applied on crops appears in the food chain. The analysis of samples of food and animal feed products produced in high pesticide use zones showed that a high proportion of these commodities contain pesticide residue beyond the maximum residue limits set for marketing and consumption [Khan et. al. (2002)]. Excessive use of chemicals is not only costly but the national health, environment, and ability of the country to export agricultural products in future are also at risk. The use of Integrated Pest Management (IPM) approach and techniques of biotechnology can reduce production costs and enhance quality of the products. There is also a need of establishing an effective network of chemical and toxic residues and quality testing labs in Pakistan. The use of biotechnology techniques to develop disease resistant varieties and integrated pest management technologies may reduce production costs and increase yields of various crops.

2.6 Poor Accessibility to Quality Inputs and Services

Most of the farmers in Pakistan, especially those operating marginal and small farms, generally lack access (physical as well as financial) to quality inputs and extension services and generally have to pay higher prices. Improvement in access of the farmer to these inputs and services would enhance agricultural production. Presently, institutional credit covers only 15 percent of the farmers and meets 30 percent of the total credit requirements. The formal financial institutions advanced an agricultural credit of Rs. 44 billion against a total credit requirement of Rs. 146 billion during the last year with the current year's target for loan disbursement fixed at 100 billion rupee. Moreover, the institutional lending is skewed towards large loans and farmers. The coverage needs to be increased with main focus on farmers operating farms of size 12.5 acres or less.

2.7 Limited Certified Seed Production Capacity

Seed production and distribution remained mostly in the public sector that mainly focused on major crops and here too had a limited capacity. Since 1994 role of private seed companies has significantly increased as a result of more liberal policy of the government. Presently 376 seed companies including four public sector seed agencies and five multinationals are involved in the seed business in Pakistan. The problem of seed adulteration, insignificant difference in yield performance of certified seed and farmers' own seed, and to some extent higher cost of certified seed are the main reasons that the farm level use of certified seed and seed replacement rate remained low. The Seed Act 1976 restricts production of pre basic and basic seed by the private sector while the capacity of production of pre basic and basic seed at the public sector agricultural research institutions is limited due to lack of funds, technical staff, seed processing plants, and seed storage facilities. There is a need to either amend the Seed Act 1976 incorporating changes that allow the private sector to start production of pre basic and basic seed or enhancing the capacity of research institutions to produce the pre basic and basic seed in sufficient quantities to meet the full requirement of the public and private sector organizations involved in seed production. We prefer the latter under which foundation seed production be continued at research stations with an effective private-public partnership where basic seed and technical guidance is provided by the research institutions and Federal Seed Certification and Registration (FSC&R) Department and actual seed multiplication by the private as well as public sector organizations with the following alternative arrangements:

a) On quantity of certified seed marketed by the private sector royalty or seed cess be charged by research institutions with a greater autonomy to use this money for seed production purposes and research or

b) Entering into a buyback contract with private companies for purchase of agreed quantity of seed of a specified quality of particular variety at a pre-settled price.

Presently, seed multiplication is mostly confined to few varieties of a small number of major crops. Certified seed for a wider range of varieties and other crops (major and minor) especially the fodders, oilseeds, and vegetables need to be produced and distributed. Moreover, the country lacks capacity in production of hybrid seed and strengthening of research efforts for development and commercialization of hybrid seeds varieties is needed. To start with hybrid seed for canola, sunflower, fodders, vegetables, flowers, rice, and wheat may be developed.

2.8 Government Interventions in Agricultural Markets

Heavy intervention by the government in agricultural markets did not let market forces to play their role and it failed to provide proper signals to the producers and incentive for private investors. As a result private sector investment in marketing infrastructure like storage and cold storage etc. remained limited and that too mostly confined to Punjab. The producers of crops like wheat, basmati rice, and cotton etc. were mostly offered lower than the world prices.

2.9 Declining Average Farm Size

The average size of farm reduced from 5.28 hectares in 1972 to 3.1 hectares in 2000 and the declining trend was observed in all the provinces after 1972 (Table 7). According to Agricultural Census 2000, farms of size 2 hectares or less (hereafter marginal farms) constitute about 58 percent of the total farms and operate only 16 percent of the total farm area whereas 5 percent of farms (of large size with farm area greater than 10 hectares) operated 37 percent of the total area (Table 8). The division of land as a result of law of inheritance is major factor resulting in reduced size of holdings. Thus increased numbers of farms are being operated as uneconomic holdings, which cannot provide acceptable levels of living to a large chunk of farming community. The farms of very large size may also be inefficient. Therefore, there is an urgent need to conduct studies determining optimal farm size and optimal cropping intensity in various agro-ecological regions of the country and to provide required incentives so that majority of farms move towards the optimal size.

