Assigned by Ministry of Agriculture, Forestry and Fisheries

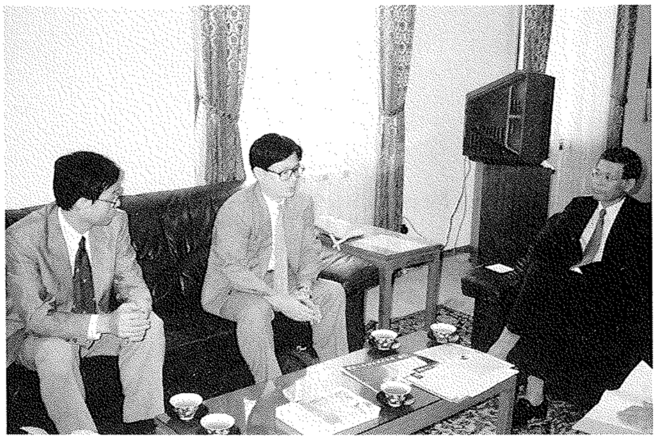
Report on the Basic Survey on Agricultural and Rural Development by Progress Stage in Asian Countries

——— Pakistan ———

(Focus on Punjab)

MARCH 1996

The Asian Population and Development Association



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Pay courtesy to Ambassador.
From Left ;
H.E. Mr. Takao Kawakami,
Ambassador ;
Dr. Seiichi Fukui, Team Leader ;
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Pay courtesy to Mr. Abdul Rauf
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Briefing from Dr. Zafar Altaf,
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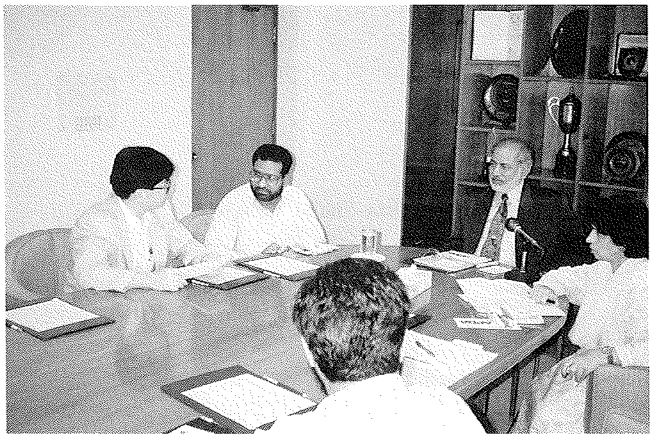
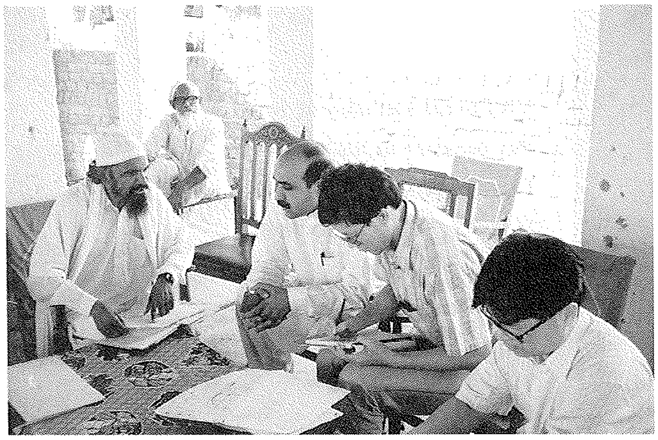
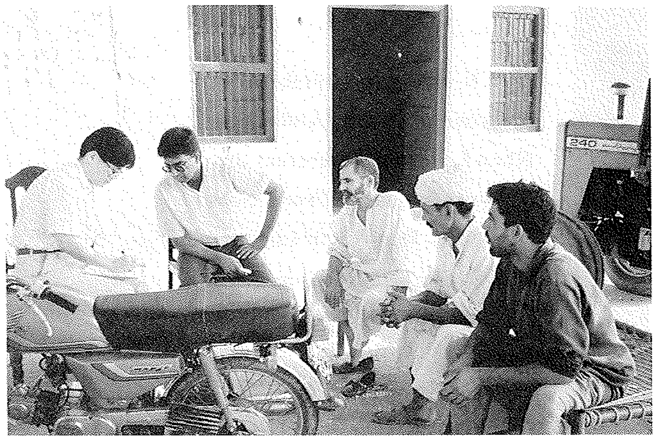
Dr. Hiroaki Sumida, Team Member.



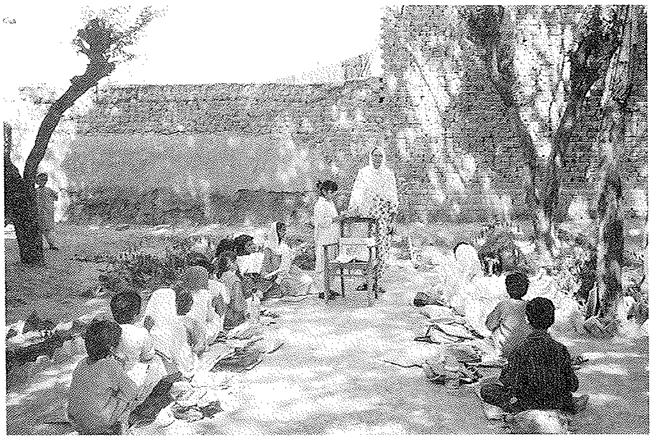
Visit to Pakistan Agricultureal
Research Council (PARC)
Second from Right ;
Dr. C.M. Anwar Khan,
Chairman, PARC.



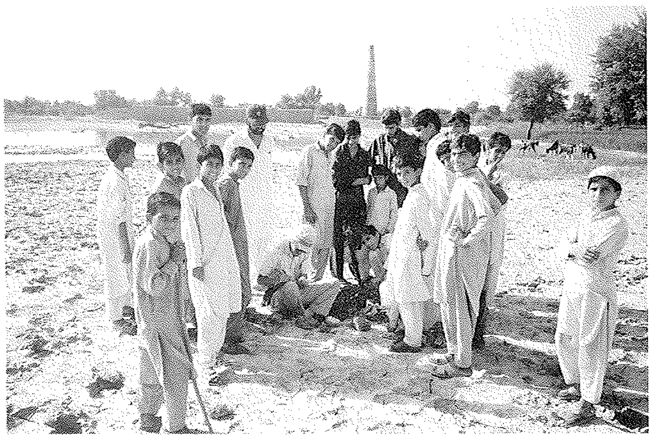
Hearing form Patwari,
Field Survey at Village K



Hearing from Farmers,
Field Survey at Village K



Girls Primary and Secondary
School at Village A



Survey on Saline Soil at Village A

Foreword

This report presents the results of the "Basic Survey on Agricultural and Rural Development by Progress Stage in Asian Countries," consigned by the Ministry of Agriculture, Forestry and Fisheries in 1995, and entrusted to be implemented by the Asian Population and Development Association (APDA) for Pakistan. The survey and compilation of the results were carried out mainly by members of APDA's survey committee (Chairperson: Dr. Shigeto Kawano, Professor Emeritus, the University of Tokyo).

The survey was conducted to pursue the following objective: "In extending assistance in terms of agricultural and rural development to Asian countries, it is neccessary to consider structural changes in the population and rural development to Asian countries, it is neccessary to consider structural changes in the population and employment of agriculture and rural regions, to clarify the fields of agricultural and rural developmental assistance, the forms of assistance and the regions to receive assistance according to the stage of development and in keeping with the country's policy issues for the comprehensive promotion and improvement of rural areas, and to offer effective and efficient assistnace accordingly.

"For this goal, a survey will be conducted in a model district selected from among Asian nations to study the forms of agricultural and rural development according to structural changes in the population and employment, thereby contributing to policy dialogue regarding agricultural and rural development."

The Field Survey in Pakistan was conducted with the guidance and cooperation of Hon. Mr. Syed Zafar Ali Shah, Deputy Speaker, National Assembly of Pakistan, Mr. Abdul Rauf Khan Lughmani, Secretary of National Assembly, National Assembly Secretariat, Mrs. Mahe Talat Naseem, Director General, Center for Research and Library, National Assembly Secretariat, as well as Ambassador Takao Kawakami, Mr. Hiroshi Fukada, Minister and Mr. Koji Yamada, First Secretary of the Japanese Embassy in Pakistan.

In Japan, members of the International Cooperation Planning Division, Economic Affairs Bureau, the Ministry of Agriculture, Forestry and Fisheries, and Aid Policy Divisions, Economic Cooperation Bureau, the Ministry of Foreign Affairs, cooperated in the Guidance of the survey substance and arrangement of the field survey. I would like to extend my deepest gratitude to these people.

I sincerely hope that this report will contribute to the advancement of the rural community and agricultural development programs in Pakistan, as well as support the Japanese government's cooperation there in an effective manner.

Furthermore, I would like to note that this report was compiled by and is the sole responsibility of the APDA, and does not necessarily reflect any views or policies of the Ministry of Agriculture, Forestry and Fisheries or the Japanese government.

March, 1996
Fukusaburo Maeda
Chairman
The Asian Population and Development Association

Contents

Chapter 1

Agriculture in Pakistan

1 Agriculture and Rural Economy of Pakistan

(1) Introduction

Located between 24° and 37° north latitude and between 61° and 76° east longitude, Pakistan has a climate that falls under the category of subtropical steppe belt. To generalize Pakistan's regional characteristics according to its topographic environment, the country consists of the Indus Plains, where climate is very dry and people have lifestyle that depends on the rivers for water, and the foothill/mountainous region where people do not depend on rivers and mainly use rainwater and water from wells. Land area is 796,100km^2 of which 26% is utilized as agricultural land.

Agriculture is the key industry of this country where farm products account for 76% of total amount of export. On the other hand, this agricultural land has to support an estimated population of 124.45 million as of 1994 which is increasing at an annual rate of 3%. The main area for agricultural production in this country is the Indus Plains which is blessed with rich natural environment of a delta region that spreads around a large river basin, suggesting a high agricultural production potential. However, productivity of farm products is at an extremely low level. In particular, the output of wheat (which is staple food) and rice (which is export grain) remains at 70 to 80% of the world average. In addition, considerable disparity in farm product output exists not only within the country but within the same region.

While economic and social structures are major causes of this situation, natural environment including climate and soil as well as farming techniques such as irrigation also play an important role. In this chapter, the disparity in agricultural production will be analyzed from the viewpoint of natural environment and farming techniques.

(2) Overview of Agriculture and Rural Economy

① The Pakistani economy maintained an annual growth rate of more than 5.25% over the period of 1949-50 to 1994-95 [Pakistan (1995b)). Compared to a population growth rate of nearly 3.0% per annum, the annual growth of per capita would exceed 2.25%. It may however, be noted that Pakistan's growth rates have consistently fallen with passage of time and are a cause for serious concern. For example, although the growth rates had accelerated from near stagnation in the '50s to 6.75% per annum in the '60s, they had plummeted to less than 5.0% during the decade of the '70s. The process of growth deceleration continued into the '90s, as the annual growth rates exceeded no more than 4.0% during the '80s and 3.3% from 1989-90 to 1994-95 [Pakistan (1995b)].

Agricultural sector has been the food mill of millions of Pakistanis who have grown at a tremendously sharp rate of 3% per annum and are currently estimated at 13 million. Although food supply was not necessarily sufficient, agriculture played a role of supplying cheap food for the growing population and has even a greater role to perform in the future. While agriculture's share in Pakistan's total output has been falling, it still is the largest commodity producing sector accounting for as much as 24% of the national income. In regard to employment structure, agriculture provides employment to more than half of Pakistan's labor force and the livelihood of the 70% population residing in the rural areas depends directly or indirectly on the agricultural sector. Furthermore, agriculture has been the gold mine of foreign exchange permitting capital imports for the uplift and development of the modern industrial sector. Almost the entire exportable surplus originates from agriculture in the form of primary products, semi-manufactures and manufactured goods. As much of Pakistan's industrial sector is based on raw materials from agriculture, trends in industrial sector must be determined by what happens to agriculture. For instance, it is difficult to think of any economic activity in an industrial sector that is heavily dependent on textile without some production of cotton. Likewise, progress of industrial sector would require the ready availability of a large market endowed with considerable purchasing power.

Agriculture has been and still is the largest commodity producing sector of the economy. Compared to the manufacturing sector's share of 18.5%, agriculture accounted for 24% of the national income in 1994-95. While crop production subsector accounted for nearly 62% of value added in agriculture, it is further subdivided into major and minor crop production subsectors with respective shares of 44 and 18%. In the same year, the livestock sector was responsible for another 33% of the share in agriculture's value added. While the forestry subsector had only an insignificant contribution of less than 1.0%, the fisheries subsector accounted for nearly 4% of agriculture's value added. It is worth noting that while the share of crop production subsector in value added by agriculture has been failing with passage of time, there has been a corresponding and consistent upward trend in the share of the livestock subsector owing to rapid growth of the latter relative to the former sector.

Because of diverse climatic and topographic conditions, a wide variety of crops, fruits, vegetables and condiments and spices can be grown. As for area allocation of land to main crops, wheat occupies more than 36% of the total cropped area. The respective shares of cotton, rice sugarcane and maize amounted to 12.7%, 9.9%, 4.3% and 4.0%. Thus the five major field crops accounted for more than two-thirds of total cropped area, while pulses (7%) other food-grain crops (8%), fruits and vegetables (2%), oilseeds (2%) and other crops including fodder (15%) held rest of the cropped area,

Among these wide varieties of crops, only a few are grown exclusively for commercial purposes or for the market. In the case of food grains, almost the entire produce is consumed by farmers. This would be especially true for small farm agriculture. However, crops such as cotton, sugarcane, fruits and vegetables are shipped almost exclusively to the market for hard earned cash. In case of a staple commodity like wheat, nearly 30-40% of the farm produce is generally labeled as marketed surplus [Cornelisse and Naqvi (1987)] which is mainly intended for the domestic market. As for rice, IRRI rice, a high yield variety, and basmati rice, a native variety, are the two main varieties. Basmati rice plays an important role in export. While it accounts for only about 20% of rice export in terms of volume, it brings in 50% of the income as it is traded at higher prices than other rice varieties.

The greatest problem of agriculture in Pakistan lies in its low productivity with yields of agricultural commodities being considerably lower than the world standard. For instance, Pakistan's yields were only 75 to 80% of the average world yields in crops such as wheat, cotton, rice and sugarcane. The yields of maize and soybeans were even lower at 40 and 25%, respectively, of world levels. For instance, compared to France and Mexico, wheat yields of Pakistan were only 29 and 42%, respectively. The rice, cane and cotton yields in Pakistan had been 38, 46 and 50% of those in Egypt, respectively. Let us compare the figures from the Punjab Province of Pakistan with those from the Punjab Province of India which lies adjacent on the other side of the border (Table 2).

While the growth of value added by agriculture has remained at 3.45% between 1949-50 and 1994-95, growth of productivity was only 2.30% per annum. Only two-thirds of this can be attributed to productivity growth and the rest came from increase in area. The fact that is particularly worthy of note is that productivity growth, like growth of value added by agriculture, has been tapering off with passage of time. The growth of agricultural productivity, which peaked at 5.13% per annum during the decade of the 1960s, fell to less than 0.80% between 1969-70 and 1979-80, rose to almost 2.0% during 1979-80 to 1989-90 but exceeded no more than 1.36% per annum over the period of 1989-90 to 1994-95 [Pakistan (1995a, 1995b, 1990, 1982)]. While these trends in agricultural productivity can be explained by reference to world events and changing weather conditions, there can be little doubt that the main cause of the faltering trends of agricultural productivity must be the adverse government policy towards agriculture.

As can be seen from Appendix 1, livestock sector, which accounts for more than 30% of value added in the agricultural sector, is a sector that has been showing rapid growth after entering the '80s and will continue to grow in the future. Work cow continues to play an important role as source of power for land preparation and transportation amidst the advancement of mechanized agriculture using tractors and buffaloes are mainly raised for their milk. The importance of livestock industry is worthy of attention from all perspectives including diversification of agriculture, diet, nutrition and agricultural capital.

② Structure within rural areas.

Let us review the realities of land ownership by using the latest agricultural census conducted in 1990. Firstly, as for distribution of land ownership, large landowners, which account for 7% of 4.83 million rural households owning land, control about half of farmland. Fourteen percent of all landowners are non-cultivating landowners that do not cultivate land themselves. They rent 3.16 million hectares of tenant land which accounts for 63% of total tenant land area. There are also considerable number of landowners who are engaged in farming themselves but rent part of the land that they own. Sixty-nine percent of farm households are independent farmers, 12% are semi-independent farmers and 19% are tenant farmers who do not own land and are farming on land that they have rented from others.

There are also a large number of non-farm households in rural areas with no commercial farms, totaling 8.52 million households in number. They consist of 2.58 million stock farming households that own 1 or more cow or buffalo and 5 or more sheep or goat, and 5.93 million other households. While a very small portion of these 5.93 million households are non-cultivating landowners, the remainder are agricultural laborers and rural general workers who comprise the poorest class in farming villages. They traditionally belonged to a class of artisans called Kammee in a class system called seeyp and included professions such as blacksmith (lohar), carpenter (tarkhan), pot maker (kumhar), barber (machhi), shoemaker (mochi), tailor (darzi) and cleaner (dhobi). These households were also the main suppliers of agricultural employed labor. However, their form of employment is rapidly changing as a result of diffusion of education and increase in opportunities for non-agricultural employment in the recent years, and the number of people engaged in non-agricultural paid labor and small-scale independent business instead of traditional hereditary occupation is increasing. Significant number of people also go to Middle East to work. These changes are particularly conspicuous in advanced agricultural regions and farming villages that are located in the suburbs of cities.

(3) Agricultural Policy

① Agricultural price policy

Since independence in 1947, the Government has intervened considerably in the agricultural price policy. In the '50s, for example, most of the agricultural commodities were subjected to compulsory procurement at substantially less than world prices [Aresvik (1967)). Interdistrict movement and exports of major agricultural commodities, with the exception of cotton, were also banned [Turvey and Cook (1976)]. Both procured and imported quantities of wheat and sugar were subsidized for urban consumers [Alderman, Chaudhry and Garcia (1988)]. A considerable overvaluation of the Rupee was maintained to encourage industrial imports, with adverse effects on agricultural exports. This policy was considerably relaxed in the middle of the First 5-Year Plan. Although the ban on exports and movement was limited to grains, overvaluation of the exchange rate continued and the government began to guarantee world prices of agricultural commodities, at least, at the level of international prices evaluated according to the official exchange rate [Aresvik (1967)]. The policy of compulsory procurement was replaced by voluntary sales, and a policy of liberal subsidies on fertilizers, pesticides, tubewells, tractors and improved seeds of agricultural commodities was also instituted [Kuhnen (1989)].

However, price policy favoring the agricultural sector that was launched during the First 5-Year Plan was reversed in the beginning of the '70s following the major devaluation of the Rupee in 1972 [Haque (1993)]. As a result of devaluation of the Rupee, the controlled prices of agricultural commodities fell short of the international price standard [Chaudhry (1980)]. Although the same should be expected with respect to input prices, a more than tripling of fertilizer prices was undertaken to curtail the burden of subsidies on the government exchequer. In view of the world energy crisis, similar, though somewhat less pronounced increases in the prices of oil and gas, electricity and pesticides also occurred. Furthermore, trade in agricultural commodities increasingly became an exclusive monopoly of parastatal organizations such as Pakistan Agricultural Storage and Services Corporation (PASSCO) and Rice Export Corporation of Pakistan (RECP) as they handled procurement, import, export and distribution of agricultural commodities. Under the nationalization program, both the production and distribution of key agricultural inputs also rested with the government.

In the beginning of the '80s, it different set of conditions determined the fate of agricultural price policy. Under the World Bank/IMF structural adjustment program, the government committed itself to bring input and output prices closer to world levels, reduce public expenditure and enhance the role of the private sector [World Bank 1991)]. As a result, a number of changes in policy became inevitable. For instance, explicit subsidies on pesticides, seeds and mechanization were withdrawn in one step in the early '80s and a phased program of removal of fertilizer subsidy was instituted, resulting in periodic increases in fertilizer prices. In the period that followed, explicit subsidies fell consistently since 1979-80 and totally vanished by 1994-95. By contrast, total subsidies continued to grow, due largely to rapid growth of implicit subsidies and began to taper off only after 1992-93 (Table 1).

The Rupee was further devalued and Pakistan moved from a policy of fixed exchange rate to a policy of managed float for determining the value of the Rupee from time to time in relation to major world currencies. In view of rising input costs, the prices of major agricultural commodities were periodically adjusted to cost of production estimates. The government also remained committed to enhancing the role of the private sector in the procurement and distribution of agricultural commodities and inputs. For instance, the ration-shop system was dismantled in 1987 [Alderman, Chaudhry and Garcia (1988)]. Private traders were inducted in the export and import of agricultural commodities, and procurement of rice and cotton was opened up to the private sector. The distribution of pesticides was handed over to registered dealers. Similar steps were also taken in the case of fertilizers, although the government remained a major distributor.

Despite the emphasis on structural adjustment reforms throughout the '80s, the creation of a distortion-free agricultural sector still remains in the offing. Although there is growing evidence that parastatals are usually more concerned with their own well-being rather than the welfare of the consumers and interests of the farmers [Bale (1985)], public corporations continue to intervene in agriculture. The Government also controls the external trade in all major agricultural commodities [World Bank (1991)]. To make such controls effective, the government continues to operate procurement, storage and distribution of major agricultural inputs and commodities. In order to avoid opposition from politically powerful urban consumers and industrialists, the Government will have to avoid raising agricultural commodity prices to world levels. For this reason, underpricing of agricultural commodities relative to world prices in Pakistan was a common phenomenon throughout the '80s [Ali (1992), Chaudhry and Kayani (1991), Dorosh and Valdes (1990), Ender (1992), Longmire and Debord (1993), John Mellor Associates and Asians Agro-Dev International (1993), Nabi, Hamid and Nasim (1990), Punjab (1991) and Qureshi (1987)].

The amount of resource transfers from agriculture, which did not exceed Rs. 20 billion per annum until the mid-'80s, were well above Rs. 40 billion on average during the second half of the decade. In addition, such transfers amounted to Rs. 72 billion in 1989-90. They averaged around Rs. 50 billion for most of the '90s and stood at almost Rs. 88 billion during 1994-95. As should be clear, underpricing of cotton and wheat, i.e. differences in parity prices and procurement prices is the major determinant of gross resource transfers.

It should be clear from the above that the price policies of the '60s and latter half of the '70s were favorable and contributed positively to growth in agriculture. By contrast, the price policies of the '50s, the early '70s and since 1979-80 have adversely affected agriculture in many ways. In reality, Pakistan's agriculture during these periods, especially since 1979-80, has faced falling or negative rates of profit (Appendix 2). [Afzal et. al (1992) and Ahmad and Chaudhry (1987)]. For this reason, such a situation bred stagnation or at least slower growth in agricultural production. In addition, although much is made of input subsidies and government expenditures for agriculture, the net outflow of resources from agriculture has grown immensely (Table 3).

Net transfers from agriculture have been considerable and rising even after the deduction of input subsidies and government expenditure for the agriculture and water sectors. Between 1979-80 and 1994-95, they rose from nearly Rs. 5.0 billion to Rs. 63.0 billion which ins an indication that investment in the agricultural sector is being deprived. Moreover, the low profit rates in agriculture will not exceed 10-15% (Appendix 3). Meanwhile, guaranteed profit rates of the industrial sector exceeding 25% and going as high as 200% in certain cases, would result in capital flight from agriculture with the ultimate outcome of an ever-impoverished agricultural sector.

② Procurement policy

Apart from price fixation, the government also intervenes in major commodity markets physically and undertakes procurement operations. It is generally claimed in the government circles that such intervention may be necessary to ensure fair prices for the producers, consumers and the industrialists. To accomplish this task effectively, the government must take full control of almost all the marketed surpluses of the major agricultural commodities by intervening in purchases from farmers as in wheat or from rice mills, ginnerie and sugar mills as in the case of rice, cotton and sugar, respectively. The buffer stocks thus accumulated are either sold to consumers at subsidized rates or are exported to other countries at substantially higher than procurement prices. Depending on the health of the harvest, the procured quantities vary considerably from year to year. For instance, during the '90s, the average procurement of wheat was in excess of 4.0 million tons per year. By contrast, the average for the decade of the '80s was no more than 3.0 million tons. Since 1979-80, Pakistan's wheat procurement figure reached the minimum of 2.3 million tons during 1984-85 and the maximum of 5.0 million tons during 1986-87. Likewise, rice procurement varied from a minimum of half a million tons during 1991-92 to a maximum of 1.33 million tons in 1989-90. As such, wheat procurement reflects an upward and rice procurement a downward trend between 1979-80 and 1994-95. Although the information on the procured quantities of cotton and sugar are not available, almost all of their production falls into government hands and procured quantities have the same intertemporal trend as that of output.

③ Rural and Agricultural Infrastructure

The rural and agricultural infrastructure consists of physical and social forms. The physical infrastructure mainly involves the development, maintenance and rehabilitation of irrigation network as well as the construction of all-weather farm-to-market roads. Irrigation water is a critical input in agricultural production and the rates of return for the input in an arid zone like Pakistan would be close to infinity as the availability of irrigation water would raise agricultural output from practically zero to some positive level. It is a fact that Pakistan has a gigantic irrigation system but the available water supplies are sufficient to meet only half of the water requirements of the crops. The problem is compounded by instability and the uneven distribution of water. It is important to note that the irrigation system, for lack of proper maintenance, has been suffering from gross inefficiencies with excessive losses of water as large as 40%.

Similarly, the farm-to-market roads are important in ensuring smooth flow of the produce between the farm and the ultimate consumers. The farm-to-market roads can go a long way in reducing the transportation costs of marketing agricultural commodities and of bringing in farm inputs.

Although much discussion has taken place with regard to importance of roads as competitive marketing system is important in ensuring proper prices for agricultural commodities and raising the profitability and production of the agricultural sector, there is no progress in the actual situation. Average road density in Pakistan did not exceed 0. 19 kilometer per square kilometer in 1991, which compares unfavorably with even the Indian Punjab figure of 0.45 kilometer per square kilometer in 1985.

Perhaps the average road density does not reflect the true picture of rural areas because of heavy concentration of roads in the urban centers. The appropriate measure should therefore be distance of a rural centers to a metalled road. An average distance of 6 kilometer from a village to a metalled road in 1988 in Pakistan points to the highly limited access of the rural population to all-weather roads [Qureshi (1993)].

As far as social infrastructure is concerned only about one-tenth of the nearly 50 thousand villages had electricity in 1993-94 (Pakistan (1995a)]. According to 1981 population census, only about 17.3% of the rural population was literate [Pakistan (1995b)]. Similar were the conditions in the health sector. In 1993, there was one hospital bed for a population of 1550, a doctor for 1,900 people and a dEntist for servicing of nearly 48 thousand persons. The gross inadequacy of social infrastructure speaks for the recommendation of considerable upgrading of the essential services.

The rural industrialization in Pakistan was characterized by diverse trends. Many of the traditional rural industries have become increasingly extinct. For example, the traditional hand looms, spinning and hand-operated ginners, earthen pottery, black smithry, bullock driven flour mills and rice mills rarely exist in major parts of Pakistan. However, parallel development with only few exceptions such as earthen pottery, have also continued. Instead of hand looms, power looms have become increasingly popular in addition to urban textile sector. Most of the modern ginneries have appeared on major farm-to-market roads in the rural areas. Rice husking mills and wheat flour mills of small, medium and large vintages seem to be of universal location. With the introduction of tubewells and tractors and extension of black-smithry, almost all rural towns have become centers of repair shop businesses and manufacture of agricultural implements and hand tools. There is also the mushroom growth of food processing industries. In the light of these developments, many of the modern rural industries seem to have grown at a faster pace than the extinction of traditional industries with the result that the rural industrial sector might be expected to have benefitted positively from recent developments.

2 Natural Environment and Condition of Agriculture in Pakistan

(1) Natural Environment

① Topography and geology

The geological diagram of entire Pakistan is given in Figure 1. Following the collision of the Indian Continent into the Eurasian Continent as a result of continental drift, many layers of thrust faults developed in the northern region and formed steep mountainous topography exceeding 3,000m in altitude. Then came the upheaval of small mountain ranges that are 1,000m to 3,000m high such as Sulaiman hills and Kirthar hills due to folding of geosyncline. As a result of these crustal movements, the geology of this country consists of sedimentary rock and igneous rock concentration from Paleozoic era in the northern region, and of sedimentary rock from Mesozoic era existing from the northwestern region to southwestern region along the folded mountain range of igneous rock. In addition, the Indus Plains slopes gently from north to south after the altitude reaches below 1,000m, and the geologic composition changes to Pleistocene igneous rock and to sedimentary and post-Pleistocene alluvial layers that were formed by debris flow from surrounding steep mountain ranges and by flooding and water deposition process of the Indus River and its tributaries Jhelum River, Chenab River, Rabi River and Sutleji River.

A more detailed study of the alluvial geology in the Indus Plains reveals the existence of flood plain deposits from the Himalayan Mountains in the area extending from northern region to southwestern region of the Indus Plains, as well as riverwash layer along the Indus River and its tributaries surrounded by terrace sedimentary layer. In addition, eolian sedimentary layer increases with distance from the river basin. The existence of buried ridges in northern and southern regions of the plains also suggests that groundwater situation differs between regions that are located north and south of this ridge.

② Climate

Distribution of annual precipitation for entire Pakistan is given in Figure 2.

The climate is subtropical arid in some regions but is primarily semi-arid or arid. As for precipitation, 75% of national land has annual precipitation of less than 250mm and the regions where annual precipitation exceeds 500mm are limited to small areas in the northern mountainous regions. Twenty percent of the land receives less than 125mm of precipitation in a year. Judging from these facts, the climate of Pakistan can be characterized as arid.

A year is normally divided into two seasons, the hot and humid khalif season from April to September and the cold and dry rabi season from October to March. However, four seasonal divisions can be identified through a detailed study of changes in precipitation and temperature throughout the year, i.e. the hot and dry season from April to June, the hot and damp monsoon season from June to early September, the cold and dry season from September to December and the transitional period into hot and dry season accompanying occasional showers from January to April. The monsoon is brought over by the wind that originates from the Arabian Sea, while the cold wind during the low temperature season comes from the Himalayan Mountains in the west-northwest direction.

Quantity of solar energy and soil moisture are climatic factors that are important for growing crops. Although no problem exists in this country with regard to solar energy, soil moisture conditions will become the limiting factor. Kyuma et al. (1972) classified the rice paddy region in tropical Asia into 9 categories by type of soil moisture. According to this classification, available soil moisture in Punjab Province did exist in small quantities from January to February but extreme shortage was seen in other months, with no sign whatsoever of the likes of surface runoff and ground permeation of water in the rice paddy regions of Southeast Asia. This is an information suggesting the importance of irrigation in Punjab Province.

(2) Overview of Soil

Main soil varieties of Pakistan have been studied eight times in the last 50 years by different organizations from the viewpoint of topography, land use, soil physiochemistry and degree of salt damage. Among them, the soil survey that was conducted from 1963 to 1983 in accordance with USDA Soil Taxonomy covered the entire country. In terms of order which is the broadest category of classification, the most widely distributed soil according to this classification was Entisol, followed by Aridisol, Inceptisol and Alfisol. Entisol, the most common soil, is very young and does not have the formative horizon for generating soil formation process. Its distribution is concentrated in northern and southeastern regions of Punjab Province. Aridisol is a slow forming soil which is typical of soil in arid regions, and has sedimentary layer of calcium or alluvial layer of clay. It is concentrated around the Indus River and its tributaries, and is also distributed in mosaic patterns in the western mountainous region. Inceptisol is older than Entisol but is believed to be a soil that has just started forming. It is distributed in the northeastern region of the Indus Plains. Alfisol is a soil that has alluvial layer of clay with excellent fertility and physical properties. This soil is found in small quantities near the Cashmere border where annual precipitation is high.

Distribution of these soil groups indicates that this area is primarily comprised of extremely young soil varieties that were deposited by water from the Indus River or by wind during the dry season. In particular, the Indus Plains is noted for not having formative horizon owing to lack of soil moisture. In addition, the dry climate is reflected in rapid soil weathering which accelerates mixture of main elements comprising the soil such as silicon, aluminum, iron, sodium, calcium and magnesium into soil solution. As a result, the solution would contain elements that cause salt damage in large quantities.

(3) Soil Deterioration and Agricultural Production

① Formation of problem soil and its rehabilitation

The population has increased by more than threefold in a period of half a century since the independence in 1947. Many problems have manifested in the soil environment after agricultural production was increased to support this population.

The most significant problem was the fact that water was positioned as the greatest limiting factor in agricultural production as a result of the majority of the country being located in semi-arid or arid zone. The development of an irrigation system unparalleled in the world to overcome this situation has resulted in concentration of soluble salts in plow layer and accumulation of exchangeable sodium on soil surface. In addition, the risks of saline and sodic soil in agricultural production, along with the risks of waterlogging caused by leakage from irrigation canal, started to manifest around the Indus Plains since the latter half of '50s.

Furthermore, topographic factors in this country makes soil erosion from water and wind a serious problem in the hills and mountains surrounding the Indus Plains. Soil erosion causes loss of top soil, which is an important part in agricultural production, as well as desertification. When evaluated from the viewpoint of soil fertility which determines productivity of the soil, the soil in this country has extremely low content of organic matter, shows alkaline reaction, has extremely low mineral nutrients for plants and shows serious lack of macronutrients and micronutrients for plants.

In this chapter, the condition of land which is regarded as problem for agricultural production, its formation factors and its recovery will be explained in detail.

② Waterlogging

Areas with groundwater level that hinders ordinary growth of many crops are generally referred to as waterlogging areas. While the level of groundwater defined as waterlogging differs from crop to crop, decline in yield is observed at groundwater level of 1.5m, and about

25% decline in yield is seen in areas where groundwater level is 1m to 0.75m (LRD 1962).

The impact of waterlogging on soil and crop includes reduction of plant rhizosphere and decrease in oxygen, damaging of soil by salt discharged from weathering of soil, falling of crops and increase in blight.

Distribution of groundwater level in respective provinces of Pakistan which was surveyed by WAPDA in 1988 is given in Table 1. The survey results collected from the entire country indicate that groundwater level fluctuates considerably before and after the rainy season, and that the areas where groundwater level ranged from 0m to 1.5m increased by 3.2 times between pre-rainy season and post-rainy season. In addition, when compared by region, the waterlogging area increased 4 times between pre-rainy season and post-rainy season in Sindh Province as opposed to twofold increase in other regions, reflecting the fact that it is located farthest downstream in the Indus Plains and that its altitude is lower than other regions. Nevertheless, the fact that increase of waterlogging area is kept down to 2.4 times in Punjab Province -- which is dependent on the Indus Plains -- is an indication that draining through SCARP is effective to a certain extent.

The existence of waterlogging region signifies existence of less permeable horizon containing fine particle soil in the layer. Entisol, which is found in the peripheries of the Indus River, is an immature soil that has been formed from river deposits, and contains coarse particle size deposits when found near rivers that are close to the source of flood but becomes finer in particle as it gets closer to its outer edge. Consequently, the percentage of waterlogging area should increase with distance from the source of flood in regions where Entisol is distributed. In the case of Aridisol distribution found in old soil that was deposited when the region had moderate climate, there is an argillic horizon formed by accumulation of clay whose horizon is believed to be forming an impermeable layer. The relationship between this soil group and waterlogging areas will have to be clarified.

The best measure for improving waterlogging is to lower the groundwater level, and although the drainage performed by SCARP up to present has been effective in some regions, securing of overflow as well as facilities adapted to regional characteristics such as drain, mole drain and bullet drain will be indispensable. This is extremely important for lowering the groundwater level as well as for reducing salt damage. Also extremely important is prevention of leakage from irrigation canal (causing waterlogging), and lining of water course is effective for this purpose.

③ Salt-affected soils

Saline soil is one of the most serious problems in Pakistan and has become a limiting factor in crop production by affecting approximately 1.2 million hectares of arable land in some form or another. In addition, its economic damage on Pakistani economy is estimated to reach $47 million a year (SSP 1988, Qqyum and Malik 1988). The impact of salt damage on the yield of crops other than paddy rice has been calculated as 20% decline in regions that are partially affected by salt and 60% decline in regions that are heavily affected by salt.

Salt-affected soil develops under poor drainage in arid to semi-arid regions. The parent material in this country is alluvial soil mainly comprised of immature marine sediments which have Na^+, Ca^{2+}, Mg^{2+}, K^+, Cl^-, SO_4^{2-}, HCO_3^{2-} and CO_3^{2-} as main ion components. Strong weathering from dry climate increases soluble salt concentration in soil solution. Another factor that increases soluble salt concentration is the use of groundwater containing various soluble salts as irrigation water. It is the concentration and accumulation of these soluble salts that limits plant growth.

There are three types od salt-affected soil in Pakistan; saline, sodic and saline-sodic. Classification of these soils is conducted according to USDA standard by evaluating electric conductivity (EC), sodium adsorption ration (SAR) and exchangeable sodium percentage (ESP).

i Saline soil

While most salts are chlorides, sulfates and nitrates whose major cations are calcium, magnesium and sodium, the percentage of sodium ion never exceeds 50% of all soluble cations. Criteria for this soil are EC>4dS/m and SAR<13. This soil has pH value of less than 8.5, and white film is found on the soil surface or accumulation of salts is found within the soil during the dry season. The high concentration of neutral salts such as sodium chloride, sodium nitrate and sodium sulfate in this soil inhibit water absorption of plants as the osmotic pressure of soil solution used by plant root becomes higher than that of plant root. In addition, wilting coefficient of soil increases and soil moisture content decreases with accumulation of salts. As absorption of nutrients by a plant is done through its root hair and is determined by the concentration and property of coexisting ions, absorption of necessary nutrients from soil is affected even when damage from saline soil is weak enough to not affect absorption of moisture by the plant.

ii Sodic soil

This soil is characterized by its high alkalinity of 8.5 to 10 in pH value (higher than saline soil) which is a result of containing very little calcium and magnesium and large amount of sodium ion in soil solution. Criteria for this soil are EC<4dS/m and SAR>13. As the clay is saturated with sodium ion, it is high in disintegration with its soil humus dissolved by alkaline soil solution. Moreover, excess sodium is highly disintegrated and distributed on soil particle surface, and changes soil color to black.

In addition to hindering plant growth similar to the aforementioned saline soil, sodic soil makes land preparation difficult and lowers permeability of water as highly disintegrated clay is accumulated on the soil surface. Then a very fine horizon is formed as the disintegrated clay shifts and accumulates on lower layers with a thin layer of coarse textured top soil left at the surface. As the physical properties of soil is completely destroyed in this manner, permeability declines and drainage from soil is hindered. Furthermore, firmness of soil increases and prevents penetration of plant roots while ventilation is impaired to bring about generation of harmful reduced compounds as a result of localized reduction.

iii Saline-sodic soil

This soil is a transitional type characterized by its highly concentrated soluble salts (EC>4dS/m) similar to saline soil, but is different from saline soil because of its high exchangeable sodium content (SAR>13). Therefore, it is problematic in a sense that it has the characteristics of both saline and sodic soils. The problems originating from high disintegration such as in sodic soil will not arise in this soil as long as soluble salts other than sodium exist in large quantities. In the event soluble salts are leached downward, pH value will exceed 8.5 and problems similar to those of sodic soil will occur. On the other hand, if soluble salts move upward, sodium adsorbed by colloid will be substituted by calcium, pH value will drop below 8.5 and the problems of saline soil will manifest.

iv Distribution of salt-affected soils

As distribution of salt-affected soils in Pakistan has been surveyed by numerous research institutions, the resulting area differs considerably due to the differences in time and method of survey and classification criteria. Here, the results estimated according to The Soil Survey Pakistan Report are given in Table 2.

Soils that were affected by some kind of salt damage were found in 1.05 million out of the 6.34 million hectares that were surveyed. Of these 1.05 million hectares, 0.55 million hectares were saline-sodic soil. In addition, 250,000 hectares of salt-affected soils had been caused by irrigation of groundwater with high salt content.

Salt damage, which is found extensively in the Indus Plains, is caused not only by topographic features of this region but by irrigation farming which has been practiced there for thousands of years, and led to a man-made calamity. The distribution area of salt-affected soils in the Indus Plains is given in Table 3.

In the Indus Plains, 20% to 30% of irrigated area has been affected by salt damage in all regions except NWFP District. When Sindh Province and Punjab Province are compared, the rate of occurrence is higher in Sindh Province which is located topographically at a lower level and the percentage against cultivated area is also naturally higher.

④ Improvement of salt-affected soils

The greatest task in improving salt-affected soils is removing salts from leaching of salts in the root zone. The aspects that are common in all improvement methods are lowering of groundwater level and securing of overflow. Unless groundwater level is lowered, reoccurrence of salt damage is inevitable no matter what improvement method is used.

In addition, as three types of problem soils with different properties exist in salt-affected soils, the method of improvement suited to the property of each soil must be applied. While physical improvement using large volume of water to leach the soil is the only available way for saline soil, combination with chemical methods will have to be used for sodic and saline-sodic soils.

i Improvement of saline soil

Removal of salts from the root zone can be best achieved by leaching the soil with irrigation water but requires a large amount of water. While downward permeation of irrigation water will have to take place smoothly in this process, crushing of clay layer and installation of culverts and open ditches are needed as soil having clay accumulation layer called argillic horizon also exists in Entisol and Aridisol which account for the majority of soil in the Indus Plains. If no draining facility is available, adding large quantity of water will raise the groundwater level and cause accumulation of salts in the surface soil.

ii Improvement of sodic and saline-sodic soil

Drainage facility and large volume of irrigation water is used in a similar manner as in the foregoing saline soil, but the effectiveness of improvement is dramatically increased through combined use of chemicals such as sulfuric acid, hydrochloric acid, calcium sulfate and sulfur. The basis of this chemical treatment is substitution of exchangeable sodium adsorbed by soil colloid with calcium as well as leaching of substituted sodium and carbonate through complete conversion into sodium sulfate (see Figure 4). Moreover, addition of sulfuric acid and hydrochloric acid is a method that causes dissociation of carbonate while isolating calcium from calcium carbonate existing in the soil and exchanging it with sodium. Addition of sulfur also has an effect similar to application of sulfuric acid as it generates sulfuric acid when being oxidized in the soil. As a result, soil pH goes down and colloid solidifies. In addition, physical properties of the soil are improved with the development of perosity and permeability.

Application of chemicals such as sulfuric acid and hydrochloric acid brings about dramatic effects; however it is extremely expensive, disqualifying it as effective method of improvement for small-scale farm households. As a result, improvement of the soil may be brought about by application of calcium sulfate (gypsum) which was found along the Pakistani coastline.

The process of gypsum formation starts with generation of byerite after sulfuric acid ion and ferric oxide in sea water react with each another in a reduced state. Then gypsum is formed as this byerite reacts with calcium carbonate which is generated under oxidized and dry/semi-dry conditions. Gypsum is found all over the Indus Plains because the region was equipped with these conditions.

An effective way to apply gypsum would be to measure the exchangeable salt content of the soil through chemical analysis to calculate the volume of gypsum needed, and apply the gypsum as particles of 100 mesh or less because of its low solubility. In addition, soil analysis regarding changes in salt concentration over time must be performed after the gypsum is applied because the low solubility of gypsum will remain effective for a long period of time, performing additional application if necessary.

iii Improvement of salt-affected soils utilizing biological resources

As the two methods mentioned above both require large amount of water for irrigation, physical and chemical improvement cannot be expected in these salt-affected regions.

Improvement of regions affected by salt damage to a medium degree requires time. However, desalinization using plants is also considered to be effective, and deep-rooted crops such as maize, millet and sorghum, in particular, are expected to be effective for desalinization as well as for improvement of physical properties of soil. Although people tend to think that there is no much biological involvement in salt-affected soils overloaded with inorganic matter, blue-green algae grow vigorously as can be seen from the fact that *Anabacna ssp.* is found universally in salt-affected soils. *Anabacna ssp.* is characterized by its high nitrogen fixing capacity which makes it a valuable source for supplying nitrogen to salt-resisting plants.

Application of organic matter is also found to be valuable in improving salt-affected soils. Application of farm waste is expected to bring about effects such as decomposition of carbonate through organic acid which is generated after the decomposition of organic matter, exchange reaction with sodium ion through dissociation of calcium ion, as well as supplement of organic matter and nutrients to the soil. Moreover, mulching of surface with plant residues is an effective method that not only prevents soil erosion but is expected to have secondary effects including supply of organic matter to soil and prevention of soil moisture transpiration.

⑤ Problems with improvement of salt-affected soils

Leaching, which uses large quantity of water, has been the mainstream method in improving salt-affected soils. However, according to a report on deterioration of farmland by salt damage and soil erosion prepared by the International Development Center, Japan, the water supply of irrigation in the Indus Plains is estimated at 800mm a year in average. This means that less than 1,000mm of water can be secured after adding natural rainfall which is hardly sufficient for leaching of salts. As many localities receive less water, securing of high quality irrigation water is the greatest challenge of all. The challenge in solving this problem would be how to utilize the water resources that exist in large quantity in the form of groundwater. Groundwater does not have uniform water quality and vary widely in its characteristics depending on the distribution of clay layer in the soil. Therefore, one of the ways to achieve this would be to study the quality of groundwater in detail for each irrigation area and actively use the groundwater that meets the requirements. It is a method in which groundwater with low salt concentration and salt-free irrigation water are used alternately to aim for improvement of leaching effect. Various improvement projects, including control of groundwater level by SCARP (Salinity Control and Reclamation Project), overflow improvement project by LBOD (Left Bank Outfall Drain) and leakage/drainage improvement project for terminal waterways by On-Farm Water Management Project, were carried out against salt damage that manifested during the '50s and '60s and achieved certain degree of success.

The rate of distribution for salt damage of surface soil in respective provinces is given in Table 4. The rate of distribution for salt-affected areas with EC=4dS/m and above has certainly decreased in all provinces between the '50s and '70s. However, more than 1 million hectares of salt damage-ridden areas have still existed in the Indus Plains as a whole. Furthermore, more than 0.55 million hectares of them are sodic soil which requires complex improvement method. As this result suggests, although improvement of saline soil was done through leaching using irrigation water, sodic soil that caused accumulation of sodium after leaching of salts was generated as a secondary product. Thus, the need to give consideration to expansion of this sodic soil in the future was recognized.

i Soil erosion

Soil erosion refers to loss of soil caused by water, wind or combination of the two and takes the form of sheet erosion, rill erosion and gully erosion.

Water erosion, which differs in its degree according to topography, precipitation, pattern of rainfall, soil variety and relationship between form of land use and percentage of vegetative cover, is a problem that is actualized in mountain regions. Rill and gully are main forms of erosion in rainfed area that cause loss of soil resources in large volume at a time. The soil that has been washed away accumulates in the river basin, causing floods and giving tremendous damage to irrigation canals.

Wind erosion is a form of erosion that occurs as fine pericle size fraction portion of the soil is blown away by wind, and manifests in regions that have little rainfall and low percentage of vegetative cover. Wind erosion is seen more often in the plain region than in the mountain region, occurring immediately after a copse that plays the role of windbreak forest is cut for fuel and vegetation is lost. With the erosion of top soil, the most fertile components, i.e. clay, silt and organic matter, are lost, leaving only sand fraction, which eventually results in deterioration of soil fertility and desertification.

ii Distribution of soil erosion

According to the estimation of SSP (1965-1988), areas damaged by water erosion in Pakistan are concentrated in North West Frontier Province and Federally Administered Frontier Province in the northern part of the country with 4.3 million hectares existing in the two provinces, followed by Baluchistan Province and Punjab Province. In addition, the total area damaged by water erosion is estimated to be as high as 11.17 million hectares in the entire Pakistan, of which 30%

is said to be seriously affected by water erosion. Wind erosion is concentrated in Punjab Province and is affecting 3 million hectares, followed by 0.64 million hectares in Sindh Province and 0.28 million hectares in Baluchistan Province. A total of 4.73 million hectares are damaged in the entire country with 40% of national land exposed to wind erosion.

Estimating from these areas that are damaged by soil erosion, a total of 38 million tons of soil flows into the Indus Plains every year due to water erosion and accumulates in the river basin.

(4) Soil Fertility and Agricultural Production

Agricultural production in Pakistan is at a low level compared to world average for all crops. This is largely due to low soil fertility as well as various forms of soil deterioration mentioned earlier. The majority of the soil groups in the Indus Plains, including Entisol, Aridisol and Inceptisol are in low fertility and strong degradation related to unreasonable irrigation. Even if rehabilitation of salt-affected soils is successful, increase in agricultural production cannot be expected unless soil fertility is recovered.

① Soil response and organic matter

Soil response (pH) is an important index in revealing the behavior of respective ingredients in the soil. Pakistan is located in semi-arid to arid climate zone and has alkaline soil with high proportion of carbonates originating from geological elements. In addition, existence of saline soil and sodic soil has caused frequent occurrence of soils indicating 8 or more in pH value, giving rise to shortage of macronutrients and micronutrients for plants.

Soil organic matter content is an important index in identifying soil fertility and plays a key role in terms of biological, physical and chemical properties of the soil. The majority of soils have humus content of 2% or less, and among 337,714 cases that were analyzed in Punjab Province, soils with humus content of 2% or less accounted for as many as 96%. This indicates lack of energy source for the activities of microorganisms which engage in conversion and metabolism of different organic and inorganic ingredients in the soil, and is seriously affecting the metabolic cycle of various matters.

② Macronutrients

While nitrogen, phosphorus and potassium are essential macronutrients for plants, there is shortage of all elements except for potassium in all of Pakistan. Nitrogen is originally found in small quantities in soils which contain little organic matter and the chemical fertilizer that are applied will be discharged into the atmosphere through dentrification process.

Most of the soils in Pakistan have high pH and contain large amount of calcium ion, phosphorus is fixed as calcium phosphate and its availability to plant is decreased.

Potassium is the only element that shows very high content, and shortage is hardly recognizable. This is attributable to the K-rich mineral, i.e. illites, in the immature soils.

③ Micronutrients

Among micronutrients, shortage of zinc and boron is most serious, followed by that of iron and copper. Content of zinc and boron in alkaline soil is extremely low from the outset, and zinc content is further reduced as it is adsorbed by carbonates (magnesium carbonate).