Table7: Average Farm Size in Pakistan (in hectares)

Years	Punjab	Sindh	NWFP	Balochistan	Pakistan
1960	3.55	5.94	3.28	9.96	4.07
1972	5.29	5.12	3.69	10.16	5.28
1980	4.75	4.69	3.14	7.80	4.68
1990	3.71	4.34	2.21	9.63	3.78
2000	2.91	4.04	1.67	7.83	3.10

Source: Pakistan (2003a and previous issues)

Table 8: Percentage of Farm Numbers and Farm Area by Farm Categories in 1999-2000

Census year	2 hectares or less		2 to <5 hectares		5 to <10 hectares		Above 10 hectares	
	% farms	% area	% farms	% area	% farms	% area	% farms	% area
1980	34	7	40	27	17	25	9	41
1990	47	12	34	28	12	22	7	40
2000	58	16	28	28	9	19	5	37

Source: Pakistan (2003a)

3. LIVESTOCK AND INLAND FISHERIES SUB-SECTORS

There are five crucial factors for the development of livestock. These include good genetic potential, availability of feed resources, improved husbandry practices, effective disease control, and fair marketing. Government efforts in all these areas have been half-hearted and fall short of sector's needs and requirements. The development expenditure in livestock sub-sector has been minimal and has never exceeded 0.5 percent of the total development outlays indicating government's apathy towards livestock development [Afzal (no date)].

Pakistan has good milk yielding local breeds like Nili Ravi and Kundi in buffalo; and Sahiwal and Red Sindhi in cow. Unfortunately, neither the public sector nor the private sector took any significant initiative to improve these breeds through selection (or breeding) and maintain the purity. As a result, the interested dairy investors cannot get animals of needed breed in desired number from any place in the country. Moreover, a large number of high yield milk animals (mostly in their early prime stage of production) are transported from rural areas (especially of Punjab) to the peri-urban dairy centers working in suburb of large cities within or out side the province. These animals rarely come back and are often culled when run dry or smuggled. Theire young stock are slaughtered usually soon after the birth. This practice is a serious threat to the genetic resource of these breeds and need to be given a serious thought.

The country is 30 percent deficit in feed resources to sustain the existing livestock population. The animals are underfed and merely body maintenance requirements are being met with little left to be converted into milk or for rapid body growth. Green fodder along with roughages (crops by-products), weeds, and grasses are being fed to the animals with little supplement from home grown grains, kitchen wastes, some concentrates/commercial livestock feed etc. The roughages and fodders have poor nutritional values/digestibility and are rarely treated to improve these factors.

Milk is the major product of the sector and only a small portion of total production is marketed (through a long chain of intermediaries) for urban consumption and commercial processing. Absence of cooling centers, long distances involved, poor road infrastructure, inadequate transport facilities, and high diesel prices result in high transportation cost to the dairy gates and urban centers. The high prices of energy coupled with low capacity utilization and inefficient processing cause high prices of the processed milk and its products relative to the fresh milk or traditionally processed milk products. As a result the demand for processed products is discouraged and at the same time, farmers do not get due price for their produce.

For increasing meat supply, there is a need to develop local beef breed with high meat yield per animal. This will require increase in feed supply through encouragement of commercial production of cattle feed. At present the cattle feed industry is still in the early stage of development. The major constraints limiting livestock production include shortage of fodder coupled with its poor quality, poor genetic potential, nondescript breeds, long gestation period, long calving interval, lack of proven sires, low adoption of artificial insemination and vaccination, low yielding fodder varieties, inadequate health care, poor management practices, inadequate marketing facilities along with consumer price control, heavy initial investment requirements and low returns.

Fish production of inland sector is projected to increase at 6.2 percent growth rate per annum [MINFAL, PARC & FAO (2000)). Indus River and its tributaries, a large canal irrigation system, natural lakes and storage reservoirs besides farm fish pounds of varying sizes can generate high value added in the sector. The potential for inland fisheries in NWFP, Punjab, and Sindh provinces can be realized through development of aquaculture by promoting the private sector. The major problems and bottlenecks limiting inland fish productivity in the country are inadequate institutional and infrastructural facilities, lack of trained manpower, shortage of quality fish seed, non-availability of modern fishing gears, aquatic toxicity, shortage of proper storage and marketing facilities, and inadequate extension facilities.