④ Improvement of soil fertility

Although the long-term standpoint is essential in rehabilitation of soil fertility, use of chemical fertilizers is indispensable in increasing crop production on such soil. With regard to deficient nutrients, application of chemical fertilizers that expected to have secondary effects are desirable. In particular, application of ammonium sulfate and zinc sulfate containing sulfate radical is expected to have effect on improvement of salt-affected soils. Additional consideration shall be given to timing of application and form of fertilizer in view of plant physiology.

Application of organic matter is the only method for recovering soil fertility in the long run. Farm and livestock wastes are extremely safe and effective materials, although majority of plant remnants are used as livestock feed in this country and cow dung is used as fuel. In addition, decomposition of organic matter advances very rapidly under the climatic conditions of this country and therefore a large volume of organic matter (at least 2 tons/hectare) must be applied to produce good results. Securing organic matter for this purpose would be an important task.

(5) Conclusion

Low standard of agricultural productivity in Pakistan is largely attributable to the soil conditions of the Indus Plains. A wide range of improvement methods that are mentioned above have been established to overcome this problem. In addition, technical standard of universities including Faisalabad Agricultural University and other research institutions is at a considerably high level, although they have been unsuccessful in solving the problem entirely. The cause of all this lies in the uniform method of improvement that was taken instead of improvement methods conforming to soil conditions, geological conditions, environmental conditions, social structure and economic conditions of the regions that are involved in this problem. Maintenance and operation following the improvement is also an important aspect.

Limiting the problem to flooded and salt-affected soils, methods that conform to regional characteristics such as recycling of groundwater resources for irrigation by fully evaluating groundwater quality, desalinization using plant resources and measures against lowering of groundwater level will be necessary. Regarding salt damage, absolute shortage of water supply for irrigation which is expected to be necessary for improvement will be the limiting factor. In addition, type of salt damage and its distribution change from year to year. Accurate improvement method will not be established unless detailed studies are conducted on salt damage.

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Table 1 Time Series Data on Agricultural Production 1954-55 to 1993-93

Year	Value Added (Rs. Million at Constant Factor Cost of 1959-60 by ;					
	Agricultural	Major Crops	Minor Crops	Livestock	Fishries	Forestry
1954-55	6948	3461	859	2553	43	32
1955-56	7093	3521	882	2610	51	26
1956-57	7254	3650	852	2667	51	34
1957-58	7393	3694	884	2724	52	39
1958-59	7689	3931	891	2780	56	31
1959-60	7711	3882	892	2837	71	28
1960-61	7695	3840	869	2887	67	32
1961-62	8171	4209	918	2940	70	34
1962-63	8597	4595	891	2996	77	38
1963-64	8813	4509	1129	3048	85	42
1964-65	8276	4888	1130	3121	91	46
1965-66	9318	4821	1172	3178	97	50
1966-67	9829	5137	1284	3242	114	52
1967-68	10982	6078	1406	3307	135	56
1968-69	11478	6408	1516	3373	121	60
1969-70	12574	7553	1363	3440	170	48
1970-71	12188	7045	1418	3509	155	61
1971-72	12611	7336	1507	3579	125	64
1972-73	12821	7473	1478	3651	128	91
1973-74	13357	7844	1585	3724	115	89
1974-75	13074	7455	1679	3799	82	59
1975-76	13659	7833	1839	3875	86	26
1976-77	14004	7944	1920	3997	98	45
1977-78	14399	8115	1962	4133	131	58
1978-79	14845	8315	2023	4274	139	94
1979-80	15826	9105	2086	4418	127	90
1980-81	16405	9463	2125	4574	153	90
1981-82	16992	9836	2189	4742	154	71
1982-83	17637	10213	2251	4941	168	64
1983-84	16571	8805	2278	5251	178	59
1984-85	18600	10388	2353	5584	187	88
1985-86	19788	11158	2406	5943	201	80
1986-87	20224	10989	2612	6301	207	115
1987-88	21124	11434	2688	6686	209	107
1988-89	22575	12234	2921	7081	113	216
1989-90	23259	12223	3072	7513	123	237
1990-91	24413	12919	3179	7889	126	248
1991-92	26732	14919	3255	8358	132	196
1992-93	25318	12592	3383	8861	140	195
1993-94	26042	12596	3564	9391	141	182
1994-95	27328	13400	3607	9911	142	194

Note : The value added at constant factor cost of 1959-60 are not available after 1987-88, figures reported here have been worked out using the annual growth rates reported in the source at constant factor cost of 1980-81.

Source : [Pakistan (1990) and (1995).

Table 2 Agricultural Productivity by Major Crops

	Pakistan	India
Wheat	2	3.8
Rice	1.1	3.4
Maize	1.1	2.3
Sugarcane	37.4	56.9
Cotton	0.6 – 0.7	0.57
Gram	0.5	0.67

Unit : Ton/ha

Source : Agricultural Statistics of Pakistan 1992-93, Ministry of Food, Agriculture and Livestock, Government of Pakistan

Agricultural Statistics At a Glance, Ministry of Agriculture, Government of India

Table 3 Agricultural Input Subsidies by Input, 1979-80 to 1994-95

Rs. Million

Year	Bubgetary or Explicit Subsidies					Concealed or Implicit Subsidies				Total Implicit & Explicit subsidies	Total Subsidies as Percentage of consolidated Govt. budget
	Total Fertilizer	Local Fertilizer	Imported Fertilizer	Pesticides Seeds & Tubewells*	Sub Total	Irrigation water	Credit	Electricity	Sub Total		
1979-80	2455	588	1867	269	2724	297	116	–16	397	3121	9.31
1980-81	2448	575	1873	20	2468	338	180	–88	430	2898	7.19
1981-82	1750	1272	528	24	1774	416	265	–11	670	2444	5.59
1982-83	1948	1007	941	24	1972	437	349	–100	686	2658	4.69
1983-84	1466	1142	324	–	1466	661	524	–153	1032	2498	3.47
1984-85	1500	829	671	–	1500	828	543	103	1474	2974	3.55
1985-86	2409	1131	1178	16	2425	1005	448	16	1469	3894	4.10
1986-87	1284	389	885	–	1248	1234	551	375	2160	3444	2.83
1987-88	1995	186	1809	15	2010	1352	785	1112	3249	5259	4.07
1988-89	2415	366	2049	–	2415	1154	1009	1139	3302	5720	3.74
1989-90	1257	208	1049	–	1257	1028	1207	1380	3615	4872	2.89
1990-91	1248	192	1056	–	1248	1545	1526	1625	4696	6220	3.11
1991-92	1191	264	927	–	1149	2701	1744	1796	6321	7512	3.28
1992-93	810	113	697	–	810	3111	1993	1724	6829	7639	2.80
1993-94	805	–	805	–	805	2565	1980	330	4875	5680	1.83
1994-95	79	–	79	–	79	2938	1986	330	5254	5333	1.54

* Figures for 1979-80 include a subsidy of Rs. 218 million for pesticides, Rs. 29 million for seeds and Rs. 22 million for tubewells. For the other years, figures reflect tubewell subsidy.

Source : [Pakistan (1995b and (1990)], Provincial Budgets, Queshi, Sarfraz khan (1993), NFDC (1993) and a communication from WAPDA, Lahore for electricity subsidy from 1988-89 onward.

Table 4 Nominal Protection Coefficients* (NPCs) and Resource Gross Transfers from Agricultural Due to Underpricing, 1979-80 to 1994-95

Years	Nominal Protection Coefficients* for :					Resource Transfers (Rs. M0 from Underpricing for :					Total
	Cotton	Wheat	Rice (Basmati)	Rice (Irri)	S. Cane	Cotton	Wheat	Rice (Basmati)	Rice (Irri)	S. Cane	
1979-80	0.57	0.57	0.28	0.47	0.38	6235	2661	1575	632	1744	12847
1980-81	0.51	0.47	0.32	0.41	0.39	8182	4842	1248	932	3459	18663
1981-82	0.68	0.44	0.29	0.43	0.5	4510	7572	1939	975	3452	18128
1982-83	0.6	0.5	0.33	0.74	0.73	7170	974	413	352	1120	5029
1983-84	0.5	0.37	0.33	0.73	0.77	6657	10088	1624	368	970	19707
1984-85	0.52	0.39	0.25	0.56	1.29	12768	6270	1580	707	-779	20546
1985-86	0.69	0.51	0.24	1.89	0.94	7543	4908	4438	231	193	17313
1986-87	0.76	0.43	0.24	1.96	1.25	5769	13088	1946	75	-840	20038
1987-88	0.43	0.41	0.28	0.67	1.41	36733	11632	2469	1036	-1708	40162
1988-89	0.49	0.41	0.29	0.47	1.09	20892	10575	2354	1846	-608	35059
1989-90	0.34	0.39	0.33	0.41	0.47	42166	15537	4313	270	7940	2226
1990-91	0.39	0.57	0.53	1.19	0.62	41176	9442	2044	-449	5401	57614
1991-92	0.47	0.52	0.59	1.1	0.74	37062	9271	1903	-315	3670	51591
1992-93	0.55	0.53	0.58	0.79	0.77	28730	9399	2253	860	3112	44354
1993-94	0.55	0.69	0.53	0.93	0.82	31735	7426	1606	81	2695	43543
1994-95	0.4	0.6	0.66	1.01	0.59	64222	12319	1290	-53	9968	87746

Source : [Chaudhry and Kayani (1991), Chaudhry (1993) and Pakistan (1995b)].

* Ratio of procurement to corresponding import/export parity prices.

Table 5 Rates of Profit in Pakistan's Agriculture Since 1982-83 to 1991-92

Commodity and Province	Rate of Profit (percentage) During									
	1982-1983	1983-1984	1984-1985	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992
1. Wheat										
Punjab	-1.70	-12.57	-3.71	6.67	0.38	0.98	7.46	15.11	16.55	10.32
Sindh	-1.70	8.29	5.74	17.47	11.11	11.79	6.38	16.08	15.70	11.71
2. Rice Coarse										
Punjab	-	-11.23	-14.39	-8.01	-11.49	-12.59	-8.84	-5.96	-4.76	-18.11
Sindh	-	-11.23	27.60	26.13	31.56	22.22	8.70	12.82	5.01	0.00
3. Sugarcane										
Punjab	-	-	14.20	13.26	26.77	24.11	23.43	23.87	15.53	10.20
Sindh	-	-	16.09	15.14	35.80	32.78	35.37	35.92	32.35	25.95
4. Seed Cotton										
Punjab	-	9.77	5.43	4.43	19.58	11.56	10.11	13.47	13.11	11.69
Sindh	-	-	-	-	65.50	16.30	15.50	18.30	14.30	11.40
5. Rice Basmati										
Punjab	-	-5.51	2.35	2.38	6.92	31.45	21.18	22.75	7.99	-7.90

Source : [Afza] et al (1992 and 1993)]

Table 6 Total and Net Transfers from Agriculture Through Price Policy 1979-80 to 1992-93 at Official Exchange Rate

Figures in Rs. Millions

Years	Transfers from Agriculture due to underPricing of Ag. Commodities	Implicit and Budgetary Input Subsidies	Annual Expenditure on Agriculture and Water	Net Transfers out of Agriculture
1979-80	12847	3121	4891	4835
1980-81	18665	2898	4956	10809
1981-82	18128	2444	6235	9449
1982-83	15029	2658	7297	5074
1983-84	19707	2498	6179	11080
1984-85	20546	2974	6461	11111
1985-86	17313	3894	9024	4395
1986-87	20038	3444	7350	9444
1987-88	40162	5259	8031	26872
1988-89	35059	5720	7379	21960
1989-90	72226	4872	8452	58902
1990-91	57614	6220	9857	41537
1991-92	51591	7512	9446	34633
1992-93	44354	7639	11922	24793
1993-94	43543	5680	14429	23434
1994-95	87746	5333	19405	63008

Source : [Chaudhry (1995), Chaudhry and Maan (1993) and Chaudhry and Sahibzada (1995)].

Table 7 Area under waterlogged where depth of watertable is 0-1.5m in different province.

Province	Area surveyed (million ha)	Pre-monsoon (million ha)	Pre-monsoon (%)**	Post-monsoon (million ha)	Post-monsoon (%)**
Punjab	9.97	0.54	5	1.18	12
Sindh	5.73	0.86	15	3.49	60
NWFP*	0.56	0.06	10	0.06	10
Baluchistan	0.39	0.04	10	0.09	23
Total	16.66	1.50	9	4.77	29

*North west frontier province

**Values in parcenthesis are % of surveyed area.

Source : SCARP Monitoring Organization, Planing Division, WAPDA. 1988

Table 8 Extent of saline and saline/sodic land accoding to soil survey.

kind of land	Extent (million ha)
Dense saline/sodic	1.21
Parous saline/sodic	1.84
Strongly saline containing gypsum	2.47
Sodicity cause by Tube well water	2.50
Total	10.49
Saline or saline sodic patches on surface	3.96

Source : SSP(1963-1988)

Table 9 Extent of salt affected area in in Indus plain (million ha)

Province	Total CCA area	Salt affected area Witin CCA	%	Outside CCA
Punjab	7.89	1.61	20.4	1.13
Sindh	5.35	1.53	28.6	1.02
NWFP	0.32	0.01	4.3	0.50
Total indus plain	13.56	3.15	23.3	2.65

* Value in percenthesis are percentages of total CCA aerea.

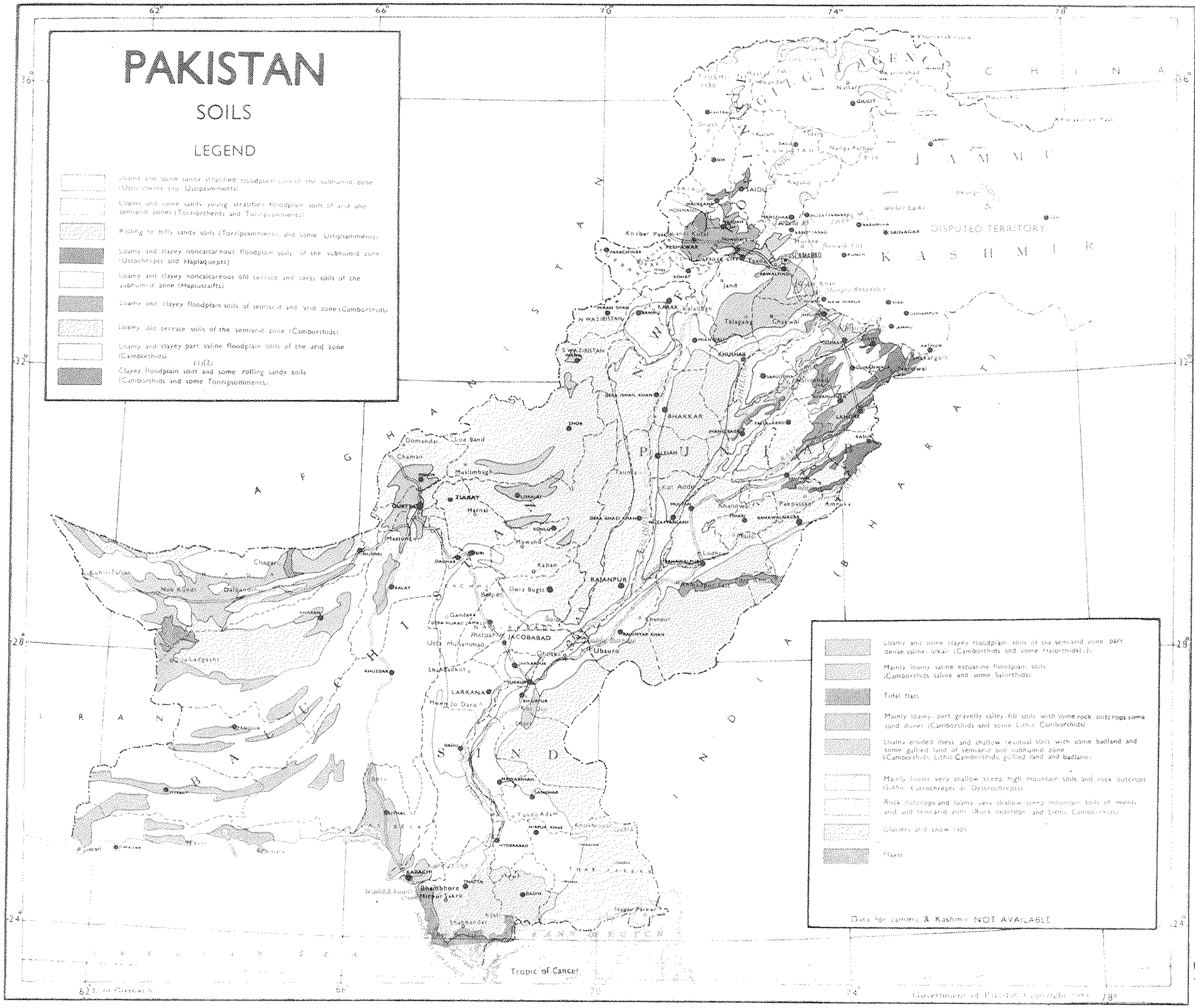
Source : Report of national commission on agriculture (1988)

Table 10 Periodical changes on extent of surface soil salinity in Indus basin.

Province	Year surveyed	Surveyed Area (million ha)	EC<4 S1	EC4-8 S2	EC8-15 S3	EC>15 S4	EC>4 S2-S3
					(%)		
Punjabu	1953-65	9.97	73.1	15.9	4.8	6.1	26.9
	1977-79	9.96	85.5	7.1	4.3	3.0	14.5
Sindh	1953-65	5.48	26.3	28.5	17.5	27.7	73.7
	1977-79	5.42	51.7	19.2	10.7	18.5	48.3
Balochistan	1953-65	0.35	69.6	14.5	7.2	8.7	30.4
	1977-79	0.35	74.3	17.1	4.6	4.0	25.7
NWFP	1971-75	0.56	82.9	10.8	3.8	2.5	17.1
	1977-79	0.55	86.8	9.0	2.4	1.8	13.2
Pakistan	1953-75	16.37	57.6	20.0	9.1	13.3	42.4
	1977-79	16.28	74.1	11.4	6.4	8.1	25.9

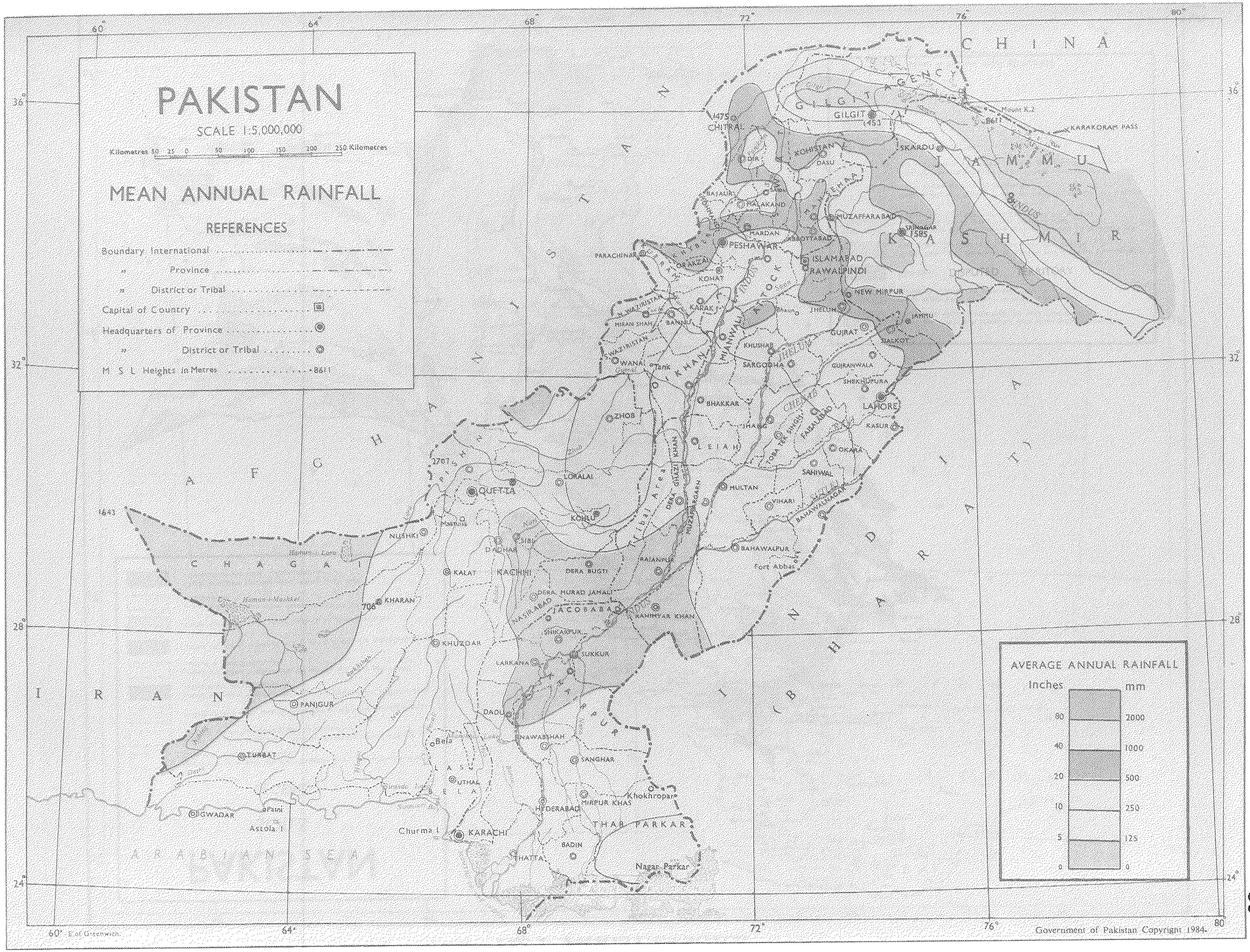
Soil surface salinity classes acoording to EC value of surface soils.
Souce : WAPDA, Soil Salinity Survey Vol. II, 1981

Fig. 1 PAKISTAN SOILS



Source : Survey of Pakistan

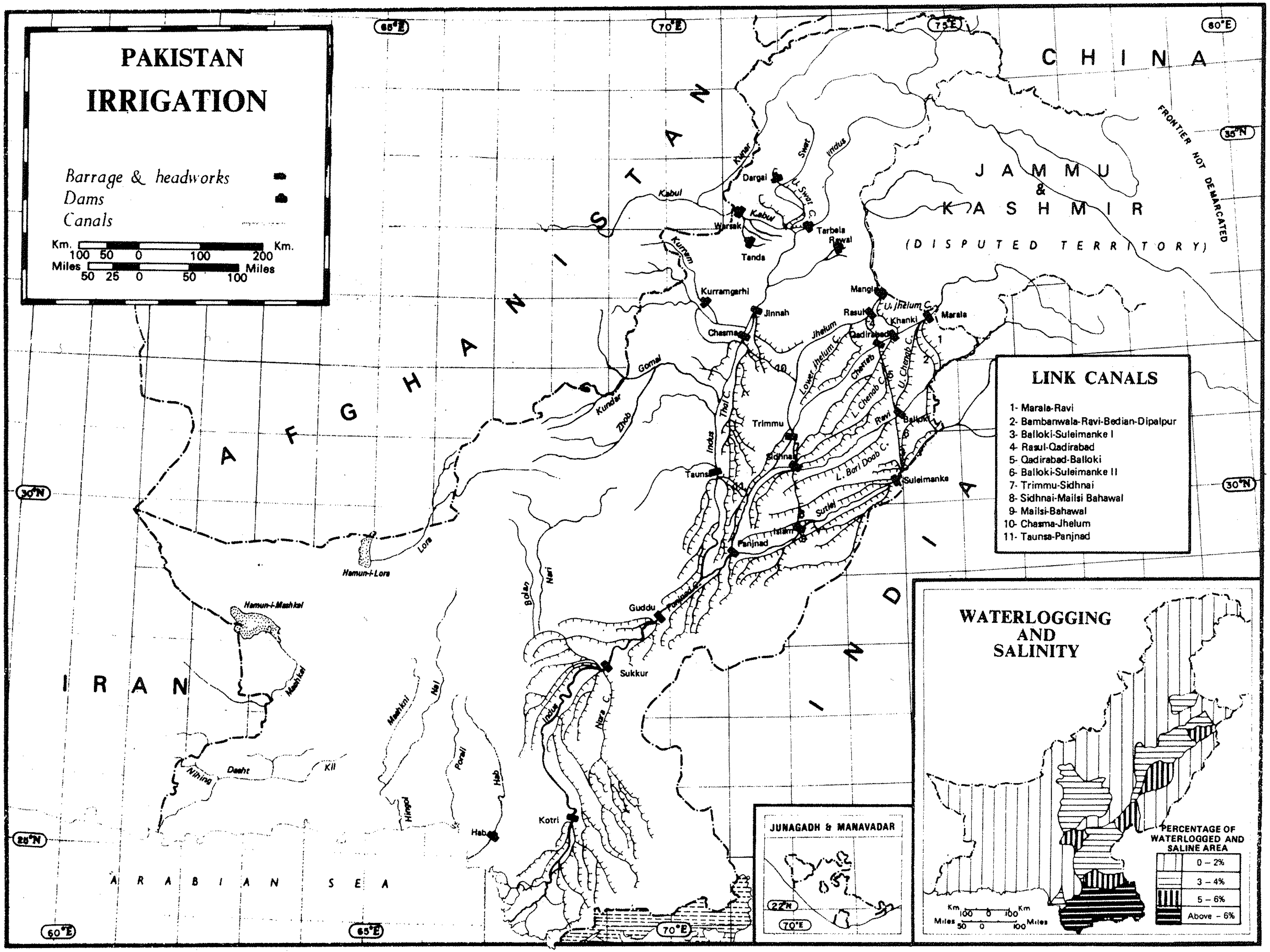
Fig. 2 PAKISTAN MEAN ANNUAL RAINFALL



Source : Survey of Pakistan

4

Fig. 3 PAKISTAN IRRIGATION



Source : Oxford Atlas for Pakistan

Fig. 4 PAKISTAN WHEAT

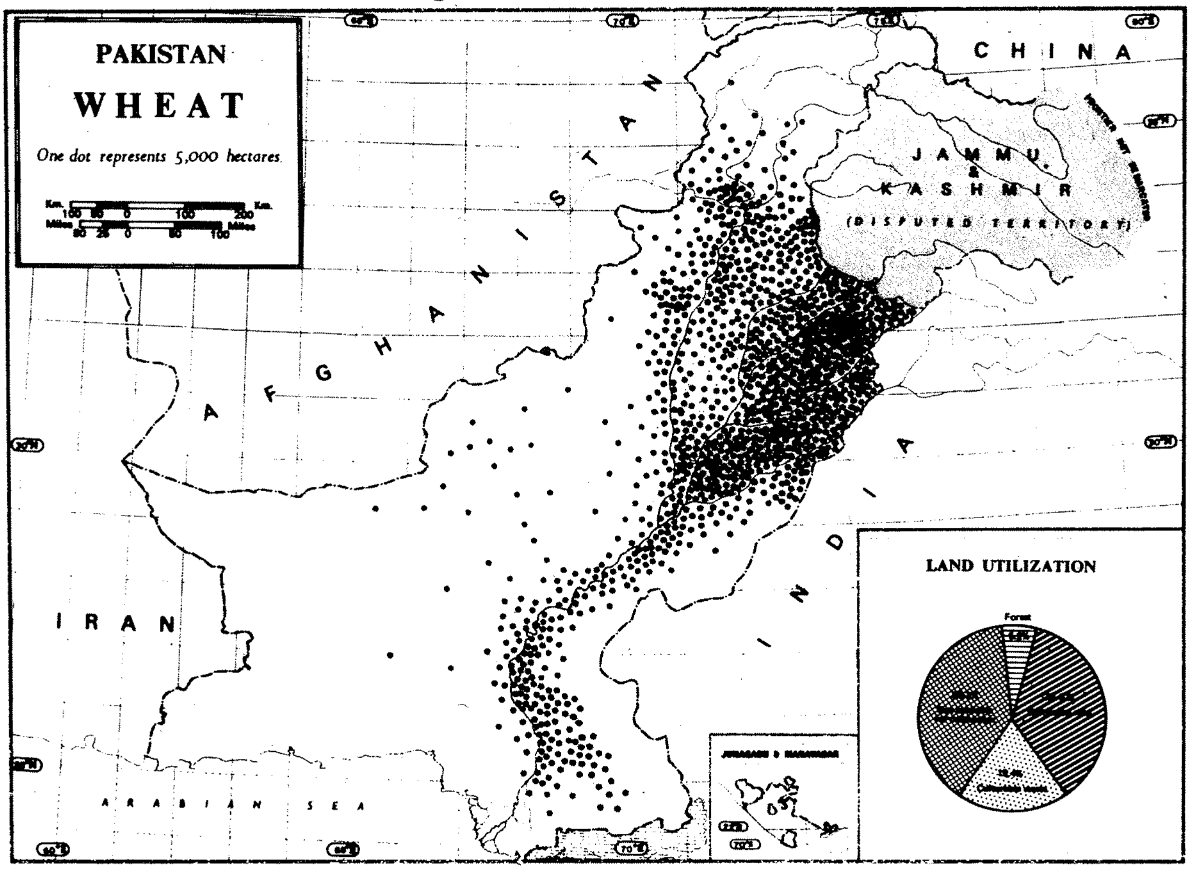
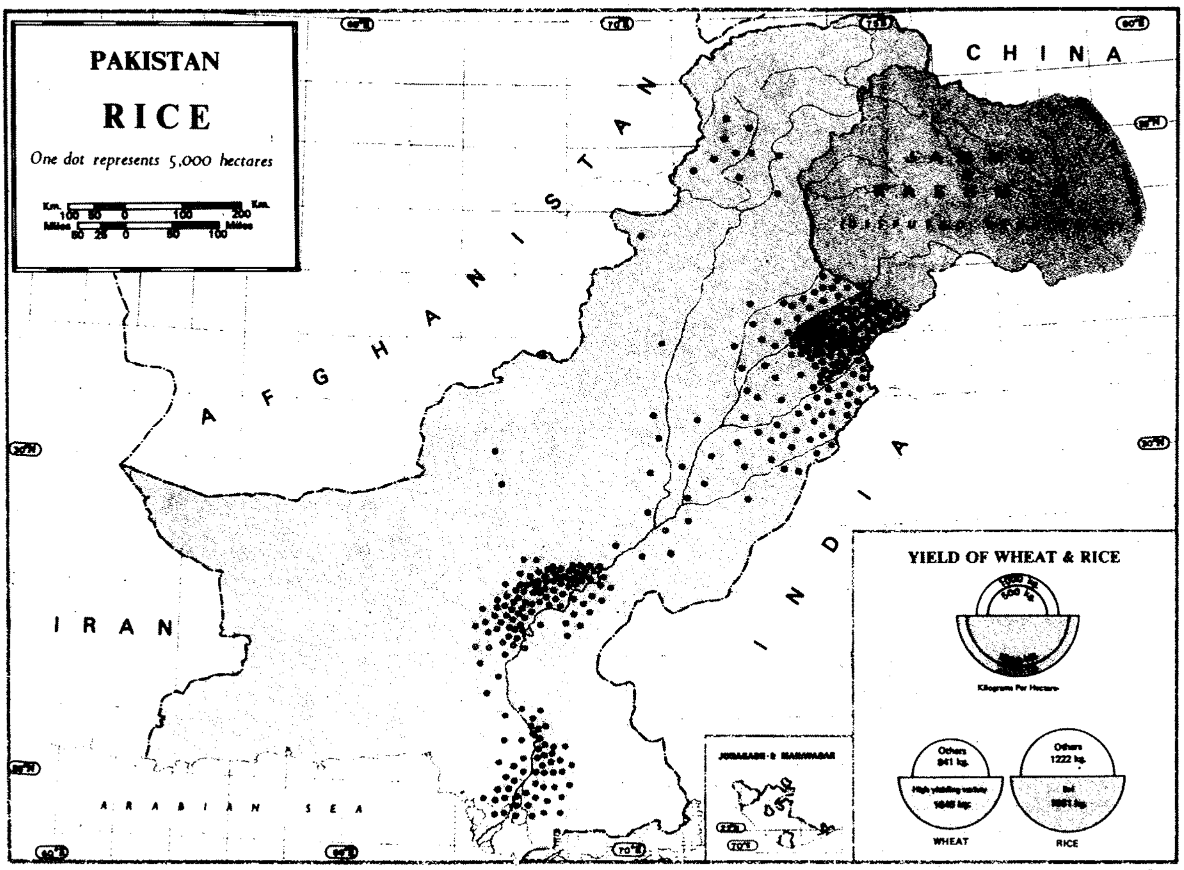


Fig. 5 PAKISTAN RICE



Source : Oxford Atlas for Pakistan

Fig. 6 PAKISTAN SUGAR-CANE MILLETS

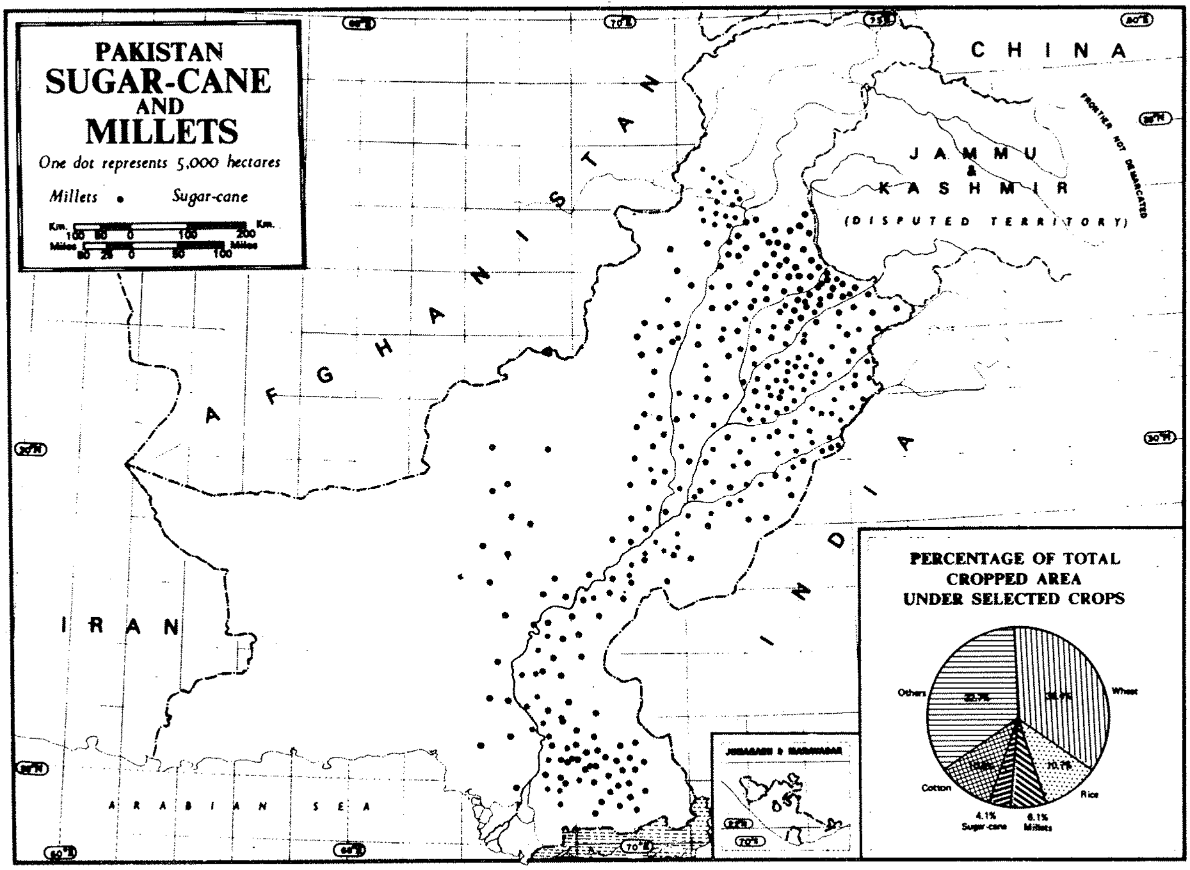
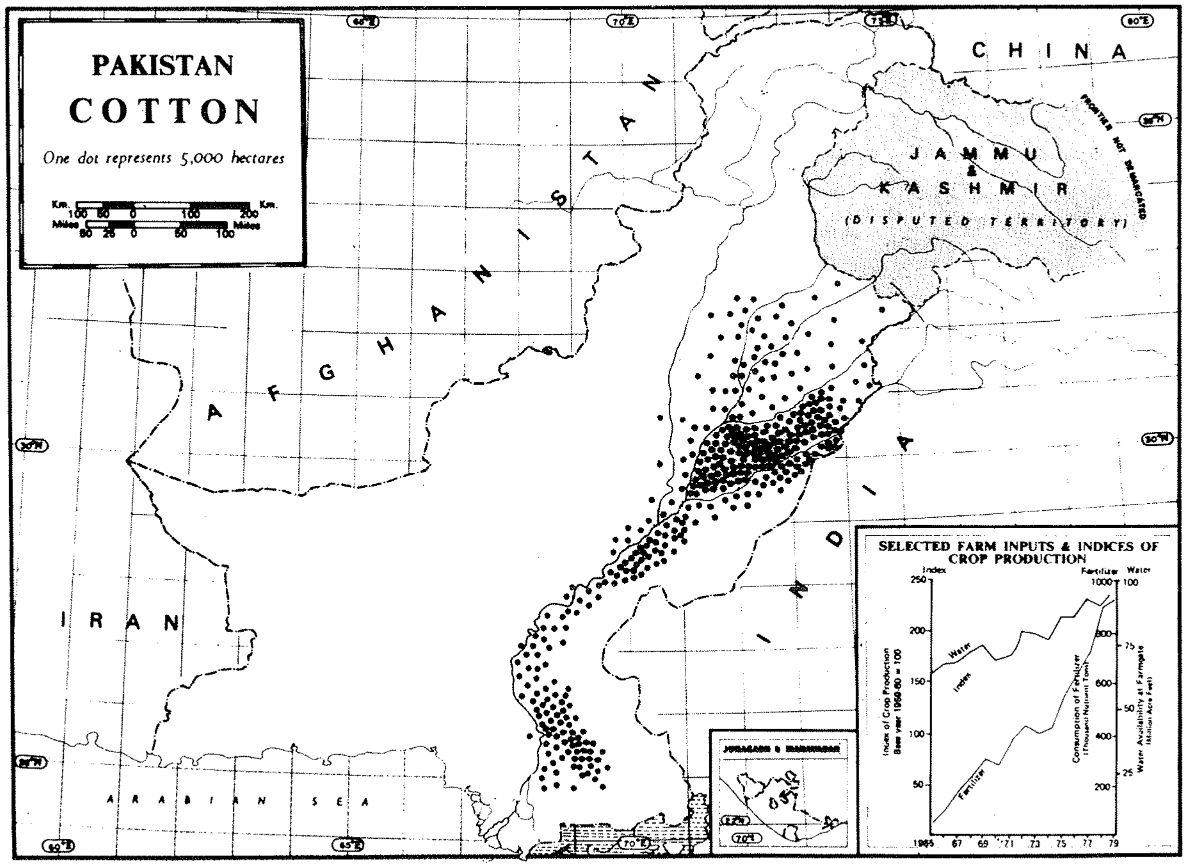
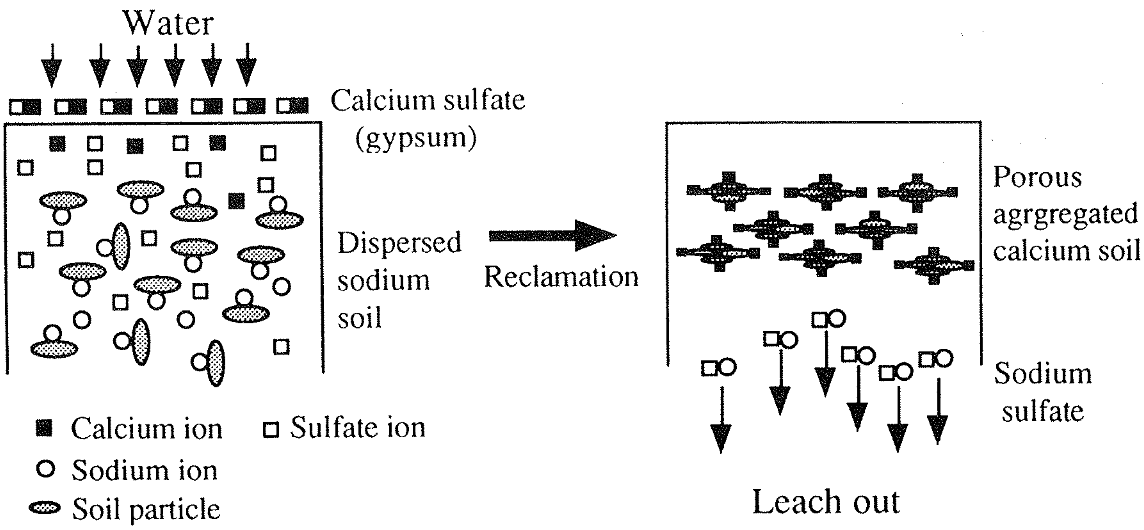


Fig. 7 PAKISTAN COTTON



Source : Oxford Atlas for Pakistan

Fig. 3 Illustration of the removal of exchangeable sodium by the addition of calcium sulfate (gypsum).



Souce: Chemical Amendments for Improving Sodium Soils, Agr. Inf. Bull., 195 USDA, 1959.

Chapter 2

Field Survey Report

1 Overview of the Surveyed Region

(1) Agriculture and Rural Economy in Sheikhupura District

There are many factors that set back agricultural development in Pakistan. We focused on the irrigation and salinity soil problems above all things and made a comparative study of two villages in Sheikhupura District under the different conditions of irrigation and soil conditions, seeking the ways to solve the problems. We chose the study area, taking into consideration of convenient location for field survey as well as the objectives of our research.

Sheikhupura District, which was chosen as the study area, is a region where the condition of irrigation is particularly favorable even from the standards of Punjab Province which is known for the better conditions of irrigation and where the SCARP (Salinity Control and Reclamation Project) has been implemented prior to other regions.

Sheikhupura District is a district located on the west bank of Ravi River opposite of Lahore which is the provincial capital of Punjab. It has a population of 3.1 million living in an area of 590,000 hectares, resulting in a high population density of 525 persons per square kilometer. Agriculture (including live stock farming) is the most important industry in this district where 57% of all households are farm households and the ratio of family members engaged mainly in agriculture accounts for 48% of all family members 10 years and above. In addition, while the percentage of irrigated area has reached nearly 100%, 13.5% of arable land still remains the saline area despite implementation of SCARP over many years (Table 1).

The major agricultural products are wheat, rice and milk. As for the cropping pattern, rice in kharif season/wheat or fodder in rabi season is the most common.

Table 2 illustrates the changes in wheat and rice production. The wheat production remarkably increased until the mid-'80s because the area planted expanded and the yield also increased due to the introduction and diffusion of high-yielding varieties. In the '90s, however, what production has been stagnant except in 94/95 crop year. As for rice, yield has declined in '90s from the level of the '70s and '80s when IRRI varieties were widely spread, because low yielding basmati rice varieties have been widely adopted in the '90s. However, the yield of basmati rice has been steadily growing due to the diffusion of improved varieties. The average yield of both wheat and rice are lower than the average yield in Punjab. This may be partially explained by the scarcity of arable land in Sheikhupura District which has a long history of development.

As mentioned earlier, livestock farming is important in Sheikhupura District. As given in Table 3, the number of buffalo and cow for milk production as well as goat for meat production is increasing. The average number of cow and buffalo holding per farm household amounts to 4 or 5 heads.

The average farm size is 8.4 acres (3.4 hectares). The number of small farmers who hold below and 5 acres (2 hectares) of farmland share 43.7% of all farmers. In Sheikhupura District, the annual income of a daily wage laborer is approximately Rs.130,000 if he works 5 days a week throughout the year. To get the same amount of income from wheat and rice farming, a farmer needs 6.23 acres of farmland if we assume the average yield given in Table 2. 1) Table 4 shows that more than half of farmers have only less than 6.23 acres. This indicates that only half of farmers can maintain a living standard that is equal to or better than daily wage laborers if the farmers solely depended on crop farming as an income source By the way, the foregoing discussion assumes. If we take tenant farmers into consideration, the actual number of farmers who can get at least the same amount of income as daily laborers is estimated to be less than half. Table 5 shows that the number of share tenants is about 30% of all farmers. This figure is smaller than the number of share tenants in Sindh Province where landlordism is a characteristic of the land tenancy system. But the share tenancy land area where is subtracted half of thee production as a land rent, accounts for 70% of total tenancy land area. Under such a share tenancy contract, the tenant farmers have to have at least 12.5 acres of farmland if they get the same amount of income as daily wage laborers.

Thus, presently there seem to be a considerable number of poor small scale farmers in Sheikhupura District. These small-scale farmers who hold 5 or less acres of farmland has been increased rapidly during the past one or two decades (Table 6). This is attributable to the progress of land fragmentation caused by population increase. Table 6 shows that more than 40% of farmers have more than two plots of land (average 2.8 plots per farmer) and the average area per plot is only 4.7 acres.

Meanwhile, mechanization of agriculture has progressed despite the fragmentation of farmland. It is very common that farmers use farm machinery such as tractors, tubewells and threshing machines (Table 7). In addition, we cannot find the fact that the larger scale farmers use farm machinery more frequently (Table 8).

While almost all arable land in Sheikhupura District is irrigated, the most method of irrigation is to use irrigation canal together with tubewell (Table 9). Farmers depend on this method because the water drawn from irrigation canal is not sufficient to meet the demand for water during the kharif season.

Chemical fertilizers are used by more than 90% of farm households. It is a remarkable feature in Sheikhupura District that the percentage of farmers who use manure together with chemical fertilizers in rice farming is relatively high (Table 10).

As mentioned above, considerable number of farmers in Sheikhupura District is use the so-called modern input, although farmers usually depend on loans to buy modern input. More than 50% of these loans are owed to the formal financial institutions including Pakistan Agricultural Development Bank, cooperatives and commercial banks (Table 11).

① Overview of the surveyed villages

We made a survey in Village K and Village A. In the former village, the saline soil problem had already been solved by implementation of SCARP while in the latter, it is still doing considerable damage to village agriculture despite the implementation of SCARP.

Village K is located 17km south of the capital of Sheikhupura District. It is a relatively small village that has population of about 1,300, consisting of roughly 100 households living in 338.5 acres of area. On the other hand, Village A is more remote from town are and larger in population and land area. It is located 66km west of the capital. The village population is about 4,500, the number of households is around 600, and the land area is 1729.5 acres.

The number of farm households in Village K and Village A is 55 and 350, respectively. The percentage of farm households in both villages is at the average level of Sheikhupura District. Cultivated area is 333 acres for Village K and 1,650 acres for Village A. The average farm size in Village A is 4.9 acres while in Village K it is 6.1 acres for the former and 4.9 acres for the latter. Both of them are considerably smaller than the prefectural average of 8.3 acres. Although the number of tenant farmers is relatively small share tenancy contracts are very common form of tenancy.

As for the condition of irrigation, irrigation from irrigation in Village K, canal irrigation is available for all arable land and1 tubewell is located for every 14 acres. In contrast, in Village A, only about 80% of arable land is irrigated by irrigation canal, so the remainder cannot help being irrigated by tubewells. In addition, private tubewells are located like that is about one in

21 acres. THis indicates that the tubewell in Village A has to cover a larger area than in Village K.

A common planting system in Village K is rice in the kharif season and wheat or fodder in rabi season. Meanwhile, in Village A, rice is not so common as khalif season crop because the cultivated area of rice has been reduced by 50% during the last 10 years due to water shortage and saline soil problems. Therefore, the most common cropping pattern is rice, sugar cane and corn (including maize and sorghum) in kharif season and wheat in rabi season. It is a remarkable feature that many farmers who are damaged by saline water leave their farmland in waste. Fodder is also grown here but the share of planted area is smaller than in Village K. The increase in sugar cane production can be explained by the high profitability and salinity tolerance.

Farm mechanization, land preparation and threshing for wheat as well as land preparation process for rice have been mechanized for the most part in both villages, whereas threshing process for rice has not been mechanized to prevent shattering habit of basmati rice. In Village A, buffaloes are still used in some areas for land preparation.

Table 14 shows the stage of cultivation for wheat and rice in the two villages. From this calendar, we can find differences of wheat and rice technologies to be as follows:

1. The seeding for rice is started about 2 weeks earlier in Village A than in Village K.
2. In Village K, the canal water is used for what production, whereas the farmers use groundwater together with canal water for wheat production in Village A because the government stopped discharging canal water in January.

② In Village A, zinc-sulphate is often applied for soil amendment.

The abovementioned features of farming in the two villages can be identified in farming practices of individual farmers. According to Table 13, all farmers in Village K (farmers A, B and C) adopt a typical cropping pattern such as rice/wheat in this village. In contrast, the farmers in Village A (farmers D, E, F and G) plant sugar cane and oil seeds as well as rice in kharif season. And the farmers usually have the idle lands. In addition, it should be noted that farmer F planted Sudan grass to cope with saline soil problem.

Productivity of wheat for interviewed farmers was higher in Village A. The income per acre was approximately Rs.3,000 in Village A as opposed to Rs.1,500 in Village K which is about one half of the former. Rice income per acre in Village K can be estimated as Rs.2,118, assuming that farmer B in Village K conducts the farming operation by himself without hiring any permanent worker and farmer C can obtain a normal crop in this village. This income is almost same as rice income in Village A (Rs.2,233). 2) In other words, it appears that farm income in Village A can be improved significantly if saline soil and water shortage problems can be overcome and planted area of rice in kharif season can be expanded.

In the following sections, the measures improving inefficient irrigation system, coping with rapid population growth and solving the saline soil problems will be investigated in more detail.

2 Renovation of Irrigation System

When a developing economy with a considerable size of population such as Pakistan seeks sustainable economic growth, its stagnant agricultural sector could impede the progress of industrialization. The increased prices of food grains caused by food shortage along with the increasing population pressure will eventuate in an increase in real wage rates, which consequently diminishes the profit rate of the industrial sector. Though grain prices can be stabilized through grain imports, it may deteriorate international payments position and, hence, will restrict the imports of capital goods and technology. This consequently hinders industrialization. This logic is known as the Ricardian Growth Trap. Pakistan economy is quite within the bounds of possibility of being caught in the trap, considering its high population growth rate and the stagnant agricultural situations.