4. AGRICULURAL PROCESSING

4.1 Milk Processing

Pakistan is ranked as the 5th largest milk producing country in the world. Buffaloes and cows contribute the major share to milk production and are raised in rural subsistence and market oriented smallholdings, rural commercial farms, and peri-urban commercial dairy farms. During the last two decades of the past century, milk production increased at a growth rate of over 6 percent. Despite a reasonable growth there are major concerns in the area of milk production faced by the dairy sector in Pakistan. The national average milk yield is quite low as compared to the potential yield demonstrated at the research stations or realized at progressive farms and in the developed and other developing countries (Tables 1). The animals are generally underfed and use of quality feed is limited. Only a small proportion of total milk production is marketed and the rural households traditionally process most of the produce to make “ghee” (butter oil) and other milk products. The raw milk marketed through a large chain of intermediaries often lack quality due to non-adoption of clean milk production practices at the farm level, lack of chilling facilities, use of substandard containers, and adulteration.

Small/cottage scale businesses as well as large-scale private companies are involved in the processing of milk in Pakistan. Presently, there are 38 major dairy plants in the commercial sector with a daily rated capacity of 2.18 million litres. However, only 13 plants are in operation with milk processing capacity of over one million litres per day. In addition, two military dairy plants are in operation on non-commercial basis. The capacity utilization of dairy plants in operation is around 40 percent mainly due to depressed demand for processed milk and milk products [Experts Advisory Cell (2003)]. Higher frequency of milk collection due to inadequate chilling facilities; increasing energy costs; inefficient milk collection, processing, and distribution system; and costly packaging result in high prices of processed milk and milk products relative to the fresh milk or traditionally processed milk products. As a result, the processed milk products have a depressed demand and there is considerable under utilized processing capacity in the industry.

Less than 2 percent of the total milk produced in the country is being processed at the dairy plants while in India 12 percent of the milk production is processed in the organized sector. The processed milk products include HTST pasteurized milk, UHT treated milk, condensed milk, dry milk powder, yogurt, butter, cheese, and some other milk product. About half of the available milk to the industry is processed into UHT milk, 40 percent into powdered milk, and the rest into other milk products like pasteurized milk, yogurt, cheese, and butter etc. Despite a fairly long list of processed products the diversification (flavor and fat based) byproduct extraction and value addition has been low. Especially, the value added cheese has the immense potential for local as well as the international market. However, to make it viable, the byproduct whey needs to be utilized fully for further product development rather than wasting.

4.2 Fruits and Vegetable Processing

The production of fruits and vegetables is increasing in Pakistan. However, low yields and inferior quality are frequent problems in horticultural crops. Non-standardized nursery plant, non-availability of disease free seeds, poor management and cultural practices, and high post harvest losses are the main issues related to production of fruits and vegetables. The availability of high quality planting material is a serious problem faced by the growers all over the country and even the growers who would like to procure better quality planting material are unable to do so. The post harvest losses are reported as high as more than 30-40 percent for horticultural crops causing a loss of over Rs.49 billion every year. Our horticultural farm products often have short shelf lives and the quality usually falls short of being suitable for processing. A long chain of marketing agents are involved before the produce reaches in the hands of final consumers. These marketing intermediaries claim a major share in consumers' rupee leaving the growers with very low returns. A major chunk of the total production of vegetables and fruits is consumed or exported in raw/fresh form and only a small proportion of it is processed.

In Pakistan, fruit and vegetable growing is highly dispersed with a large number of (usually small) farmers involved in production of these crops. They usually grow poor planting material of different species/varieties of fruits and many among them follow diverse and usually un-standardized cultivation practices. As a result, the quality of fruits and vegetables is not uniform. This affects quality of processed products and their acceptability by the consumers, specifically in the international markets. Moreover, no distinct varieties are being developed for table consumption and processing purposes. For example, mango which have firm pulp containing little if any fiber are most suitable for table consumption and mangoes with soft pulp (may be more of less fibrous) will be good for juice. The color of pulp may be less important in table mangoes and more important in juicy mangoes. Similarly, mangoes making raw material for pickles, jams and canned slices may be of totally different color, taste, and aroma.

In horticultural crops harvesting is mostly done manually with age-old tools. While the manual harvesting of fruits may continue, improved hand tools and with a possible training of the pickers to reduce fruit injuries during harvest may be employed. The use of effective pre-cooling techniques is rarely employed and most of the growers/contractors use conventional method of storing in shade and sprinkling it with water. Grading of the produce is done rarely and mostly by visual inspection. In main production areas for some fruits (e.g. citrus) and vegetable (e.g. potatoes), mechanical grading has started. The farm level storage facilities are improper and markets usually lack adequate cold storage capacity. The limited available cold storage capacity in the country is mostly confined to Punjab. The processors depend on a large number of markets and growers to meet their needs resulting in operational difficulties of coordinating with a large number of growers and monitoring raw material quality. The processing industry comprises of generally small cottage businesses though there are also large scale processing units. The traditional technologies used for preservation and processing especially in small units need to be improved.