Agriculture in Pakistan is now at the crossroads. Land frontier has already disappeared, and therefore extensive expansion of arable land is no more expected. So called modern inputs comprising Green Revolution technology, namely high-yielding varieties (HYV), chemical fertilizers and irrigation, are not necessarily producing desirable results. Renewal of HYV seeds, which is required for every sowing, is only done at an average of every three years. This leads to a decline in yield. Moreover, explicit subsidies on chemical fertilizers, HYV seeds, mechanization and irrigation have now been reduced as a result of financial difficulties of both the Central and Provincial Governments and the conditionality of the World Bank/IFM structural adjustment programme that aims at bringing input and output prices closer to world levels.

Of the problem the Pakistan agricultural sector is faced with, difficulties associated with the canal system is to be discussed in this section. The vast Canal Colonies were formed in the British Punjab. The canal system, however, have become obsolete to meet the needs of modern agriculture, being faced with serious problems of salinity and waterlogging. The canal system is in urgent need for rehabilitation and is confronted with the demand for system renovation including financial independence and privatization of the irrigation bodies. If these tasks are not properly addressed, the obsolete canal system would have an undesirable effect on the future of the Pakistan economy, as can be inferred from the Ricardian Growth Trap.

The canal system currently faces three major problems. Firstly, water conveyance efficiency is deteriorating owing to superannuation of canals. Overall water losses from canals is said to reach 50%, including 10% in the main and branch canals, 15% in the distributaries and minors, and 25% in the watercourses. Another 10% is lost through evaporation. Accordingly, less than half of the water from the canals reaches the crops. Rehabilitation as well as appropriate operation and maintenance(hereafter O&M) of the canal system to reduce the losses are urgent tasks for Pakistan's agriculture.

Secondly, the improperly maintained canal facilities with poor drainage inevitably raises the groundwater level. This has caused salinity and waterlogging, which are said to be damaging

40% of cultivated areas of the country.

Thirdly, in spite of numerous measures taken to address these problems, financial difficulties are compelling these measures to be reconsidered before they were able to obtain full results due to the vast areas to be covered and inefficiency of government organizations.

(1) Irrigation System

① Canal irrigation

First of all, let us take a brief look at the irrigation system of Pakistan. Figure 1 shows a typical canal system. A barrage constructed in a river diverts water to a main canal. The main canal is then split up into branch canals. No water up to branches is provided for watercourses. Water is sent down to the distributaries or minors(small distributaries). Then, water is taken from the distributaries or minors into watercourses through an outlet called a mogha.

WAPDA(Water and Power Development Authority) of the Central Government is in charge of constructing the main irrigation facilities, and their O&M is transferred to Provisional Irrigation Departments(PID). On the other hand, Water Management Sections of Provincial Agricultural Departments are in charge of O&M for 89,100 watercourses of Pakistan. This complexity of competent bodies is one of the obstacles in realizing efficient operation of the irrigation system.

Figure 2 shows a watercourse in Village K, which is a small village in Sheikhupura district of the Punjab(338.5 acres). The village draws water from a single outlet along with adjacent Village M. In the Canal Colonies generally the land is divided into squares. One square comprises of 25 quadrate(1 or 1.1 acre) farmland called a killa. A group of squares varying from 30 to 70 (750 to 1,750 acres) forms what is known as a chak, which is practically equivalent to a village. Chack boundaries are laid out in such a manner that the efficient water management including drainage is realized.

An outlet is a masonry structure through which water is admitted from a distributary or a minor into a farmers' watercourse. The management of water after outlets is in the hands of the village authorities. The outlet is designed to discharge a constant quantity of water, 1 to 3 cusecs(1cusec: 2 cubic feet per second). The water taken into a watercourse is distributed to each farm field from turnout structures, called nakka. The distribution of water is managed by the water scheduling system known as the warabandi system(wari means turn). The farmers used to decide their own water distribution schedule in the past through what is called the kacha warabandi. Under this system influential persons tended to have advantage in receiving water more than allotted. Now, the water distribution is prepared by the Provincial Irrigation Department through a system called the pakka warabandi.

Table 15 shows a (pakka) warabandi of Village K. Intake of water starts at 1:39 am of Friday based on Islamic calendar from killa no. 4 in square no.6 which is located nearest to the outlet. Water supply time is set at 14 minutes for one killa, which is one minute shorter than the normal time of 15 minutes. This is because the village has a public tubewell(SCARP tubewell) that supplies additional water to the watercourse.

Let us now take a look at the third farm(killa no.5, square no.8). This farm is provided with water from a different nakka. As this farm has an area of 4.57 acres, 1 hour and 3 minutes of water supply time is allotted. However as the farmer is located at the end of a watercourse, it takes 1 hour and 45 minutes (corresponding 25 minutes per square) for water to reach the nakka of this farm after closing the preceding nakka. This is added to the water supply time of the third farm. In addition, as the water remaining in the watercourse flows into the farm field even after water distribution to this field is completed, this portion is subtracted from water supply time as lead time. Therefore, the total supply time amounts to 2 hours and 9 minutes. When there are several farmers in command area of one nakka, water distribution schedule has to be arranged among those farmers. Though water is normally supplied under a weekly rotation system, in areas where water is poorly available the cycle of rotation is extended.

The warabandi system as a matter of form is rationally arranged to assure beneficiary farmers of equal rights. It is, however, subject to some weaknesses. For instance, the scheduled amount of water often fails to reach the farm field at the end of the watercourse, as described in an old Punjab saying , "a chamar(untouchable) who owns farm field near the outlet of a canal is better off than a Brahman who owns his field at the end of a watercourse." In particular, if O&M of watercourses are neglected or a watercourse runs through a sandy area, tail-end farmers will be at a disadvantage in terms of water supply, since about 40% of water taken into watercourses is said to be lost during conveyance.

However, one of the greatest shortcomings of the canal irrigation is that schedule and volume of water distribution is arranged without taking the requirements of the demand side into consideration. Water cannot be supplied whenever needed. For this reason whenever a farmer gets his water turn, he tries to use as much of it as possible. This often eventuates in over-utilization of water and, therefore, causes salinity and waterlogging. This provides rationale for a discussion on the conversion of the rotation-based irrigation system to a demand-based system.

We may consider the subject under the following heads: 1) the potential for developing alternative water resources, and 2) the potential for improving the existing canal irrigation system. The latter has to be further divided into two parts before examining; a) the potential for introducing a demand-based water distribution system and b) the potential for facilitating irrigation efficiency without altering the existing warabandi, the rotation-based irrigation system.

② Possibility of using groundwater

Mining of groundwater can be a promising alternative of canal irrigation. Table 16 shows the changes in proportion of farm area irrigated by different sources in the Punjab in contrast to the Indian part of the Punjab(currently Punjab and Haryana). Unlike canal irrigation, tubewells can supply the right amount of water at the right time and at the right place on a demand base.

Therefore, introduction of tubewells is indispensable for diffusion of HYV rice for which water management is particularly crucial. In fact, tubewells became rapidly popular in Indian part of Punjab where a cropping pattern of wheat in rabi and HYV rice in Kharif has become widespread in the process of the Green Revolution since the latter half of 1960's.

In contrast, diffusion of tubewells was slow in the Pakistan Punjab for the following two reasons.

Firstly, farmers are unwilling to introduce electric tubewells despite the fact that electric tubewells are more maneuverable when compared to diesel tubewells. Actually, in the Indian part of the punjab, electric tubewells are dominant. Nevertheless, diesel tubewells are more popular in Pakistan(Table 17). According to a survey conducted by Punjab Economic Research Institute, the main reasons of electric tubewells not becoming popular among farmers having diesel tubewells include: reliability and flexibility of diesel tubewells(82%); higher variable cost of electric tubewells(72%); higher fixed costs of electric tubewells(59%) and load shedding problem(49%). It can be said in Pakistan the cost of electricity is expensive.

Secondly, saline groundwater and rising groundwater level often hinder introduction of tubewells. Several suballuvial rock ridges run in the north-western part of India. In the Pakistan Punjab ridges run across the Province at right angles to the direction of the flow of river. Groundwater level on the upstream side (north) of the ridge is shallow, since the natural drainage is checked by the ridge. Therefore, such areas when irrigated by the canal system are often subject to waterlogging and, hence, salinity. Downstream of the ridge, on the other hand, there is no such danger. However, upstream areas of the ridge is suitable for mining of groundwater, since the water is not brackish. In contrast, on the south of the ridge excessive mining of groundwater is restricted since brackish groundwater may cause salinity. For example, the Delhi-Shahpur(presently Sargodha) ridge runs across the Punjab. Owing to fresh water availability, on the north side a rice-wheat zone is prevailing. On the other hand, on the south side, a wheat-cotton zone is dominant since both wheat and cotton are water saving crops as compared to rice. Therefore, tubewells for irrigation are mainly installed on the north side. Note that in Uttar Pradesh of India where the canal system is considerably developed, no serious waterlogging and salinity is reported. This is because the ridges there run parallel to the direction of the flow of the Ganges.

Mining of groundwater as an alternative water resource in Pakistan must be carried out under the restriction of high cost of electricity and saline water. It is especially required to have strict regulatory measures that can guide the installation of private tubewells in the areas having difficult aquifer conditions.

It can be concluded, from what has been said above, that it is more practical to give policy priority to increasing irrigation efficiency through rehabilitation and renovation of the present canal system, since alternative water resources can not supply enough water to meet the growing demand for irrigation due to brackish water. Needless to say, tubewells should be installed to exploit fresh groundwater in potential areas to supplement canal irrigation. For this purpose, improvement of power generation capacity is indispensable because a shortage of electricity and its high price are major impediments of diffusion of tubewells.

(2) Changes in Irrigation Polices

As irrigation policies of developing countries are concentrated on construction of new irrigation infrastructure, development investment and international aid have been granted for this purpose in Pakistan. At present, however, irrigation policies of developing countries are said to have shifted from "construction phase" to "management phase". At the backdrop of this shift is a recognition that the existing irrigation facilities have deteriorated and are not achieving expected irrigation efficiency, as well as the completion of irrigation infrastructure facilities to a certain degree.

In addition, the financial strait that the governments of many developing countries are undergoing leads to a retrenchment in the budget for irrigation. In fact, the finance of the Pakistan Central Government is in a state of constant deficit. The development expenditure which used to account for 37.5% of annual expenditure in fiscal 1977/78 has been compressed to 25.9% in 1987/88 and to 22.2% in the budget for 1995/96. Irrigation policies of Pakistan are obliged to reconsidered under this financial stringency.

International Irrigation Management Institute(IIMI) is proposing financial independence of the irrigation body that at least ensures full recovery of O&M expenditures, participation of farmers in O&M and rehabilitation of the canal system. The World Bank, which is financing irrigation projects in Pakistan, has also given a conditionality for furnishing loans based on this concept. This is reflected in the reform of irrigation system in the Eighth 5-Year Plan(1993-98). Summery of pertinent sections will be introduced in the following as it will identify how policy-makers are interpreting the irrigation system issue and how they are trying to deal with it.

In the Eighth 5-Year Plan, the amount that has been earmarked for development of water resources is Rs. 55.569 trillion, of which Rs. 38.997 trillion is directed towards drainage and land improvement program(SCARP), and Rs. 13.483 trillion is spent to secure water resources, reflecting a budget system with continued emphasis on SCARP projects to fight salinity and waterlogging. The goal of irrigation policy as described in the Eighth 5-Year Plan is "progressively increasing surface water supplies, replacing public tubewells with private ones, improving existing management practices using the latest technologies available, and protecting land and infrastructure from waterlogging, salinity, and floods." Recognizing that the canal irrigation system of Pakistan is facing many difficulties including the advancement of superannuation, low irrigation efficiency, salinity and waterlogging, many strategies are proposed for implementations. The main points are as follows.

1) Measures against salinity and waterlogging: It is proposed to complete on-going reclamation projects as early as possible. In Saline Groundwater Zones, the latest technology will be used for new projects and the most economical measures should be employed to tackle the disastrous areas. In Fresh Groundwater Zones, reduction of financial burden must be sought by deferring the installing of new public tubewells and facilitating the transition of tubewells from public to the private sector. Moreover, salinity and waterlogging should be checked through farm field canal improvement project including efficient on-farm management practices, lining of minors and watercourses, and construction of surface drainage facilities.
2) Recovery of O&M costs: The maintenance of irrigation facilities after the completion of projects is unsatisfactory. As mentioned above, the government can not afford adequate budgets fully to increase the efficiency of O&M due to financial difficulties. Measures should be taken to improve O&M funding through improving the system of O&M recoveries from farmers. This will be done in phases through increased water charges, drainage cess and other appropriate measures.
3) Privatization: Policies that mobilize the private rural resources for development and O&M of the canal system have not been adopted so far. The private sector can play an important role in a) groundwater development, b) on-farm improvement including water conservation, land leveling and improved water distribution, and c) construction of field drainage facilities, and O&M up to minor and tertiary drain level.

The intentions behind these goals is apparent. Suffering from financial stringency, the Central Government is trying to shift the burden for irrigation as much as possible to Provincial Governments and eventually to farmers. Part of the forgoing policy suggestions have already been implemented or is scheduled to be implemented in the near future. Their associated problems and policy suggestion will be discussed in the following.

(3) Possibilities of modifying irrigation policies and their problems

① Measures against salinity and waterlogging

Salinity Control and Reclamation Projects(SCARP) and On-Farm Water Management(OFWM) are the main measures taken against salinity and waterlogging. As several new attempts are made in these projects, they will serve as reference for implementation of ODA.

SCARP : In 1959 the Government has initiated SCARP programme to control the twin menace of salinity and waterlogging by pumping water through SCARP tubewells. In Fresh Water Zones pumped water is supplemented to canal water for irrigation. This project has contributed towards solving salinity and waterlogging problems by lowering groundwater level. While WAPDA is the competent body for installing SCARP tubewells, O&M of them after installation is consigned to the Provincial Irrigation Departments. The initial objective of controlling groundwater level was achieved to a certain extent by this project, although the following problems remain: a) O&M expenditures(particularly the electric charges) have become enormous, b) supply of additional irrigation water has not been performed efficiently due to poor management, and c) drainage capacity has dropped because of superannuation of pumps, but SCARP tubewells can not be replaced due to budget shortage.

Therefore, a decision was made in the Sixth 5-Year Plan(1983-87) to replace SCARP tubewells with private ones through assistance of the World Bank. However, SCARP tubewells were left for the purpose of drainage in Saline Water Zones as private tubewells could not be expected for drainage only. What had taken place in the process of the early phase of SCARP project needs to be explained in some details as they are expected to offer suggestions and insights that would be beneficial in preparing policies for future renovation of the irrigation system of the country.

In SCARP Transition Pilot Project(1984-1992), 213 SCARP tubewells were closed and replaced by 3,700 private tubewells through subsidization in the areas underlain by fresh groundwater. These private tubewells are expected to pump more groundwater than SCARP tubewells and to adequately meet the drainage requirements of the area. However, several problems came up in the process. Firstly, the amount of subsidy rose to an enormous level, leaving no choice but to limit the number of farmers that could install tubewells. Further, as a certain scale of farmland is required for efficient use of a tubewell, installation of tubewells became an excessive investment for small farmers. Incidently, water from SCARP tubewells had been added to irrigation water from the canal and distributed among all farmers according to the warabandi system. However, the use of groundwater was limited to tubewell owners once SCARP tubewells were replaced by private wells, and the volume of water distributed to non-owners(generally small farmers) was reduced. In order to safeguard the interest of small farmers, the following criteria laid down for allocation of subsidy in the Second SCARP Transition Project: a) first priority would be given to Water Users' Associations(WUAs) that jointly install private tubewells; b)second priority would be given to groups of small farmers applying for installing private tubewells jointly; and c)farm households that do not own their farm fields near an outlet.

The second option involves a new experiment in that farmers organization jointly owns a 'community tubewell.' The farmers organizations have to be registered as formal entities or as sub-set of WUAs under the WUAs Ordinance 1981. The farmers organizations would establish a bank account, and deposit funds for their share of the tubewells cost and cost for one month's operation of the tubewell. A fund for future replacement of the tubewells would be generated through water sales.

The second SCARP transition project has been consigned to a private consulting company, OFWM section of Provincial Agricultural Department, NGOs and Provincial Irrigation Departments(PID). As for their respective progress, the consulting company and OFWM sections are successfully implementing their transition work, NGOs are experiencing some difficulties and PID are lagging behind.

The reason behind the success of OFWM section is that it have direct relationship with WUSs and therefore is able to govern the farmers in carrying out the transition work. On the other hand, the method taken by the private consulting company is also worthy of attention. This company hires 30 college students as social organizers who majored in rural sociology. The most important work of the social organizers lies in identifying a farmer who will become the leader of a farmers organization and motivate him to install and manage a community tubewell. Social organizers then facilitate to form an organization and assist in the procedures for installation of private tubewells. As is well known as Tragedy of the Commons, collective ownership of means is subject to devastation of resources since individuals concerned would be likely to take opportunistic behavior. To prevent it some kind of morale or legal regulations are required. It is farmers organizations that are expected to prevent the Tragedy from taking place. The method adopted by the consulting company of placing farmers organizations in charge of O&M of community tubewells is worth of attention in this sense. Attention must also be given to the principle of competition that the World Bank has introduced by assigning SCARP Transition Project to several concerns and gradually increasing the assignment according to the progress of their respective performance.

OFWM : To address the problem of water losses at watercourses, the Punjab Government launched the OFWM Project in 1976/77 with assistance from the USAID assistance. Later on, technical and financial assistance was offered by the World Bank and Asian Development Bank. The goal of the OFWM project is to increase irrigation efficiency by preventing water losses through properly designed channels, partial concrete lining and installation of concrete turnout structures(pakka nakka). Water was initially diverted at nakkas by banking the watercourse. This work, however, requires labor as well as time, and has become the cause of irrigation dispute.

When commencing this project, the WUAs are organized and registered on each watercourse taken up for renovation. The OFWM project cover 70% of the costs of materials for improvement of watercourses, while the WUAs pay for the remaining 30%. The labor cost for watercourse renovation will be arranged and provided by the WUAs. The WUAs are also in charge of O&M of watercourse after its construction according to the instructions from Provincial Agricultural Department. For this purpose, membership fee of Rs.10 to 20 is collected from each farm household after every harvests (rabi and kharif) to pay for O&M of the watercourse. Thus, participation of beneficiaries plays a pivotal role in the successful implementation of the OFWM project.

Since shortage of funds does not allow application of lining on all watercourses, 15 to 30% of each watercourse is improved. The priority of lining is given in the order of a) watercourse near the outlet, b) watercourse that runs through a residential area, c) sandy area, and d) lifted areas from which water tends to overflow. In the Punjab about 20,000 among 55,000 watercourses have been improved.

The effectiveness of the OFWM project can be inferred from Table 18. Percentage of water losses has been improved by 7 points, resulting in reduction of non-arable land by 2.2 points. In addition, significant improvement in land productivity of main crops are observed in crops that require proper water management such as IRRI rice and sugarcane. Furthermore, reduction of disparity in productivity between farm fields that are located near the outlet and those located at the end of watercourses is worthy to note.

From the viewpoint of reducing water losses, there is no reason for giving priority to lining of watercourses over that of main canals, branch canals, distributaries and minors. The greatest reason for giving priority to improvement of watercourses is its potential for mobilizing rural resources in the form of active participation of the farmers in O&M of watercourses, which in turn will open the door for reducing the financial burden of the government.

In other words, investing in watercourses will make mobilization of rural resources relatively easy and give scope for voluntary O&M among farmers because the effects of investment to watercourses by the farmers can be internalized. In contrast, internalization of investment will become more difficult as it is offered upstream from minors all the way to main canals. As irrigation facilities in these areas will assume more characteristics of public goods, it will not only make mobilization of rural resources more difficult but will be incompatible with privatization.

Survey in two villages in Sheikhupura district of the Punjab suggests the effectiveness of this project by showing active interest among farmers in OFWM. However, there are some survey results that question whether farmers organizations and the WUAs can function over a long period of time as organizations. Measures that will establish agricultural cooperative-oriented businesses, such as cooperative purchasing of chemical fertilizers, cooperative sales of farm products and agricultural financing, by linking them with irrigation organizations to invite more commitment from the farmers may strengthen the farmers organizations for irrigation.

② Recovery of O&M costs

In line with the above-mentioned IIMI proposal, the World Bank is recommending the raising of water charges to ensure full recovery of O&M expenditures. Water charge was raised by 25% according to the Central Government proposal. Although the Punjab did not follow this in the beginning, it is carrying out an annual raise of 10% between 1993 to 1998. As results of such a pricing policy, two effects are anticipated; a) enhancing efficiency of water use and b) financial independence of irrigation bodies.

As a beginning, we will examine if raising water charges leads to increased efficiency of water use. At the backdrop of this claim by the World Bank to raise the water charge is a recognition that low water charges(Rs.45/acre for rice and Rs.29.7/acre for wheat) are causing excessive use of scarce water resources and is aggravating water shortage, waterlogging and salinity. According to the experiences of other parts of the world, however, collection of water charges or raise of water rates did not lead to improvement of irrigation performance. Water charges have to be linked with volumetric supply of water so as to increase efficient use of water resource. However, as it is virtually impossible to measure volumetric supply of water to each farm field in a gravity irrigation system, water charges in canal irrigation are obliged to be fixed per unit size of farm field. Accordingly the price-efficiency link can hardly be realized in a canal irrigation system.

When these are considered, it can be concluded that the warabandi system can be a second best water management system, although it can not provide demand-based water supply. Therefore it would be more practical to seek improving efficiency of the warabandi system for enhancing irrigation efficiency.

③ Can privatization and financial independence be a panacea?

The second question is if privatization and financial independence of irrigation bodies would enhance irrigation efficiency. In September 1995, the Water and Power Ministry issued a notification addressed to Provincial Irrigation Departments as advocated by the World Bank, ordering them to become independent institutions (including financial independence) as of July 1, 1996. Provincial Irrigation Departments are to establish Area Water Boards to supervise water distribution, manage canals and collect water charges from the beneficiaries. In addition, one distributary in each province is transferred to a WUA on an experimental basis. The initiative would render farmers groups responsible for water distribution, the payment of charges and the maintenance of the system. If this experiment is found successful, the system will be applied to all distributaries.

For the reasons stated above, however, it is doubtful whether this attempt will be successful. As we have discussed, motivation of the farmers cannot be expected beyond the watercourses. Furthermore, these changes in the system tend to turn our into political issues. For instance, the former minister of finance issued a statement opposing this official announcement immediately and said that he will launch an opposition campaign. Provincial Governments would also be hesitant to implement such changes because financial independence of irrigation department would entail considerable raise in water charges which will obviously be opposed by the farmers(voters). One staff at agricultural department of the Punjab said, "Since only 30% of the irrigation-related expenditures is currently covered by water charges, the charges have to be tripled to realize financial independence of governmental irrigation institutions. As the present water charges are set at an extremely low level, tripling the charges in itself will not become enormous burden for the farmers. Considering their opposition, however, it is not easy to raise the charges."

Attention must be given to the fact that the degree of financial independence can be also improved by raising the collection rate of water charges which is only 55% at present. One reason for this low rate of collection is that revenue collection and O&M funds allocation are handled by different agencies. Although water charges are fixed according to farm size in Pakistan, the crop planted on each plot have to be monitored at rabi and kharif seasons because water charges are determined by the type of crops being planted. This work is performed by the officials of the Provincial Irrigation Department (Revenue Patwari and Irrigation Patwari). Based on their data, Provincial Revenue Department collects water charges through village tax collectors (lumbardar) who receive 3.5% of the amount collected as compensation. In the case of Village K, the compensation for lumbardar is less than Rs. 500 for each season even if the rate of collection is 100%. The collector of Village K hires a landless villager as an agent, and according to an agreement with the village people, each farm household pays Rs.10 to the agent each time for collection. Since there are 55 landowners in the village, the agent earn an income of Rs. 550 for each season, which is larger than the compensation received by the tax collector. If the compensation for the agent is regarded as the market price for collection, the incentive of collection for lumbardars is said to be extremely weak. Furthermore, no penalty is imposed on the tax collectors even if they do not make a complete collection. A district chief(zilladar) is supposed to order payment to farmers who do not pay charges, but big landowners who are influential in the region are often excluded. Raising water charges without improving the collection rate would cause serious problems associated with free riders.

Water charges collected by Provincial Irrigation Department are divided between irrigation department and water board of agricultural department. The fact that different institutions are in charge of revenue and allocation of expenditures for irrigation is believed to be the cause of weak incentive for full collection of water charges. The existing O&M mechanism should be modified in such a way that the bodies involved both water charge collection and O&M fund allocation are performed by a single body.

Although details are unknown, the foregoing government notification of September 1995 appears to be indicating the direction of such unification. However, it should be noted that unification does not necessarily call for financial independence. The need for financial independence arises strictly from the financial difficulty of the Central Government, not from improvement of irrigation inefficiency.

④ Problems of Irrigation Policies

Pakistan agriculture is currently at a turning point. A series of policy shifts including cutbacks in subsidy for irrigation, chemical fertilizers, and procurement prices will ultimately place the agricultural sector itself under the control of market mechanism and expose it to competition in the international market. So long as the existing policy brings about increase in water charges including electric charges for irrigation and prices of chemical fertilizer as well as decline in support price, its negative impacts on agricultural performance can be easily predicted. Moreover, the funds allocated to irrigation infrastructure will be reduced significantly if financial independence of irrigation bodies is carried out as planned.

Japanese experience in the early phase of economic development will good insights for assessing Pakistan's agricultural polices. In Japan irrigation facilities had already been equipped to a considerable extent when industrialization started after the Meiji Restoration in 1868. Even though, intersectoral resource flows for several decades after the Restoration had been done from the industrial sector to the agricultural sector. As have been examined up to know, the infrastructure of Pakistan agriculture is insufficient and deteriorating especially in the area of irrigation. Changes in agricultural policies in line with the World Bank conditionality would decrease the resources flow to agricultural sector. If that were the case, a need would arise for transfer of resources to agricultural sector to be recovered partially by the assistance from international institutions for sustainable growth of agriculture. Assistance to the irrigation system shall be given the highest priority among them.

Conclusion : Possibility of ODA for irrigation infrastructure

Assuming that improving irrigation facilities is an important aspect that will determine the fate of Pakistan agriculture, what kind of ODA can be considered? Possible options are; a)construction of dams and power plants; and b) lining and rehabilitation of canals facilities and construction of drainage facilities. Either will improve irrigation efficiency and contribute to increase in agricultural production. However, O&M of irrigation facilities shall be given priority to deal with the salinity and waterlogging problems. In addition, the following must be mentioned with regard to comparison of the above options as subjects of assistance. While the former option of the construction of dams and power plants requires large-scale investment, the latter is characterized as technologically divisible investment. In other words, small funds can line a small portion of canals, and the projects can be accumulated one by one.

However, applying lining to all canals would require a large budget. Therefore, assistance resources need to be properly allocated. It goes without saying that, for this purpose, irrigation facilities to which mobilization of rural resources and voluntary participation of beneficiaries for O&M are expected would be ideal subjects of investment. Mobilization of rural resources including voluntary participation of the beneficiaries can be most expected in the watercourses since the effect of investment to watercourses can be recognized directly by the beneficiaries. In other words, the effects of investment to the watercourses can be easily internalized as compared to investment made to the main canals to minors. Thus, the canal system from main canals to minors is characterized as public goods for which it is difficult to mobilize rural resources. Therefore, priority for lining should be given to watercourses for the time being.

Installation of private tubewells is also a desirable method of water resource development in watercourses. However, high electric charges and lack of stable supply of electricity hinder diffusion of electric tubewells despite their good maneuverability when compared to diesel tubewells. Electric charges are expected to skyrocket after the power wing of WAPDA is privatized. Its effects are self-evident. Little can be expected from subsidy towards private tubewells due to financial difficulties of the Central and Provincial Governments. In addition, in Saline Groundwater Zones, installation of tubewells has to be strictly regulated. This also suggests that priority should be given to watercourse improvement.

The following points will have to be considered with regard to the method of ODA. a) The irrigation system of Pakistan is now in the process of decentralization in that the authority for making decisions related to irrigation is likely to be transferred to provincial governments and eventually to district governments. Planning of ODA has to be discussed with the Provincial Governments rather than the Central Government. b) As reorganization and coordination of irrigation authorities is being planned, ODA on the area of irrigation has to be provided after ascertaining how this will turn out. c) Forming the beneficiaries as WUAs and farmers organizations for jointly-owned tubewells, and voluntary participation of the beneficiaries for O&M of watercourses are indispensable for watercourse improvement. Therefore, projects incorporating the ideas of social science are required as discussed in relation to a consulting company of the Second SCARP Transition Project.

3 Population in Regions Surveyed

(1) Population of Punjab Province and Sheikhupura District

The rate of population growth in Punjab Province is estimated as 2.67%, slightly lower than that of Pakistan as a whole which is 2.68%. Even at this population growth rate, however, it only takes 26 years for the population to double in number. Despite the fact that this region has a long history of development, mortality rate and infant mortality in this region rate is higher than the national average. In addition, birth rate is lower than the national average in spite of high infant mortality rate which contradicts the theory of "Infant Survival Hypothesis" outlined in the Overview (Table 19). This may be signifying that excessively high population density has made it difficult to solely rely on agriculture for living, which, in turn, increased the number of regions where that is operating as a limiting factor of birth.

Increase of agricultural production in fiscal 1994 marked an unprecedented growth in the recent years. However, there is no land suited for cultivation that has been left undeveloped, and land productivity is low compared to world average. Although one may say that there is room for improving productivity by only looking at the figures, drastic improvement of productivity is not that easy so long as causes for low yield such as salt damage exist. In fact, an opinion of a high official in Punjab Province Department of Agriculture was that efforts for improving agricultural productivity must be made, although it is extremely difficult as a practical matter to support the population that will double in 26 years.

A study of changes in number of population in Pakistan shows that population of ages 0 to 4 fell below that of ages 5 to 9 for the first time in the 1981 census. It would be very interesting to find out how that has changed now after 15 years. However, as far as can be seen from changes in total fertility rate (TFR) based on the results of a sample survey, no drastic changes have occurred.

Nevertheless, the potential and sign of change do seem to exist. We were unable to conduct sufficient hearing survey with regard to population matters in this survey. Although the surveyed cases were too few for generalization, the results from the hearing survey that we were able to perform are shown in the following.

(2) Field survey

Hearing survey on population issues was conducted in Village K and Village A. In particular, a hearing survey was conducted on teachers at primary school for boys, at primary school for girls and at secondary school for girls in Village A.

① Hearing in Village K

Village K is located at a distance in straight line of 17km from Lahore, the provincial capital of Punjab, and has factories in the vicinity producing textile, soap and dairy product. It has a population of about 1,300 living in high density of 949 persons per square kilometer. This figure is about three times as large as the average of Punjab Province and is almost twice as large as that of Sheikhupura District.

In this village, about half of male population, which corresponds to a quarter of the entire population, are employed as factory workers. This situation is said to have resulted from many farm households owning very small cultivated land after their land was divided under the influence of Islamic equalized inheritance, making it impossible for them to earn enough income from agriculture alone. Therefore, there were many people in this village who had to spend their lives as bachelors. In addition, as expanded family was common, there are many families in which brothers, sisters and their family shared their livelihood.

In one example, in one family where 3 brothers shared livelihood as one family, 20 persons including their spouses and children lived as one family. In this case, 1 or 2 of the brothers cultivated the land they had inherited from their father and the rest worked as factory workers and contributed their cash income to the family.

In this Village K, there is an primary school for boys and an primary school for girls up to fifth grade, and the percentage of school attendance is said to be close to 100%. Although some of the farmers that were included in the hearing survey had not received any school education, they had strong interest in having their children educated. However, percentage of school attendance, which is nearly 100% for both boys and girls in the primary education level, changes dramatically after reaching the secondary level as it drops to 30% for boys and as low as 5% for girls.

According to the hearing survey, the reason given for this sharp decline was not so much the priority given to boys but the difficulty for girls to commute to secondary school as it was located 30km from this village, which meant that girls had to find some kind of boarding. The general tendency among parents to keep their girls at home is said to be the reason for low percentage of secondary school attendance among girls. Thus, the general opinion was that girls' attendance would go up if there was a school for girls within a commutable distance.

Some were of the opinion that they only needed one child if it were a boy. In addition, all of the 7 persons that were included in the hearing survey said that they were willing to accept means of family planning provided that it was acceptable in some way or another.

② Hearing in Village A

Village A is located at a distance in straight line of 65km from Lahore, the provincial capital of Punjab. It has a population of about 4,500 and possible density of 643 persons per square kilometer. Twenty percent of adult male population is said to be public servants. We were also told that there were quite a few people with master's degree. Percentage of primary school attendance in this village is said to be between 70% and 85%. No difference in percentage of school attendance existed between boys and girls of this village, either. Indeed, higher percentage of girls moved on to secondary school than boys because the village had both primary and secondary school for girls but only primary school for boys.

This situation is said to have existed for the last 10 years. In this village, the number of people employed as public servant is rapidly increasing. It was said that as many as 50% of male population will be working for the government in the next 10 to 20 years, and this change is said to have resulted in more girls attending school. The percentage of girls attending school, which had been markedly lower than that of boys, was suddenly improved.

③ Hearing among school teachers in Village A

In this hearing, questions were asked on the number of students on the register for each grade, dropout rate, final schooling of teachers, ideal number of children considered among teachers and awareness regarding family planning.

i) Primary school for boys

The number of students on the register by grade ranged from 40 to 20 (Table 20). Dropout rate was approximately 50% for first grade through fifth grade. Final schooling was completion of 12th grade for all 4 teachers at boy's primary school and one of them had a teaching diploma. As for the ideal number of children, one teacher said "2," two said "4," and one said "6 to 7." When asked about family planning, their response was that it was not necessary and that more population would lead to higher income. In response to a question about how to support such increase in population, their opinion was that it was God's responsibility and that it was not something for people to worry about.

ii) Primary and secondary school for girls

Primary school and secondary school for girls are integrated into one school and have seven teachers. The number of students on the register by grade ranged from 16 to 40, corresponding to about 75% of each age group's population. Dropout rate was between 15% and 20% for first grade through fifth grade. As for final schooling, four teachers had completed 10th grade, two teachers had completed 12th grade and one teacher had a bachelor's degree (completion of 14th grade).

In response to the question about the ideal number of children, one teacher said "1," three said "3," another three said "4" and two said "5." When asked about family planning, their response was that education, particularly literacy, was the most important factor and that some kind of measures including family planning was necessary.

iii) Comparison of boys' school and girls' school

When these two schools in the same village are compared, it can be seen that, in contrast to the national statistics for Pakistan, percentage of school attendance is higher and dropout rate is lower among girls. Although this situation has only come about recently, it is an interesting case because it can be seen as a phenomenon that accompanied the changes in employment structure. One of the possible reasons for high dropout rate among boys is the demand for labor in outdoor activities including agriculture. No marked difference in number of children considered as ideal was identified among teachers, although female teachers had higher awareness of the need for family planning.

(3) Religious education, school education and population programs

In Japan where education based on modern education system played the role of breaking long-established conventionality, the education based on modern science rarely had to experience conflict with traditional education. However, when we asked the teachers in the villages we surveyed whether there was any contradiction between religious education and school curriculum, their response was that it was not possible.

Primary school teachers are in charge of basic religious education while "Ulama," who are Islamic scholars also acting as religious leaders, are generally offering higher religious education. For this reason, no contradiction exists between institutional education and religious education as institutional education is incorporated into the Islam ideology. As Ulama usually have diplomas comparable to master's degree, they possess higher education and authority than primary school teachers.

Therefore, it is always important to solicit the cooperation of religious leaders when dealing with population issue in Pakistan. Ulama organizations are incorporated into the system of religious authority regardless of their sect or alma mater and are institutionalized, and therefore plays a strong role in maintaining traditional and social customs in Pakistan. In other words, this means that a powerful system for propagation of knowledge is in existence.

As mentioned earlier, no obstacle exists in principle in soliciting cooperation from Ulama as International Conference of Parliamentarians on Population and Development (ICPPD) in Cairo has been more or less acknowledged by the Islamic doctrine. Moreover, many of the residents are waiting for the introduction and implementation of family planning methods that are religiously approved and acceptable, and demand is high as far as in the villages that were included in the survey are concerned. Addressing the population issue is also essential for realizing agricultural production that will support the increasing population. Seeking participation of Ulama and realizing population programs in ways that involve them are prerequisites for solving the population issue in Pakistan.

4 Characteristics of Nature and Soil in the Subject Region

Judging from topographic characteristics of Pakistan, Punjab and Sindh are the center of economic and agricultural production in Pakistan. These provinces are located in upstream and downstream regions, respectively, of the flat Indus Valley which has an average slope of only 1/ 5,000. In particular, the statistics have shown that Punjab Province is the main production center of staple grains in Pakistan. Having 60% of the national population, Punjab Province produces 65% of wheat and 95% of basmati rice of the entire country.

The climatic conditions supporting this largest agricultural production in the country are classified into semi-arid and arid category with annual precipitation of less than 500 mm, making water the greatest limiting factor in production of crops. For this reason, emphasis of agricultural production has been placed on irrigation in Punjab province, and as a result, the percentage of irrigated area in the whole arable land exceeds 85%. As to soil, all of the groups including Entisol, Inceptisol and Aridisol are low in fertility. In addition to these conditions of climate and soil, farms are affected by serious salt damage problem with the development of artificial irrigation, which further lowers the fertility of these already infertile soils.

Even though the agricultural production of Punjab is at the highest level in Pakistan, it is ranked quite low when judged according to the worldwide level of agricultural production. In addition, a wide gap exists among different areas of the region. In this part, two villages will be selected from Sheikhupura District of Punjab Province to discuss the factors responsible for this gap in agricultural production from the viewpoint of natural environment and farming technique.

(1) Natural conditions of Sheikhupura District

① Climate

Annual precipitation and average monthly precipitation for the past 5 years in Sheikhupura District are given in Figure 1. The climate of this district is characterized by the dust that occurs constantly due to high temperature and strong dry wind in summer, and low temperature and strong monsoon wind that blows in winter. Temperature during the high humidity season from May to June reaches 38 to 41 C˜ and has gone up as high as 48 C˜. On the other hand, December is the coldest month of the year with temperature dropping to 4 C˜. In addition, fog is frequently seen from November to January. Average annual precipitation over the 5 year period is 460mm. About 70% of annual precipitation is concentrated in the 3 month monsoon season, which starts in July and continues into September. The remaining 30% comes in the form of small rainfall of 30 to 40mm a month between January and June. As small as it may be, having rain during the hot and dry period from May to June is extremely effective for agriculture in this region.

② Land use

The form of land use in Sheikhupura District is given in Table 21. The total land area is 590,000 hectares, of which 79% is used as agricultural land and nearly 100% of this land has been irrigated. Meanwhile, the percentage of uncultivated land against total cultivated area is 21%, with abandoned cultivated land accounting for about half of such land. It is presumed that the abandoned areas were the result of salinization of cultivated land (Table 21).

③ Distribution of groundwater level

The Second SCARP Transition Project covering four counties (Faisalabad, Hafizabad, Sheikupura and Jhang) is in progress. A distribution diagram of groundwater level in the region covered by this project before and after the monsoon is given in Figures 2 and 3.

Groundwater level tends to get low before and after the monsoon to below 5m from surface in the southeastern part of Sheikhupura District. This, combined with the existence of buried ridge in Zafarwal Applied Plot, appears to be making the groundwater level of this region deeper compared to other regions. In contrast, groundwater level exists within 5m from surface in most areas of the northwestern region. Before and after the monsoon, however, ascension of groundwater level is noticed mainly in the northwestern region while areas where groundwater level is found within the first 5m increase in the southeastern region.

④ Main varieties of soil distributed in Sheikhupura District are shown in Table 22.

By area of distribution, kotli is most prevalent, followed by lyallpur, warirabad and bhalwal. In particular, kotli, the most common soil series, is known among the locals as "missie" soil and contains 2:1 type montmorillonite in large quantities as dominant clay mineral. Since cation exchange capacity of this silicate clay mineral exceeds 100 meq/100 g, it has high adsorption rate for fertilizer ingredients and can be regarded as having high fertility in terms of clay mineral. However, montmorillonite is a clay mineral high in swelling and shrinkage that can retain many times water than its own volume. Large cracks are formed on this soil series during the dry season. Because of this high water adsorption rate, it is considered unsuitable for rice paddy cultivation in areas where irrigation water is limited.

Soil of hard lyallpur series are found among top soil in the central region of Sheikhupura District. This fine-textured soil is suitable for paddy rice cultivation. This soil series contains a large amount of illite and chlorite, and there is no need to worry about potassium shortage with this soil because it contains hydrolytic mica and is rich in potassium ion. Salt damage is also seen in almost all soil series of this region and is posing a serious problem.

Distribution area of salt-affected soils is given in Table 23. As many as 270,000 hectares, which account for 46% of total area under cultivation in Sheikhupura District, have been affected by salt damage. Salt-affected soils can be classified into 4 categories. IIa signifies existence of alkali-sodic soil, which is weak saline, on the outermost layer due to irrigation. IIIa is intermediate saline soil, sodic soil or saline-sodic soil found in areas where there is irrigation facility and groundwater level exists within 3m from surface. IVa is strong saline soil or sodic soil created by extremely poor water permeability that exists within an irrigated area. VIIIa is weak saline soil or sodic soil that exists in an unirrigated area.

(2) Comparison of villages that were surveyed

① Present condition of Village A and Village K

The villages that were included in the survey were Village K where salt damage problem was solved by the measures taken through SCARP and Village A where salt damage continues to be a serious problem for agricultural production.

Soil condition in Village K can be classified into aridsol and lyawlpur series which is mainly fine-grained silty soil while that in Village A can be classified into vertisol and kotli series which is fine-grained mineral clay containing montmorillonite. While the difference between the two villages in amount of irrigation water is the determining factor for salt damage, difference in soil condition and topography are also important factors. The soil in Village A shows high clay content and generates an argillic layer (clay accumulation layer) in a position not deep from the surface layer leaching of clay in the weathering process. It is considered that lowering of groundwater level and leaching of saline is prevented by the low water permeability of this layer. Desalinization effect of SCARP has shown in Village K owing to relatively favorable permeability of its silty soil. In contrast to Village K where existence of buried ridge has allowed groundwater level at about 10m from surface, groundwater level in Village A is only 1m to 2m deep. These natural factors made it difficult to perform salinity control in Village A.

While neither district has any problem with quality of irrigation water obtained from the canal, they must secure irrigation water by using tubewell if they cannot secure sufficient irrigation water. However, an analysis by Agriculture Department of Punjab Province has concluded that 15% of groundwater in Sheikhupura District can be used as irrigation water and that remaining 85% is not suitable for irrigation. Canal irrigation can provide sufficient water in Village K because of its proximity to the main canal. However, paddy rice cannot be grown in Village A because it is located at the end of the canal.

No significant differences were observed in the hearing survey between Village A and Village K in terms of farming technique, although the need for technical improvement was recognized in both villages.

As for seeds, most farmers buy their seeds once every 3 years and use the seeds they produced at home to make up for any shortage. Farmers that have smaller scale of management use seeds that are obtained from neighboring farms, which is regarded as one of the causes for low yield. Common forms of fertilizers include use of urea for nitrogen and diammonium phosphate for phosphorous. Zinc sulfate is also used in some parts of Village A. In addition, timing of application has been standardized and not performed according to crop growth. In addition, a lot of land in Village A has been affected by salt damage and the percentage of sodic soil is particularly high. Although the use of ammonium sulfate fertilizer is effective in such a region because it contains sulfuric acid radical as nitrogen, the village is dependent on urea. It appears that the reason for using urea is to avoid complication of farm work because denitrification is faster on alkaline soil and the timing of fertilization will have to match the time when nitrogen is needed by the crop. Although the field survey was conducted during the paddy rice growing season, signs of sufficient cultivation management was not noticed and all paddies had rampant weeds. Weeding is an important farm work during the crop cultivation period.

In Village K where salinity control was successful, maintaining and improving soil fertility will be important requirements for higher productivity in addition to the foregoing improvements in farming techniques. On the other hand, overcoming salt damage would be the most important task for Village A.

② Tasks for development

The large-scale soil improvement in progress is one of the measures that are taken against salt damage. However, we must determine whether a method of rehabilitation requiring enormous funds is a truly effective method.

Lowering of groundwater level and leaching using high quality irrigation water are extremely effective methods for improving salt-affected soils. Lowering of groundwater level has been dealt by using deep well such as in SCARP. However, the problems concerning maintenance and operation as well as reuse of drained water have not been solved, giving rise to an alternative method of lowering groundwater level using biological resources. In other words, plants that have strong resistance against salt and high water transpiration such as Eucalyptus shall be planted as windbreak forest for farm fields. This will not only prevent lowering of groundwater level but prevent erosion of soil by wind and provide source of fuel and pulp.

When trying to secure high quality irrigation water, there exists shortage of absolute quantity of irrigation water in Pakistan compared to the Nile basin in Egypt and the Tigris basin in Iraq which are typical river irrigation regions in arid climate. Moreover, water leakage from canals not only aggravates shortage of irrigation water but causes salt damage. While prevention of leakage through application of lining on canals is an extremely effective method, improvement using concrete and cement is economically unfeasible. In addition, improvement of branch canals in rural farm fields is considered to be more effective than applying lining on main canals. Using clay in argillic layer (clay accumulation layer) found in salt-affected soils as lining material may be an economic way to approach this.

Salt-resisting and salt-removing plants such as Sudan grass grown in Village A are effective in removing salt from the soil. Pasture of this type can also be used effectively as livestock feed. As mentioned in relation to improvement of salt-affected soils, use of deep-rooted crops is also considered effective. Incorporating these methods into On-Farm Water Management Project should enable rehabilitation of salt-affected soils that matches regional characteristics at low cost.

Improvement of farming technique is just as essential as measures against salt damage for improvement of productivity, although its diffusion activities are not sufficiently implemented at present, and excellent results that are obtained at universities and research institutes are not fully utilized on the field. In addition, the results from 5,900 cases of soil analysis performed each year in Sheikhupura District are used only for calculating the amount of plaster application. It is also possible to perform diagnosis of soil and improvement of fertilization on each farm field of farm household by taking advantage of such useful soil information. However, the matter of utmost importance is securing and educating diffusion personnel that will serve as the liaison between research institutions and farm households. Furthermore, substantiation of rural community organizations for receiving such technique is indispensable.

1) Agricultural income per acre for wheat and rice can be estimated from yield per area in Table 2 (1994/95), government procurement price (Rs.165/40 kg for wheat and Rs.180/40 kg for basmati rice) and 35% agricultural income rate (Cheema and Saleem [1994]). In addition, the lower limit for farm area of 6.23 acres can be obtained by dividing Rs.13,000 with this income standard.
2) Agricultural income can be obtained by subtracting operating expenses from gross profit in Table 13. As the average yield of rice was 1.2 tons/acre in Village K, average rice crop income per acre for farm households A, B and C would be Rs.2,118 after recalculating the gross profit for Farm Household C according to this standard and subtracting wages for full-time workers at Farm Household B from operating expenses.

3) For instance, attention must be given to the fact that economic liberalization in India started after being free from the fetters of grain import through Green Revolution after entering the '80s. Consideration also must be given to the fact that India experienced a long-term economic stagnation phase after the mid-'60s when it started depending heavily on imported grain to address the problem of increasing population and stagnant agriculture.
4) e.g. "Agriculture in Pakistan -- Its Reality and Tasks of Development", Association for International Agriculture and Forestry Cooperation, 1990; "Report on the Basic Survey of Agricultural Resource and Management Plans for Global Environment", International Development Center, 1994; "Outline of Agriculture, Forestry and Fisheries Industry in Pakistan", Embassy of Pakistan in Japan, 1995
5) Included as operation in WAPDA Chapter are; 1) generation and transmission of electricity, 2) supply and drainage of irrigation water, 3) prevention of floods and implementation of land improvement projects in areas affected by smoke pollution and floods, 4) flood control, and 5) investigation, research and execution of plans with regard to inland navigation.
6) Groundwater level is dropping 1 to 2 cm a year in Punjab Province and the region north of the ridge in Haryana Province of India due to diffusion of tubewells, and conversion from shallow tubewell to deep tubewell is being made as a result.
7) For instance, in Uttar Pradesh where irrigation network similar to that in Punjab Province of Pakistan was built during the British settlement period, salt damage and flooding problems have not occurred because there was an alluvial ridge running parallel to Ganges and Yamuna River.
8) An international organization established in 1984 to study irrigation control in developing countries. Financial base is offered by the Ford Foundation, the World Bank and Asian Development Bank.
9) Refers to devastation of resources that occurs after excessive use of resources by individuals that resort to opportunistic actions when resources are being shared. Some kind of moral or legal regulations are required to prevent it.
10) Water was initially drained at the raceway by changing its course with banking. However, this work has become the cause of irrigation dispute as it requires labor as well as time.

Bibliography

Cheema, Muhammad Anwar and Saleem, Muhammad Aki, Farm Accounts, Family Budgets of Rural Families and Cost of Production of Major Crops in Punjab; 1991-92, Punjab Economic Institute, 1994

Note : It should be noted that current economic liberalization of India could be implemented only after India had become free from the fetters of grain imports through the success of Green Revolution in the first half of the 80's.

Table 1 Overview of Sheikhupura District

	Punjab	Sheikhupura
Annual Rainfall * (mm)	726	465
Population (1,000) 1994 *	68828	3102
Number of Household (1,000)1994 **	8332.6 (100)	360.7 (100)
Farm Household (without Livestock)	2998.2 (36)	121.3 (34)
Farm Household(with Livestock)	1760.6 (21)	83.5 (23)
Non Farm Household	3563.8 (43)	155.9 (43)
Reported Area 1,000 ha *	17459 (100)	589 (100)
Cultivated Area	12024 (69)	465 (79)
% of Irrigated Area		(99.6%)
Uncultivated Cultivatable Area	1913 (11)	63 (11)
% of Saline Soil	12.3	13.5
Population Density(person/km2) *		
1972	183	278
1994	335	520
No. of Agricultural Laborer 10 and Above(1,000) **	11015.3	479.4
No. of Non-Agricultural Laborer 10 and Above(1,000) **	11724.1	509.7

Source : * 1986,1994,Punjab Development Statistics, Bureau of Statistics, Gov. of the Punjab.
** 1990 Cencus of Agriculture, Province Report Vol.II, Part-2, Punjab, Gov. of Pakistan,
Economic Affairs and Statistics Division, Agricultural Census Organization.