Due to high prices of processed food items and seasonal availability of one or the other fresh fruit/vegetable throughout the year, demand for the processed products is low. The high energy and packaging costs are among the major reasons for high prices of processed products.

5. Agricultural Research in Pakistan

Pakistan has a sizeable national agricultural research system (NARS) consisting of federal as well as provincial research institutions. Overall, there are 74 research establishments at the federal level and 106 research institutions/agricultural research stations at provincial level [PARC (1996)]. Each province has its own commodity-based/multidisciplinary agricultural research institutes/research stations and substations, covering crops, livestock, forestry, and, in some cases, fisheries. There are 63 research establishments in Punjab, 22 in Sindh, 15 in NWFP and 10 in Balochistan [MINFAL, PARC & FAO (2000)]. The provinces have also established mono-crop institutes concentrating on specific crops.

All the provinces except Balochistan have agricultural universities where applied and basic research is a vital part of their academic activities. These universities are financed by the federal government through the Higher Education Commission (HEC) but are under the administrative control of the provincial governments.

The indicators of research staff and research funding sufficiency include ratio of agricultural scientists to population, percentage of Ph. Ds in total scientific manpower, per scientist funding, and agricultural research expenditures as percentage of agricultural GDP. In Pakistan agricultural research is poorly staffed and under funded in all the above senses. The proportion of agricultural scientists with Ph. D degree is only 10 percent in Pakistan, which is low compared to other developed and developing countries. The limited number of highly qualified scientists is not evenly distributed and about 50 percent of the Ph. Ds are located in universities, 33 percent in the federal institutions and the rest of them are in provincial research institutions [FAO-GOP (2002)]. This shows a severe lack of qualified manpower in provincial research systems.

In Pakistan, there were 44 agricultural scientists per million people during 1988 as compared to 2360, 1400, and 300 agricultural scientists per million people respectively in USA, UK, and Egypt [John Mellor Associates (1994)]. The number of agro-ecological zones, types of agricultural production systems, and 130 commercial crops that the country's agricultural research deals with, demands for a much greater number and more qualified scientific staff to be engaged in agricultural R & D activities [PARC (1996)].

The recent number of agricultural scientists and estimates on the level of funding for agricultural research are not readily available. The research expenditures per agricultural scientist in Pakistan were 8.9 thousand US dollars (240 thousand rupees) during 1980 as compared to 56.4, 30.2, and 21.8 thousand dollars per agricultural scientist respectively in Malaysia, Indonesia, and India (Annexure III). It came down to Rs. 194 thousands per scientist during 1992 in real terms (at 1990 prices).

Research funding level is around 0.2 percent of agricultural GDP as against 1.5 percent recommended by the Pakistan National Commission on Agriculture [Pakistan (1988)]. The ratio of salaries to operating cost is at about 85:15 compared to internationally accepted ratio of 60:40. Most of the budget allocation is meant for research on crops (mainly for the major crops) whereas disproportionately small amounts are allocated to research on livestock, horticultural crops, natural resource management, and fisheries etc. The share of agriculture in total PSDP/ADP declined from 12.78 percent in 1980-81 to as low as 0.13 percent during 2001-02 and at percent is 0.94 (Annexure IV). The share of agriculture in total PSDP should be increased to at least 6-8 percent if agricultural production has to be enhanced by a considerable margin.

It is also identified that the research system in Pakistan offers limited career growth opportunities and little financial incentives even to the highly qualified scientists [FAO-GOP (2002)]. The high level research leadership often lack skills of human resource management. There is rapidly aging profile of agricultural scientists and a continuous brain drain from the system. Most of the institutions lack access to quality literature and modern lab equipment to undertake quality research. The scientists have inadequate links with the international and national research and educational institutions, entrepreneurs, extension agents, and the farmers. The science gap is widening due to fast moving scientific development internationally. The present national research system is ill-equipped to meet even the present challenges not to speak of 2020 and beyond. Pakistan must introduce a more knowledge-intensive agricultural research system that focus on technological innovations at the system level and has access to modern biological sciences.

It is widely accepted that the conventional breeding, extensively used during the Green Revolution era, no longer offer any significant breakthroughs in the yield potentials and in providing solution to the complex problems of pests, diseases, and drought stress. The recent achievements in the field of biotechnology offer the potential to increase the crop and livestock productivity; improve nutritional quality, broaden crop tolerance against biotic and abiotic stresses, and enhance crop resistance against pests and diseases. The tools of modern biotechnology are precise and make development of new strains of improved crop and livestock more rapid [Asian Development Bank (2001)]. It is envisaged that the next breakthrough in agricultural productivity would be due to recent developments in plant molecular biology, genetic engineering, and rapid advancement in genomics [Zafar and Malik (2003)].