Table 2 Sown Area and Production of Wheat and Rice

Region	Crop		1978/79	1983/84	1985/86	1990/91	1991/92	1992/93	1993/94	1994/95
Punjab	Wheat	Sown Area (1000 ha)	4788.2	5241.8	5343	5712	5669	5961	5771	n.a.
		Production (1,000 ton)	7297.2	8775.6	10432	10514	11492	11742	11218	12710
		Yield(ton /ha)	1.52	1.67	1.95	1.84	2.03	1.97	1.94	n.a.
	Rice	Sown Area (1000 ha)	1078.4	1098.4	1113	1262	1231	1222	1301	n.a.
		Production (1,000 ton)	1485.2	1456	1478	1422	1342	1404	1588	1689
		Yield(ton /ha)	1.38	1.33	1.33	1.13	1.09	1.15	1.22	n.a.
Sheikhupura	Wheat	Sown Area (1000 ha)	222.6	240	246	254	253	254	254	259
		Production (1,000 ton)	355.6	532.5	520	458	538	509	504	605
		Yield(ton /ha)	1.60	2.22	2.11	1.80	2.13	2.00	1.98	2.34
	Rice	Sown Area (1000 ha)	177.4	189.4	195	215	203	202	207	215
		Production (1,000 ton)	249.4	263.4	272	218	176	219	238	251
		Yield(ton /ha)	1.41	1.39	1.39	1.01	0.87	1.08	1.15	1.17

Source : 1986,1993,1994, Punjab Development Statistics, Bureau of Statistics, Gov. of the Punjab, and Bureau of Statistics, Gov. of Punjab.

Table 3 Number of Livestock

(1,000)

		1972/73	1976	1980	1986	1990
Punjab	Cattle	8113	8108	9254	8818	7665
	Milch Cows,	2126	2048	2868	2872	3097
	Buffaloes	7410	7979	8687	11150	10862
	Milch Buffaloes	4315	3834	4808	5581	5600
	Sheep	5617	8037	6309	6685	8218
	Goats	5439	7767	7305	10755	13908
Sheikhupura	Cattle	262	255	279	260	258
	Milch Cows,	58	54	74	77	99
	Buffaloes	541	532	545	621	661
	Milch Buffaloes	311	243	294	305	337
	Sheep	226	230	154	156	208
	Goats	101	148	168	259	326

Source : 1990 Cencus of Agriculture, Province Report Vol.II, Part-2,Punjab, Gov.of Pakistan, Economic Affairs and Statistics Division, Agricultural Census Organization.

Table 4 Number of Farm Households by Farm Size

Farm size(acre)	Punjab	Sheikhupura
<5	1342683(45.4)	52583(43.7)
	[31.6]	[34.2]
5< <12.5	1006916(34.0)	47795(39.8)
	[39.1]	[41.9]
2.5< <25.0	405502(13.7)	12954(10.8)
	[19.4]	[16.7]
5.0< <50.0	147158 (5.0)	5213 (4.3)
	[7.2]	[5.3]
50.0<	55122 (1.9)	1671 (1.4)
	[2.6]	[1.8]
Total	2957381 (100)	120216 (100)
	[100]	[100]

Note : Numbers in parentheses indicate percentage
Numbers in brackets indicate percentage as of 1980

Table 5 Farm Area by Tenancy Form

1990 (1,000 Acre)

	Farm Size (Acre)	Tenancy Farm						Share of Farm Area by Owned Farm Size
		Owned Land	Tenancy Land				Total	
			Share Tenant	Lease Holder	Others	Sub-Total		
Punjab Average Farm Size	<5	2462 (13)	382 (7)	149 (7)	14 (9)	545 (7)	3009 (11)	13
	5< <12.5	5337 (27)	1821 (35)	596 (27)	32 (21)	2450 (32)	7787 (29)	25
	12.5< <25.0	4286 (22)	1586 (31)	603 (27)	29 (19)	2218 (29)	6504 (24)	20
	25.0< <50.0	3170 (16)	907 (17)	454 (20)	29 (19)	1389 (18)	4559 (17)	16
	50.0<	4276 (22)	498 (10)	429 (19)	45 (30)	972 (13)	5248 (19)	28
	Total	19533 (100)	5194 (100)	2231 (100)	149 (100)	7574 (100)	27107 (100)	100
Sheikhupura Average Farm Size	<5	91 (13)	27 (12)	11 (12)	0.19 (6)	38 (12)	129 (13)	14
	5< <12.5	225 (33)	101 (46)	41 (43)	0.45 (14)	143 (45)	367 (36)	29
	12.5< <25.0	135 (20)	55 (25)	22 (23)	1.31 (40)	78 (24)	212 (21)	17
	25.0< <50.0	118 (17)	25 (11)	15 (16)	0.57 (17)	40 (13)	158 (16)	16
	50.0<	122 (18)	13 (6)	6 (6)	0.79 (24)	20 (6)	141 (14)	23
	Total	689 (100)	221 (100)	95 (100)	3.3 (100)	319 (100)	1008 (100)	100

Table 6 Fragmentation of Farm Land

Total Number of Farm Household	120216
Size (1,000 Acre)	1008
Average Farm Size (Acre/ Household)	8.4
Farms Not Fragmented	68372
Area (Acre)	338
Average Farm Size (Acre/ Household)	4.9
Number of Plots	51844
Area (Acre)	670
Average Farm Size (Acre/ Household)	12.9
Number of Plots Per Households	2.8
Average Plot Area (Acre/ Plot)	4.6

Source : See Table 3

Table 7 Use of Agricultural Machinery

(%)

Agricultural Machinery	Punjab			Sheikhupura		
	Own	Rent	Total	Own	Rent	Total
Tractor	8.7	77.8	86.5	9.7	78.4	88.1
Tube well / Pump	15.7	45.4	61.1	15.6	71.7	87.3
Thresher	4.7	75.0	79.7	5.0	76.9	81.9
Reaper	0.6	5.1	5.7	0.8	10.0	10.8
Reaper Sprayer	7.8	31.8	39.6	3.9	26.0	29.9

Source : See Table 3

Table 8 Use of Tractors, Draught Animals or Both for Cultivation by Farm Size

(%)

Farm Size (Acre)	Punjab			Sheikhupura		
	Tractor	Tractor and Draught Animals	Total	Tractor	Tractor and Draught Animals	Total
< 5.0	76	12	88	81	11	92
5.0< <12.5	57	28	85	61	25	86
12.5< <25.0	54	34	88	54	34	88
25.0< <50.0	64	28	92	68	27	95
50.0<	78	18	96	81	15	96
Average	66	21	87	69	20	89

Source : See Table 3

Table 9 Area irrigated by Mode of Irrigation

1993/94, (1,000 ha)

Region \ Mode of Irrigation	Canals	Tubewells	Canals and Tubewells	Others	Total
Punjab	3971 (31.9)	2334 (18.7)	5945 (47.7)	201 (1.6)	12451 (100)
Sheikhupura	36 (5.4)	52 (7.8)	561 (84.4)	16 (2.4)	665 (100)

Source : See Table 2

Table 10 Use of Fertilizer and Manure

(Acre)

		Fertilizer and Manure	Fertilizer	Manure	Total Sown Area
Punjab	Wheat	2051157 (15.1)	10140961 (74.6)	309421 (2.3)	13600720 (100)
	Rice	384145 (11.5)	2615208 (78.3)	30920 (0.9)	3338826 (100)
Sheikhupura	Wheat	117339 (19.5)	451317 (75.0)	9849 (1.6)	601729 (100)
	Rice	108743 (21.0)	359482 (69.3)	7491 (1.4)	518901 (100)

Source : See Table 3

Table 11 Debt of Farm Household

	Punjab			Sheikhupura		
	Institutional Source (%)	Non - Institutional Source(%)	Average Debt (Rs/ Household)	Institutional Source (%)	Non - Institutional Source(%)	Average Debt (Rs/ Household)
All Households	49.7	50.3	2969	45.3	54.7	2909
Farm Households	56.8	43.2	5634	54.6	45.4	6357
Non Farm Households	43.8	56.2	1342	18.8	81.2	994

Source : See Table 3

Table 12 Overview of Surveyed Village

	Village K			Village A		
1) Population	1300			4500		
2) Area (Acre)	338.5			1729.5		
Cultivated Area	333			1650		
4) Number of Form household by Owned Farm Size						
< 5 Acre	34 (62)			315 (90)		
5 < < 12.5	18 (33)			25 (7)		
12.5 < < 25.0	2 (4)			10 (3)		
25.0 <	1 (2)			–		
Total	55 (100)			350 (100)		
Average Owned Farm Size (Acre/ Farm Household)	6.1			4.9		
5) Mode of Tenure	Owner/ Fixed			Owner/ Fixed		
6) Crop Intensity	1.5			1.25		
7) Irrigation	100% Canal Irrigation			80%Canal Irrigation, 20%		
8) Sown Area of Major Crops (Acre)	1985 (Kharif)	1994 (Kharif)	1994 (Rabi)	1985 (Kharif)	1994 (Kharif)	1994 (Rabi)
Wheat	-	-	115.34	-	-	1194
Rice	228	208.57	-	309	168	-
Maize	-	-	-	69 (sorgum)	252 (maize/sorgum)	
Fodder	59	97	104.22	4	26	159
Sugarcane	1	1.19	-	87	132	-
Tobacco	-	1.29	-	-	-	-
Fruits and Vegetables	-	1.11	2.34	141	69	69
Cotton	-	-	-	23	27	-
Sesame	-	-	-	102	-	-
Green Manure	-	-	-	22	21	-
Others	8	-	1.33	29	14	47
Total	296	309.16	223.23	786	709	1469
9) Rental Rate of Agricultural Machine	Tractor (Rs.60/acre/time), Thresher (4kg/40kg), Tubewell (Rs.30/hr)			Tractor, 75% 25% Buffalo (4kg/40kg), Tubewell (Rs.60/hr)		
10) Average Land Lent	Rs. 2500/acre/yr			Rs. 1500-2000/acre/yr		
11) Wage (Agricultural Laborer)	Wheat Harvesting Wage 120kg/acre Rice Harvesting Wage · · 1/8 of Harvest			Wheat Harvesting Wage 160kg/acre Rice Harvesting Wage · · 1/8 of Harvest		
12) Yield						
Wheat	1t/acre			1.4t/acre		
Rice	1.2t/acre			?		
13) Underground Water Level (ft.)	below 35			25		
14) Number of tap	1			3		
15) Private Tube well	24			80		
16) School	Primary School (Boys and Girls)			Primary School (Boys and Girls), Secondary School (Girls)		

Source: Field Survey

Table 13 Farm Household Economy

Item \ Farm Househokld No.	A	B	C	D	E	F	G
1. Number of Household Memb ers	20	7	7	7	7	8	5
2. Family Labor*	5 (3)	1 (1)	1 (1)	2 (1)	4 (4)	1 (1)	1 (1)
3. Farm Asset							
1) Farm Land	5	15	9	12	44 (27acredistributed among three sons)	4.5 (Share with Brother)	8.25
2) Agricultural Machinery	-	Tube Well 1	-	Tractor1,Reaper1 Thresher1,Trolly1 Tube Well1 (Tractor ; Rs.260000, Thresher ; Rs.40000)	Tractor1,Tiller1 Trolly1,Reaper1 Thresher1,Tube Well1 (TW ; Rs.25000)	-	-
3) Animal	Buffalo 2	Buffalo 10 Cattle 3	Buffaloes 15 (Calf 10)	Buffaloes 21 (Calf 12) Cattle 3,Sheep 10,Goat 6	Buffalo 7 (Calf 2)	Buffalo 1	Buffalo 1
4. Land Utilization							
1) Kharif	Paddy 4 Fodder 1	Paddy 20 Fodder 5	Paddy 9	Paddy 4 Sugarcane 5, Linseed 6 Fodder 6, Fallow 6	Paddy 10 Sugarcane · Linseed 5 Fallow 12	Fodder 1 Sudan Grass 2 Fallow 1.5	Paddy 2 Fodder 2 Fallow 4.25
2) Rabi	Wheat 3 Fodder 2	Wheat 16 Fodder 9 (10acre/rent-in, Rs.2000/acre/yr)	Wheat 7 Fodder 2	Wheat 22 Fodder 6 (16acre/rent-in, Rs.18300/yr)	Wheat 20 Fodder 2 Sugarcane 5 (17acre/rent-out, Rs.1500/acre/yr)	Wheat 0.5 Sudan Grass 2 Fodder 0.5	Wheat 6 Sudan Grass 1 Fodder 1
5. Agricultural Production	(t) (Rs)	(t) (Rs)	(t) (Rs)	(t) (Rs)	(t) (Rs)	(t) (Rs)	(t) (Rs)
1) Wheat	5.6 23100	16 66000	7 28875	26.4 105600	28 122500	0.6 2475	6 24000
2) Rice	5.4 24975	20 95000	5.4 24975	1.8 8100	12 54000	- -	2.4 11100
3) Milk	7.3 54750	18.25 109500	3.7 25550	7.3 43800	- -	0.5475 4380	- -
6. Expenditure for Farm Management (Rs)	Wheat Rice	Wheat Rice	Wheat Rice	Wheat Rice	Wheat Rice	Wheat Rice	Wheat Rice
1) Land Rent	- -	8999 11111	- -	18000 -	- -	-	- -
2) Fertilizer and Manure	2775 4200	14800 13500	5310 5310	15620 3080	16700 7900	420	2355 920
3) Insecticide	- 1980	- 8000	- 4140	- -	- 3000	-	- -
4) Weedicide	375 -	2400 4000	- -	4400 -	4500 2100	-	- -
5) Hired Labor	1500 3922	10770 20625	2835 3847.5	4400 1810	6300 7900	-	3840 1510
6) Tractor and	1800 1920	8000 10800	2700 3960	3300 1680	5600 4200	130	2700 900
Thresher	2475 -	6600 -	2887.5 -	3520 -	4083 -	225	2400 -
7) Tubewell Irrigation	90 855	240 4000	- 225	660 520	600 1300	-	450 350
8) Seeds	495 92.5	2640 760	1665 185	3520 90	3500 180	82.5	960 37
9) Total	9510 12969.5	54449 72796	15397.5 17667.5	53420 7180	41283 26580	857.5	12705 3717
7. Off Farm Employment	Village Doctor			Policeman		Daily Wage Labor (Rs. 50/day)	
Note		Permanent Laborer (Wage : Wheat 1ton, Rice 1 ton)	Rice havest failed due to damage by insect	Rs. 25, Income from Machine Lease and Sugarcane Rs 18,000 income from Linseed	Rs.20000 Income from Machine Lease, Sugarcane and Linseed	Rice is not grown during kharif season because the farmers cannot afford to buy water	Rs. 3000 income from Flax

Source : Field Survey

Table 14 Agricultural Calendar 1994/1995

Month	Village K	Village A
1995 January	· Irrigation, Fertilizer Application (Urea) <1Bag/acre> · Weedicide Application (Study Fas) <1 Bottle/acre> · Irrigation Wheat Cropping	Weedicide Application (Gremina) <Rs.225/acre> Fertilizer Application (Urea) <1 Bag/acre>, Irrigation Fertilizer Application (Urea) <1/2 Bag/acre>, Irrigation
February	· Irrigation · Fertilizer Application (Urea) <1Bag/acre>	Wheat Cropping
March April	· Harvesting, Hired Labor & Reaper · Threshing (Thresher)	· Harvesting, Hired Labor & Reaper · Threshing (Thresher)
1994 May	· Fertilizer Application (D.A.P) <1Bag/acre>	· Seeding, Seed Bed Making<4-5kg/acre> · Ploughing, Harrowing, Leveling (50hp tractor) , Irrigation, Fertilizer Application (D.A.P) <1Bag/acre>
June	· Seeding, Seeding<4-5kg/acre> · Fertilizer Application (Urea) <1Bag/acre> · Ploughing, Harrowing, Leveling (50hp Tractor) , Irrigation	· Transplanting (Hired Labor & Reaper, <Rs.200/acre>) · Agricultural Chemicals (Spray) <Rs.150/acre>
July	· Transplanting (Hired Labor , <Rs.200/acre>) · Agricultural Chemicals (Podan) <1Bottle/acre>	· Fertilizer Application (Urea, Zin-Sulfate) <1Bag/acre,1Bag/acre> · Agricultural Chemicals (Spray) <Rs.150/acre>
August	· Fertilizer Application (Urea) <1Bag/acre>, Weedicide Application (Study Fas)	· Wheat Cropping (Roan Star) <Rs.210/acre> <1 Bottle/acre>
September October	Rice Cropping Basmati Variety	Rice Cropping Basmati Variety · Harvesting, Threshing (Manual) <Hired Labor >
November	· Harvesting, Threshing (Manual) < Hired Labor >	· Ploughing, Leveling (50hp Tractor) · Seeding<40kg/acre>, Fertilizer Application (D.A.P) <1 Bag/acre>
Decembe	· Ploughing, Leveling (50hp Tractor) · Seeding<40kg/acre>, Fertilizer Application (D.A.P) <1 Bag/acre>	· Irrigation

Note 1 : The method of wheat irrigation in village K is canal irrigation. But in village A, the tube well is used for wheat irrigation from late December to late January because canal water is not available.

Note 2 : The farmers draw water from canal and tubewell into paddy fields every four days after transplanting, for rice cropping in both villages.

Table 15 Pakka Warabandi of Village K

Name	Farm Land			Square (killa) No	Water Supply Time	Additional Time	Lead Time	TW Time	Total Supply Time	Supply Schedule
	Cultivated Area	Culturable Waste	Total							
Ghulam Ali[+2]	13.10	.03	13.13	- 6/4	3-0	0-30	0	0	3-30	Fri 01:39 - 05:09
Md Riaz[+1]	7.59	.32	7.91	6/4 - 6/4	1-44	0-5	0	0	1-49	Fri 05:09 - 06:58
Noor Md[+2]	4.57	.00	4.57	6/4 - 8/5	1-3	1-45	0-39	0	2-9	Fri 06:59 - 09:07
Sohna	.44	.00	0.44	8/5 - 7/5	0-6	0-25	0-30	0	0-1	Fri 09:07 - 09:08
Md Din[+3]	18.06	.20	18.26	7/5 - 7/5	4-8	...	...	0	4-8	Fri 09:08 - 13:16
Natha[+3]	4.68	.00	4.68	7/5 - 7/5	1-3	0-1	...	0	1-13	Fri 13:16 - 14:29
Zulifgar Ali[+2]	11.64	.14	11.78	7/5 - 7/5	2-38	...	...	0	2-38	Fri 14:29 - 17:07
Sher Md[+2]	4.42	.00	4.42	7/5 - 2/21	0-56	0-15	...	0	1-11	Fri 17:07 - 18:18
Kher Md[+1]	3.90	.00	3.90	2/21 - 2/21	0-53	...	...	0	0-53	Fri 18:18 - 19:11
Rana[+3]	10.53	.00	10.53	8/25 - 2/21	2-36	0-10	...	1-30	4-16	Fri 19:11 - 23:27
Md Hussain[+3]	8.81	.00	8.81	8/5 - 8/25	2-0	...	0-9	1-0	2-51	Fri 23:27 - Sat 02:18
Hussain Ali[+2]	11.44	.05	11.49	8/5 - 8/5	2-37	...	...	0	2-37	Sat 02:18 - 4:55
	. . . .									
	omitted hereafter									

Total area	694.96 acre
Not Available For Cultivation	42.62 acre
Total area Cultivated Area	649.34 acre
Water Supply Time (per week) of the SCARP TW	148 hours 13 minutes
SCARP TW Tapping Capacity	3 cusec
Additional Time	7 hours 59 minutes
Lead time	5 hours 40 minutes
Water Supply Time (per week) from the Outlet	168 hours
Capacity of the Outlet	1.80 cusec
Allotted Water Sapply Time per Acre	14 minutes

Note Affixed numerals denote the number of farmers using a same nakka.

Table 16 Area Irrigated by different Sources (%)

	Punjab (Pakistan)				Punjab (India)				Haryana			
	Canals	Tube Wells	Others	Total	Canals	Tube Wells	Others	Total	Canals	Tube Wells	Others	Total
1965/66	75.3	9.9	14.8	100.0	41.3	29.5	29.2	100.0	77.0	20.0	3.0	100.0
1970/71	70.0	24.9	5.1	100.0	44.7	55.1	0.2	100.0	62.1	37.5	0.4	100.0
1980/81	71.2	27.0	1.8	100.0	42.3	57.3	0.4	100.0	54.4	44.1	1.5	100.0
1990/91	71.3	27.2	1.7	100.0	39.9	59.8	0.3	100.0	51.4	48.0	0.6	100.0

Source : Government of Pakistan, Ministry of Food, Agricultural Statistics of Pakistan, Islamabad,1993/94.

Govenernment of Punjab (India), Statistical Abstract of Punjab 1993, Chandigarh, 1994.

Government of Haryana, Statistical Abstract of Haryana 1992/93, Chandigarh, 1994.

Table 17 Tubewells

	Unit	1990-91	1991-92	1992-93
Total	Thousand Number	296	310	328
Diesel	〃	214	230	247
Electric	〃	82	80	81

E : Estimated as on 31st December.

Source: Bureau of Statistics, Government of Punjab, 1995

Table 18 - 1 Benefits of OFWM Programme

		Improved Watercaurses	Unimproved Watercourses
Cropping Intensity	Head	162.3	157.9
	Middle	160.9	155.8
	Tail	154.7	146.0
	Overall	159.3	153.2
Culturable Waster Land as Pooportion of Farm Area	Head	2.8	4.4
	Middle	3.0	4.2
	Tail	2.9	6.5
	Overall	2.9	5.1
Conveyance Losses (%)	Main	14	21
	Branch	19	25
	Overall	32	39
Gross Farm Income Rs/ACRE	Head	7582.0	6980.9
	Middle	7596.1	6760.9
	Tail	6739.7	5880.6
	Overall	7272.4	6551.3

Table 18-2 Benefits of OFWM Programme (Cont'd)

Land Productivity (40Kg/Acre)		Improved Watercources	Unimproved Watercources
Wheat	Head	23.0	21.1
	Middle	23.7	21.4
	Tail	24.0	20.1
	Overall	23.6	20.8
Cotton	Head	16.9	16.3
	Middle	16.4	15.6
	Tail	15.8	13.3
	Overall	16.3	15.1
Rice (Basmati)	Head	22.3	18.8
	Middle	22.4	19.5
	Tail	22.0	18.0
	Overall	22.6	18.8
Rice (IRRI)	Head	30.6	27.0
	Middle	29.0	17.3
	Tail	28.3	14.9
	Overall	29.2	19.9
Sugarcane	Head	453.3	435.6
	Middle	509.5	394.8
	Tail	516.6	305.9
	Overall	493.8	379.6

Source : Mahmood Ali Saleem et al. Evaluation of On-Farm Water Management Programme in Punjab, Punjab Economic Research Institute, Publication No.281,1993.

Table 19 Birth Rate / Death Rate / Infant Mortarity Rate in Palleistan and Punjab

	Pakistan	Punjab
Birth Rate	39.5	38.4
Death Rate	9.8	10.1
Infant Mortality Rate	102.4	110.6

Source) Bureau of Statistics, Government of Punjab 1995

Table 20 Number of students registered by grade in Village A

Grade	Number of students registered	Number of students registered
Primary	boys' school	Girls' school
1	42	49
2	32	32
3	28	41
4	32	28
5	24	18
Secondary		Girls' school
6	-	16
7	-	38
8	-	9

Source : Hearing survey

Table 21 Land utilization in Sheikhupura district.

Land utilization	Extent area (ha)	% in total area	% in each area
Cultivated area	465,344	79	100
Irrigated area	462,580	78	99
Rainfed area	2,764	1	1
Uncultivated area	123,508	21	100
Culturable waste	63,240	11	51
Forests	2,964	1	2
Not available for cultivation	57,304	9	47
Total area	588,852	100	

Source : Brief note on agriculture activities in Sheikhupura district

Table 22 Taxonomic classification of soil series in Sheikhupura district.

Soil series	Orde	Family
Kotli	Vertisol	Fine, montmorillonitic, Non-calcareous, hyperthermic, EnticChromustert
Lyallpur	Aridisol	Fine-silty, mixed, hyperthermic, Ustollic Comborthid
Wazirabad	Alfisol	Coarse-loamy, mixed, Udic Haplustalf
Bhalwal	Aridisol	Fine-silty, Mixed, hyperthermic, Ustollic Haplargid

Souce : Clay mineralogy of some selected alluvial soils of Indus plains.
Pakistan journal of soil science, Vol. 8, 3-7 (1993)

Table 23 Extent of soil salinity/sodicity in Sheikhupura district

Class	Type of irrigation	Area (ha)	% in salt affected area	% in total land area
IIa	Canal irrigation	93,400	34	16
IIIa	Canal irrigation	72,400	26	12
IVa	Canal irrigation	680	1	1
VIIa	Rainfed	107,280	39	19
Total saly affected area		273,760	100	46
Total land area		588,852		100

Souce : Soil survey of Pakistan (1963-1983)

Fig. 1 Punjab Province (PAK.)