Traditional biotech activities particularly related to plant tissue culture have been carried out in few academic and research institutions of Pakistan since 1970s. An exclusive national center of Molecular Biology (CEMB) was established in 1983-84 at Lahore. The National Institute for Biotechnology and Genetic Engineering (NIBGE) started work at Faisalabad in 1994. During the past few years, there is growing interest in establishing Biotech centers in major cities. Despite all these developments, there is no coherent national policy regarding biotechnology in general and agriculture biotechnology in particular.

Agricultural Biotechnology: Agricultural Biotechnology R&D is suggested to focus areas of traditional biotechnology as well as modern biotechnology like genetic engineering and plant genomics. The techniques of modern biotechnology can be applied to diagnosis of pests, diseases, contaminants, vaccine development, and quality traits; micro-propagation to provide disease free plantlets of vegetatively propagated species (that do not readily produce seed); generating genetic markers, maps, and genomic information in marker assisted selection and breeding; and in developing transgenic plants with higher yields, disease and pest resistance, tolerance of environmental stresses, and improved nutrition in crops.

The agriculture sector has so far not benefited from the full potential of tissue culture technology except potato and to some extent in banana, as research effort at public and private levels is small. The size of these efforts in term of researchers and financial resources are still very small and unable to reach commercial scale in other plants.

Biological pest control is another promising area for research in agricultural biotechnology. The high use of chemical pesticides to control pests and diseases has not resulted only in high production costs but also has serious implications for environment and national health. The chemical pesticides are highly inefficient as most of the sprayed chemical are washed away from plant surface and end up in the soils. The chemical residues have already started appearing in our food chain and feeds of livestock. In these circumstances, it is particularly important that efforts are made to substitute chemical pesticides with bio-pesticides, which are environmentally friendly and are more target specific (do not destroy beneficial organisms) and do not leave harmful residues.

In Pakistan, soils are generally deficient in organic matter and essential plant nutrients, due to high temperature and intense microbial activity. The application of organic fertilizer (farmyard manure and green manure) is limited and that of chemical fertilizers is increasing. This coupled with unbalanced use and faulty management practices the fertilizer efficiency is quite low. It results not only in rising production costs but also in degradation of land and water resources. The development and use of bio-fertilizers in combination with organic and chemical fertilizer may improve crop yields, reduce costs, and conserve land and water resources. In Pakistan, the government directly or indirectly supports much of the production of bio-fertilizers. NIAB/NIBGE, Faisalabad, NARC, Islamabad, University of Agriculture, Faisalabad and several provincial institutes are involved in research on bio-fertilizers.

The demand for bio-fertilizers is nominal due to poor and uneven quality, short shelf life, absence of distribution system, and small contribution to crop yield. The research efforts to increase the shelf life and effectiveness of bio-fertilizers through genetic manipulation of strains are crucial for enhancing acceptance and use of bio-fertilizers in the country.

The modern biotechnology has widened the range of useful traits that can be applied to develop new varieties by the virtue of technical ability to transfer genes conveying desirable traits from any organism into any other. Moreover, it reduces time in which desired changes in plant characteristics can be made to about half of that required through traditional methods. These techniques can be applied to develop disease and insect resistance, tolerance to abiotic stresses, product quality, and increasing yield potential. Incidence of pest and insect attacks, diseases, drought, high temperature, and salinity/sodicity are among the most important constraint to agricultural production in Pakistan. Development of varieties resistant to pests and diseases and with improved tolerance to abiotic stresses should be the main focus of future crop breeding research.

In Pakistan, crop improvement efforts using modern technology started as early as 1985 at CEMB, Lahore and later NIBGE initiated genetic engineering of plants during early 1990s. Most of the activities are related to rice and cotton but recently tomato and potato are also taken up. Although transgenic plants have been developed at these centers, work on field evaluation is blocked due to absence of biosafety rules. Further, delay and uncertainty is expected due to actual performance of genetically engineered crop in the field and difficulties to protect it from further use by various public and private seed agencies. According to the most optimistic estimates, it will take at least 2-3 years before plants with desired traits can be produced and used in breeding programs [Zafar and Malik (2003)].

The delivery of the products is strictly regulated by various international conventions thus co-current national capacity building for application of biosafety guidelines, handling of GM products and import/export of GM crops/foods are equally important and vital for its commercial applications. The national efforts except development of GM crops are much below the desired level.

Construction of genetic linkage maps is fundamental step for detailed genetic study and marker assisted breeding approach in any crop. In Plant Genomics, the country is yet to take a start. NIBGE, Faisalabad, has conducted research for estimating genetic diversity among different crop plants. Efforts are being made to develop genetic linkage maps for different traits of interest in cotton as well as of wheat. The uplift of the genomic research in the country is needed.

6. CONCLUSIONS AND RECOMMENDATIONS

Agriculture is the largest sector of the economy and would stay important for quite some time. The higher growth rate for the agriculture sector than performed in the past is imperative for a rapid overall growth of the economy, macroeconomic stability, employment generation, and reduction in rural poverty in Pakistan. The leading factors in terms of their contribution to agricultural growth in the past are less likely to play the same important role in growth of the sector in future. The shortage of irrigation water would be the most limiting factor in the coming years and there is a dire need to maximize output per drop of water through developing/adopting water conserving technologies, enhancing irrigation efficiency, and rationalizing the acreage under crops that use water more extensively and in which the country does have comparative advantage. Additional reservoirs need to be built soon to store every drop of water in excess of what is required to regularly flow in the sea for deltaic conservation. Of course, this optimal flow requires a proper quantification by the impartial experts/agency.

The expansion of cultivated area has already slowed down. The culturable waste lands of 9 million hectares may offer good opportunity for bringing in more lands into production however it would require huge investments and enhanced water availability. Improvement of 1.83 million hectares of cultivated saline/sodic lands being in canal commands may make a cheaper potential source. The factors like higher cropping intensity, increased fertilizer, and intensive use of pesticides are expected to play relatively a less important role in future. Thus Pakistan has to rely more heavily on productivity enhancement through technological change and improvement of technical efficiency for the desired rapid agricultural growth in future.

While the conventional breeding need to be continued in future it no longer offer any significant breakthroughs in the yield potentials and in providing solution to the newly emerging complex problems like pests, diseases, and drought stress. Therefore, the application of recent advances in the field of agricultural biotechnology is crucial to increase the crop and livestock productivity, improve nutritional quality, broaden crop tolerance against biotic and abiotic stresses, and enhance crop resistance against pests and diseases. The tools of modern biotechnology are more precise and involve shorter time for development of new strains of improved crop and livestock. It is envisaged that the next breakthrough in agricultural productivity would be due to recent developments in plant molecular biology, genetic engineering, and rapid advancement in genomics

The national agricultural research system (NARS) is poorly funded, ill equipped, weakly linked with international and national stakeholders, thinly staffed with mostly low capacity and unmotivated scientific manpower, lack autonomy, and generally mismanaged. The NARS cannot deliver up to the future expectations without funding at a higher level, essential human resource development, provision of modern laboratories and good library facilities, creation of a nice working environment, and offering the scientists good career opportunities and financial incentives.

Various issues identified/discussed in previous sections and the suggested R&D efforts and other essentials are summarized in the following

Low Yields and Unachieved Potential

Issues	Actions/Technologies
➢ 67 to 83 75 % unachieved potential with existing technology Extension Gap= 31-75% Research Gap= 25-57% Gap world's Highest Avg.= 50-83% ➢ Stresses like drought, high temperature, and pest and diseases reduce yields ➢ Inadequate and poor quality seed production: ➢ Formal seed industry produces seed for few varieties of certain crops ➢ Meets only 40% of yearly seed requirements ➢ Costly hybrid seed and monopoly of multinationals ➢ Low exploitation of potential in organic farming ➢ Increasing costs/use of pesticides/ fertilizers and their adverse effects on health and environment ➢ Low use of agricultural biotechnology and limited capacity in research ★ *Lack of bio safety regulations* ★ *Insufficient institutional credit*	➢ Strengthening of agricultural extension system ➢ Development of HYV varieties resistant to biotic and abiotic stress (use of agricultural biotechnology) ➢ Strengthening seed production and distribution system ➢ Development of hybrid seeds ➢ Production of virus free seed through tissue culture ➢ Development of technologies for organic food production ➢ Development of effective bio-fertilizer ➢ Search of novel bio-pesticides with improved efficacy, potency, and increased shelf life ➢ Development of genome maps ➢ Strengthening plant genomic research ★ *Approval and enforcement of bio safety regulations* ★ *Increased supply of institutional credit at competitive rates.*

Degradation of Land Resources: Nutrient Mining and Salinity

Issues	Actions/Technologies
➢ Mismanagement of plant nutrients and declining soil fertility ➢ Unbalanced fertilizer use ➢ Slight to moderate salinity/sodicity on Area : 1.83 million Ha Losing: yearly Rs. 21 billion of GDP ➢ Tube wells pumping brackish water 70 % tube wells -- adding to salinity ➢ Nutrient/fertility status of most of soils unknown Low fertilizer use efficiency, yield, and quality of produce	➢ Integrated plant nutrient system (IPNS) ➢ Gypsum application for treatment of saline / sodic lands ➢ Crop and soil nutrient indexing

Inefficient Use of Irrigation Water

Issues	Actions/Technologies
➢ Low field level water use efficiency Unleveled fields and traditional irrigation ➢ Low overall irrigation efficiency: Overall water losses = 60% Watercourse level = 50% of total losses Canal level = 33% of total losses ➢ Deteriorating canal system due to lack of funds for proper O&M Burden on Govt. exchequer	➢ Using of laser leveling technology ➢ Water conserving irrigation technologies ➢ Lining of canals and water channels ➢ Studies on proper water pricing reflecting scarcity of resource

Low Milk and Meat Yields per Animal

Issues	Actions/Technologies
➢ Low milk yield: Extension Gap=61% Research gap=52% Gap world's highest Avg.= 78% ➢ Underfed livestock: Feed shortage by 30-40% ➢ Infectious diseases outbreaks Vaccination only 10% ➢ Large number of non-descript breed: 70% cattle ➢ Low use of artificial insemination Only 10% ➢ Lack of breeds for mutton and beef production	➢ Improvement of local breeds of buffalo and cows ➢ Vaccine development ➢ Improvement of non descript breeds through artificial insemination ➢ Strengthening/up gradation of semen production units ➢ Development of beef and mutton breeds ➢ Promotion of balanced feed for milk production ➢ Fodder and range land management

High Post Harvest Losses

Issues	Actions/Technologies
➢ High post harvest losses: Range in Fruits/Veg. =12 to 40% Yearly loss: Fruits = 31 billion Vegetables 18 billion ➢ Short shelf life of fruit and Vegetable varieties ➢ Lack of cold chain infrastructure	➢ Improvement of post harvest handling technologies ➢ Development of storage, cold storage, and transport infrastructure ➢ Improving shelf life of fruits & vegetables

Lack of Proper Quality Control System

Issues	Actions/Technologies
➢ Lack of proper quality control system ➢ Inadequate number of quality testing labs	➢ Establishment of 16 quality testing and residue testing labs

Weak National Agricultural Research System

Issues	Actions/Technologies
➢ Poorly funded agricultural research Research budget = 0.2 % of Agri. GDP Ideal = 1.5 % of Agri. GDP ➢ Share of Agri. in PSDP declined from 12.8 % in 1980-81 to 0.13 % in 2001-02. Currently 0.94 % ➢ High Establishment Expenditures: Est. to Non-Est. Expenditure ratio = 85:15 Ideal = 60:40 ➢ Small number of Ph D scientists unevenly distributed Ph D scientists only 10% mostly in Universities and federal institutions ➢ Lack of lab equipment and library facilities ➢ Poor service structure and lack of incentives	➢ Human Resource Development for NARS ➢ Access to digital library facilities ➢ Upgrading of laboratory facilities ➢ Service structure for NARS scientists similar to PAEC

Low Exploiting of Potential of the Inland Fisheries

Issues	Actions/Technologies
➢ Limited institutional/human resource capacity ➢ Poor quality fish seed ➢ Over exploitation of shrimp resources ➢ Lack of proper fish feed	➢ Strengthening of fisheries research ➢ Improving the quality of fish seed ➢ Aquaculture and cage culture for shrimps ➢ Use of brackish water for fish production ➢ Development of fish feed

Milk Processing

Issues	Actions/Technologies
➢ Low proportion of milk production processed Processing = only 2% ➢ High price of processed milk depress demand ➢ Most of milk production not marketed due to lack of chilling facilities ➢ Large unutilized processing capacity Out of 38 major plants only 13 operate Out of 10 powder milk plants 6 operate at 50% capacity ➢ High collection, processing, and packaging cost ➢ Limited product diversification and low extraction of byproducts	➢ Milk chilling units at village level and use of LPS for milk preservation in remote areas ➢ Promotion of demand for processed milk and powder milk ➢ Product diversification ➢ Development of packaging capacity

Fruit and Vegetables Processing

Issues	Actions/Technologies
➢ Lack of certified nurseries and poor quality planting materials ➢ Heterogeneous quality of horticultural produce ➢ Limited grading and faulty packaging ➢ High cost of processed products ➢ Limited cold storage capacity	➢ Establishment of certification system for nursery plants ➢ Establishment of irradiation plants ➢ Development of grading and packaging capacity ➢ Development of cold chain

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Annexure I: Cropping Intensity at Various Farm Sizes (Percent)

Province and Farm Sizes	1980 Census	1990 Census	2000 Census
Punjab			
Private Farms Total	123.60	141.48	154.15
Under 2.0	143.11	160.30	168.95
2.0 to under 5.0	130.73	148.15	159.89
5.0 to under 10.0	122.22	138.13	151.48
10.0 and above	115.40	131.35	141.22
Sindh			
Private Farms Total	129.52	139.91	129.60
Under 2.0	157.12	161.31	145.63
2.0 to under 5.0	140.86	150.52	140.06
5.0 to under 10.0	123.49	130.52	130.52
10.0 and above	112.13	126.07	113.63
NWFP			
Private Farms Total	120.59	132.06	141.51
Under 2.0	154.56	156.36	160.27
2.0 to under 5.0	133.63	138.69	144.67
5.0 to under 10.0	114.34	121.69	126.72
10.0 and above	90.42	102.16	112.15
Balochistan			
Private Farms Total	31.51	94.38	77.86
Under 2.0	38.41	107.64	91.62
2.0 to under 5.0	34.67	105.10	92.61
5.0 to under 10.0	33.52	98.84	82.92
10.0 and above	29.29	89.25	68.68
Pakistan			
Private Farms Total	121.71	136.66	142.14
Under 2.0	146.23	158.51	161.54
2.0 to under 5.0	131.86	145.89	151.07
5.0 to under 10.0	120.06	132.93	140.20
10.0 and above	109.19	122.68	123.79

Source: Pakistan (1983, 1993, and 2003)

Annexure II: Fertilizer Consumption in Selected Countries (Kgs per Hectare)

Year	Netherlands	Germany	Japan	France	Egypt	Italy	USA	USSR	Pakistan	India
1979-80	805	479	478	312	212	189	111	75	51	30
1980-81	789	471	372	301	232	170	112	81	53	31
1981-82	767	418	387	298	248	163	102	83	53	39
1982-83	738	435	412	299	335	161	87	87	61	35
1983-84	789	431	437	312	361	169	105	99	59	39
1984.85	841	445	452	326	387	178	126	-	63	-
1985-86	770	428	427	309	319	169	92	114	86	57
1986-87	688	421	433	299	351	190	93	182	83	54
1987-88	702	433	491	328	388	254	95	120	83	53
1988-89	685	468	468	335	448	231	94	119	84	67
1989-90	663	467	467	341	452	201	100	109	91	70
1990-91	610	394	451	316	401	200	96	111	92	72
1991-92	599	-	431	309	405	220	71	85	91	77
1992-93	599	239	395	253	339	156	101	42	101	72
1993-94	560	221	407	237	-	148	108	-	97	73
1994-95	554	240	400	242	304	159	103	12	103	80
1999-00	-	243	-	248	355	-	-	-	117	99
2000-01	470	232	-	225	-	211	106	-	138	103

Source: Pakistan 2003a. Data from 1995-96 to 1998-99 not available
Note: - Not Available

Annexure III: Research Expenditure per Scientist in Selected Asian Countries (1980)

Country	Thousand US dollars
Malaysia	56.4
Papua New Guinea	45.9
Indonesia	30.2
India	21.8
Bangladesh	16.2
Philippines	15.5
Thailand	15.3
Nepal	12.4
Sri Lanka	10.9
Pakistan	8.9

Source: Azam et. al. (1991)

Annexure IV: Share of Agriculture and Water in Total PSDP/ADP

Years	Amount in million rupees			Percent Share		
	Agriculture	Water	Total	Agriculture	Water	Agriculture + Water
1980-81	3340	1616	26137	12.78	6.18	18.96
1981-82	3427	2808	27000	12.69	10.40	23.09
1982-83	3457	3840	29563	11.69	12.99	24.68
1983-84	2798	3381	28161	9.94	12.01	21.94
1984-85	2920	3541	32606	8.96	10.86	19.82
1985-86	4435	4589	37576	11.80	12.21	24.02
1986-87	3221	4129	42579	7.56	9.70	17.26
1987-88	3493	4538	46548	7.50	9.75	17.25
1988-89	3990	3389	47844	8.34	7.08	15.42
1989-90	3012	5440	57705	5.22	9.43	14.65
1990-91	3042	6815	88412	3.44	7.71	11.15
1991-92	3692	5554	89629	4.12	6.20	10.32
1992-93	3461	8461	119890	2.89	7.06	9.94
1993-94	2164	12265	145252	1.49	8.44	9.93
1994-95	2004	14109	153720	1.30	9.18	10.48
1995-96	1561	14947	172816	0.90	8.65	9.55
1996-97	1210	15740	139743	0.87	11.26	12.13
1997-98	940	11233	141495	0.66	7.94	8.60
1998-99	431	12319	152707	0.28	8.07	8.35
1999-00	540	11380	148767	0.36	7.65	8.01
2000-01	820	11596	150325	0.55	7.71	8.26
2001-02	168	16177	130000	0.13	12.44	12.57
2002-03	797	10914	134000	0.59	8.14	8.74
2003-04	1500	14689	160000	0.94	9.18	10.12

Source: Pakistan 2003b (Statistical Supplement)