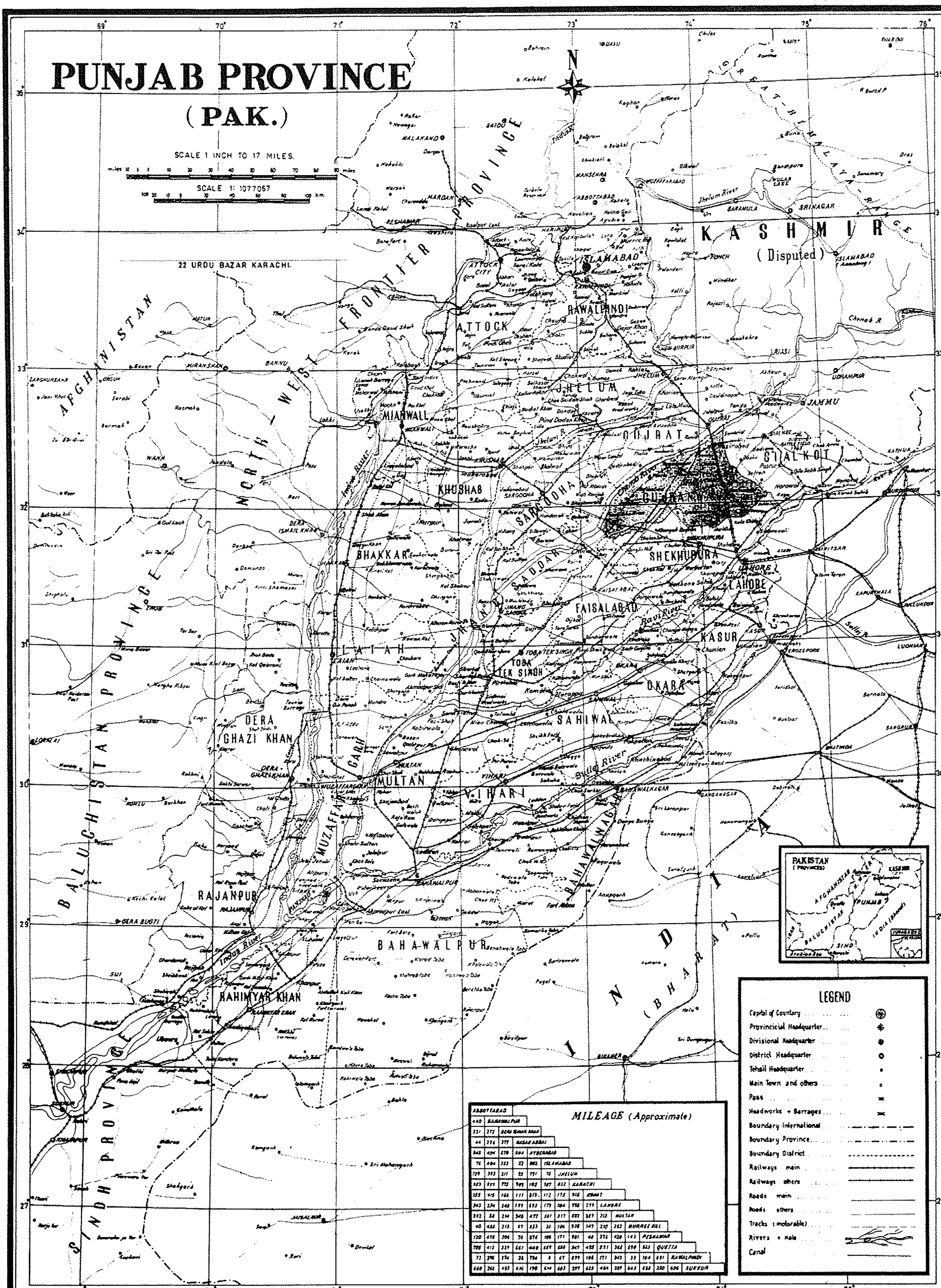


Fig. 2 A Typical Irrigation System

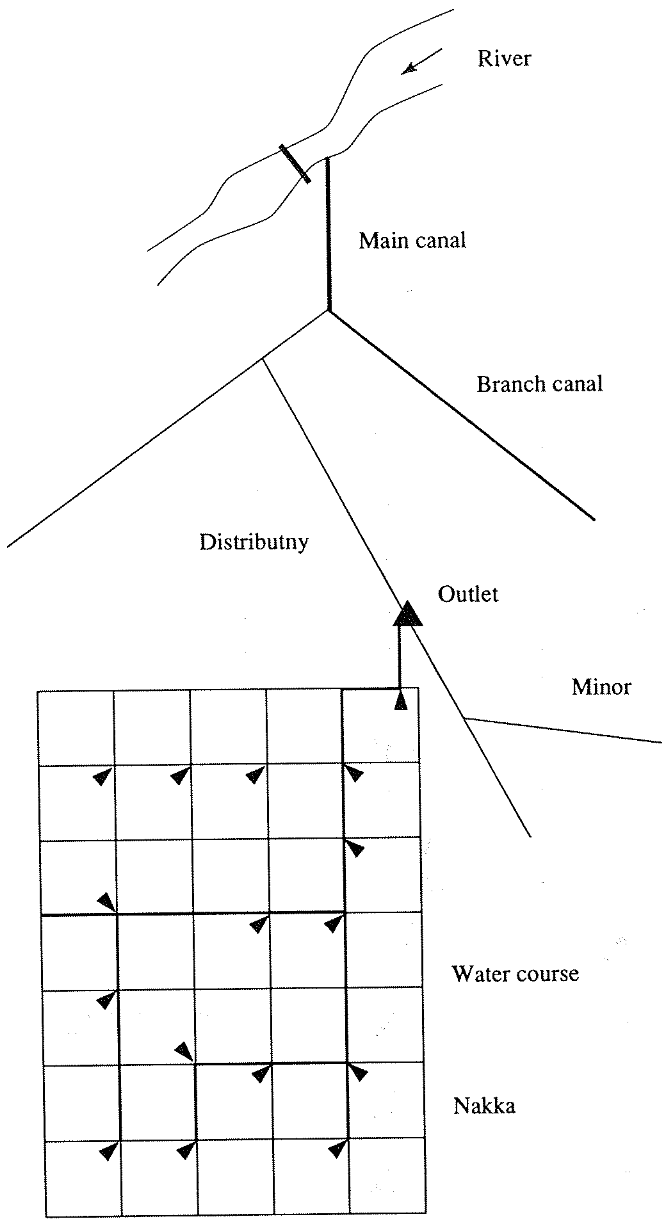


Fig. 3 Water course in Villagde

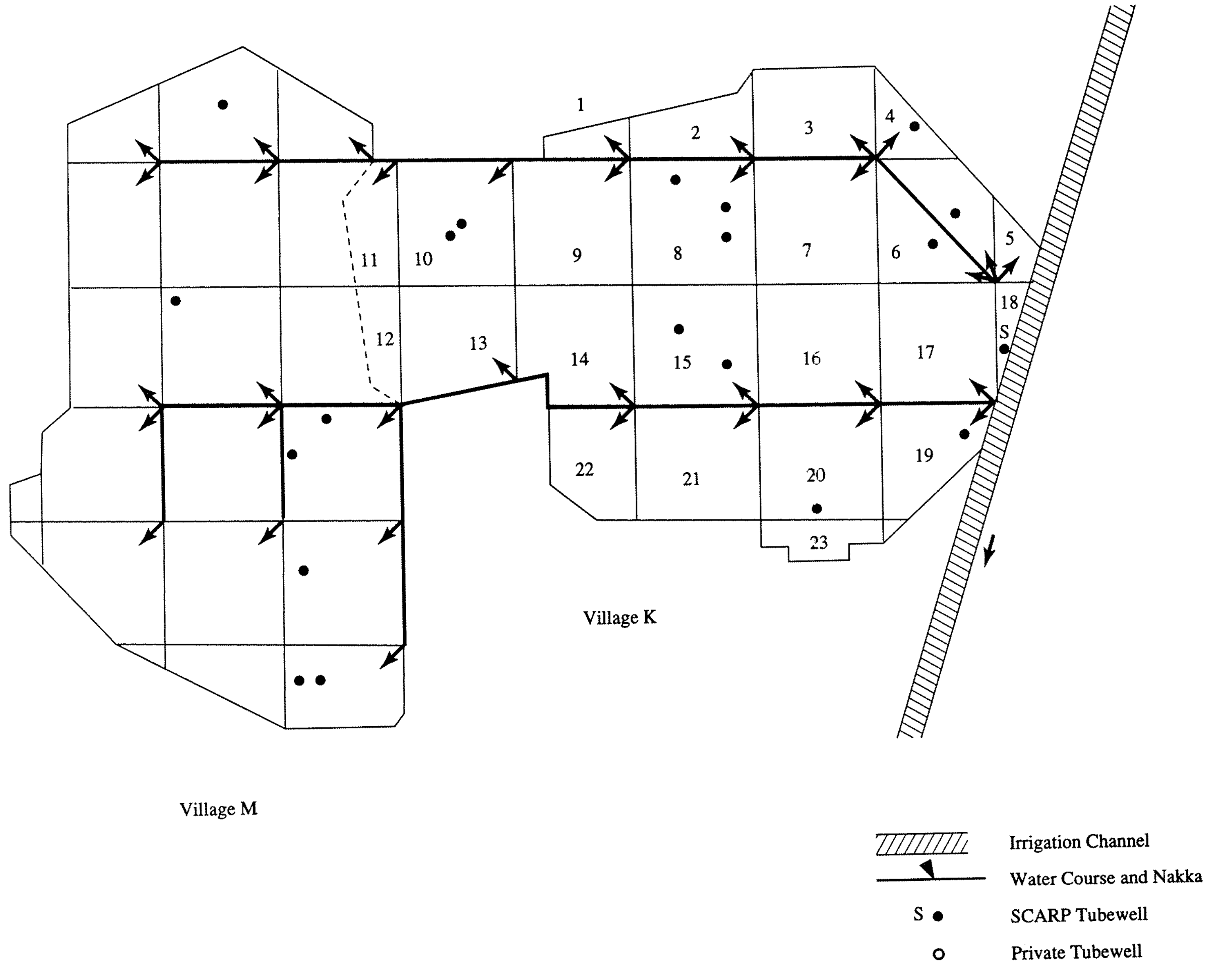
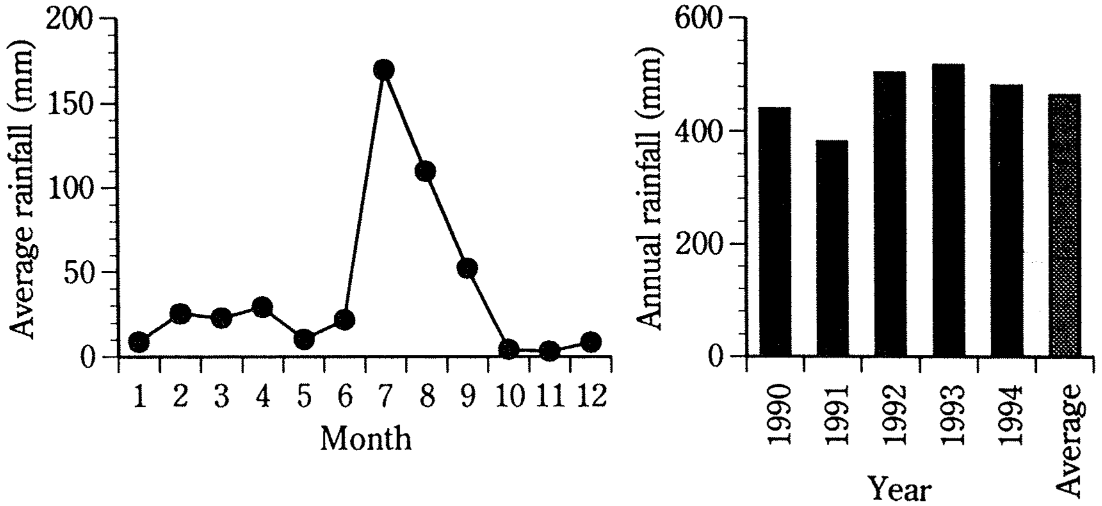


Fig. 4 Monthly average rainfall and annual rainfall during 5years



Source : Brief note on agriculture activities in Sheikhupura district

Fig. 5 Distribution diagram of groundwater level in Second Scarp Transtion Project area befor monsoon (Unit; m) (Observed at June in 1994)

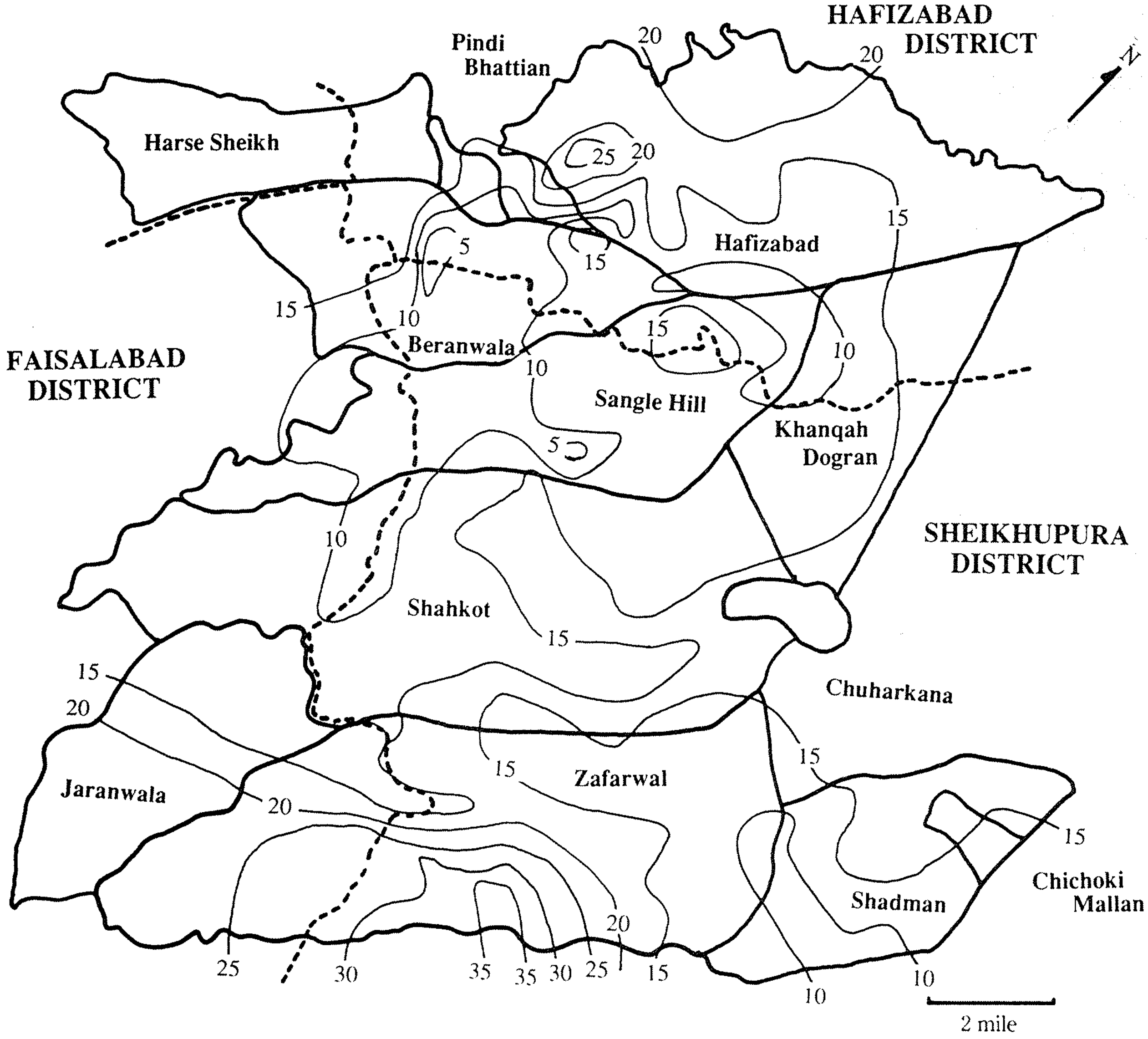
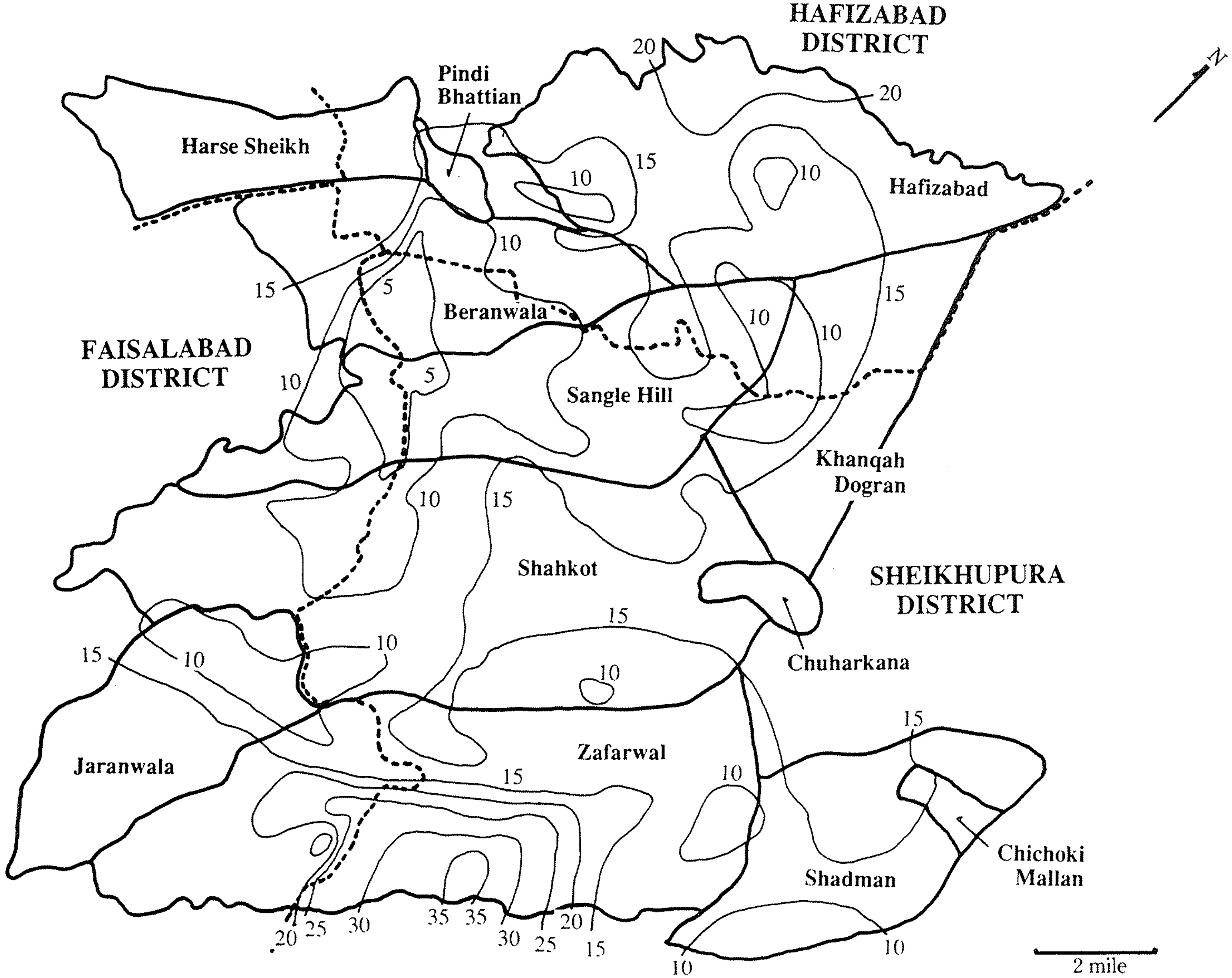


Fig. 6 Distribution diagram of groundwater level in Second Scarp Transtion Project area after monsoon (Unit; m) (Observed at October in 1994)



Chapter 3

The Tasks for Development in Pakistan

1 The Tasks for Agricultural and Rural Development

(1) Low productivity issue

The greatest problem in Pakistan is the fact that, despite its favorable condition for production including irrigation, the level of unit yield for crops is extremely low compared to the world standard and that its potential is not fully utilized. The cause of this low productivity will be discussed in the following.

The first factor is the difference in the quality of irrigation. Although the percentage of irrigation is both 100% in Pakistan and India, excavation density of tubewells is high in India, indicating high efficiency of irrigation. In addition, the ratio of tubewell irrigation against cultivated area in Punjab Province of India is 53% as opposed to 35% in Punjab Province of Pakistan. The main cause of low excavation density of tubewells in Pakistan is its topography. Considerable difference also exists in percentage of electrification, and the situation is exacerbated by the low quality of groundwater. A research conducted by Punjab Soil Fertility Institute of Pakistan indicated that only 25% of tubewells were supplying groundwater that was "usable." On the other hand, 21% of tubewells were supplying groundwater that was "marginally usable," and the remaining 54% were supplying groundwater that was "hazardous" including water with high salt concentration [Byerlee and Siddiq (1994)].

The second factor is the difference in the volume of chemical fertilizer input. Average volume of chemical fertilizer input during rainy and dry seasons was 162kg/ha in Punjab Province of India in contrast to 100kg/ha in Punjab Province of Pakistan. This difference is partially attributable to the difference in quality of irrigation mentioned above.

The third factor is the environmental problem including salt injury and waterlogging, the intensity of which has already been discussed and will not be repeated here.

The last factor are the issues that are being experienced by the entire system of technical development and technical diffusion in agriculture. First, there is shortage of research funds for testing and research institutions as can be clearly seen in the increasing percentage of labor cost in non-development budget of institutions. A direction of decreasing the percentage of labor cost and increasing the percentage of research funds is recently being pursued as government policy.

Secondly, there is the weakness of diffusion system (Kurosaki (1990)]. In the case of Punjab Province, one agricultural officer has about 5 field assistants working under him and is in charge of areas ranging from tens to hundreds of thousands of acres. This means that one agricultural officer would be in charge of thousands of farm households and that it would be the job of field assistants to get in touch with the farmers in reality. Moreover, field assistants are in charge of 1,200 households on the average which is by no means a small number. According to a survey in Punjab Province, the percentage of farmers that knew their agricultural officers ranged from 2 to 10% among small farmers, from 17 to 29% among intermediate farmers and from 5 to 86% among large farmers. Meanwhile, the percentage of farmers that knew their field assistants ranged from 21 to 44% among small farmers, from 43 to 63% among intermediate farmers and from 46 to 75% among large farmers [Sarwar et al. (1990)]. An obvious trend seen in this survey is that the percentage is higher in irrigated regions than in regions that are dependent on rain water, and that it increases with scale of farming.

The minimum qualification for agricultural officers is Bachelor of Science, Agriculture and the minimum qualification for field assistants is diploma from agricultural training school. At 8 agricultural training schools that are in the country, intermediate level education is offered on agricultural techniques and diploma is issued after 2 years of practical training. In reality, however, training is limited to agricultural studies on main crops and is not capable of meeting the needs of the farmers because of the short training period. In addition, the training agricultural officers and field assistants receive at federal or provincial institutions related to agriculture to update their knowledge and skills usually lasts only a day or so. As for the level of their wages, agricultural officers receive fairly high salary of Rs.5,000 to Rs.6,000 whereas field assistants have to settle for very low salary of about Rs.2,000. The problem felt on the job site appears to be the difficulty in attracting good talents because of the poor remuneration and lack of enthusiasm towards work.

(2) Diversification of agriculture

Diversification has now become an important task in development of agriculture in Pakistan.

Firstly, shifting of agricultural production to sectors that have high income elasticity of demand such as stock farming, horticulture and fisheries is already in progress and shall be promoted further.

Secondly, stock farming, horticulture and fisheries are important from the viewpoint of advancing less developed regions, as they often benefit rural areas that have been left behind in terms of development. For instance, there are prospects of increased fruit production in Baluchistan Province and North West Frontier Province. They are also meaningful in the sense that they are important source of income for the poor (particularly women) in developed agricultural regions and offer opportunities of employment.

As this survey has shown, dairy farming is extremely important in that it is an innegligible source of income as well as important source of nutrition for the majority of rural households in Punjab Province. Roughly speaking, number of buffaloes and cows raised per household is 3 to 4 heads for farmers and 1 to 2 heads for peasant households. These households consume 80% of the milk that they produce and sell the rest. Stock farming (mostly milk) accounts for 25 to 30% of income for farming households and 20 to 25% of income for peasant households [Sarwar and Saleem (1993)]. A good percentage of milk that is sold is transported to urban consumers by milk collectors who make a round of rural villages, thereby offering an important employment opportunity for the poor people.

Improvement of breed for cows is lagging behind with local breed accounting for 80% of all cows. Diffusion rate of improved breed is particularly low among peasant households. The percentage of households exceeding 12 liters in daily milking volume is only 20% among cows that are raised by farmers and nil among those raised by peasant households. About 30% of farmers have daily milking volume of 8 to 12 liters and 35 to 45% have daily milking volume of 4 to 8 liters. In the case of peasant households, the percentage of those with daily milking volume of 4 to 8 liters is 65% while those with daily milking volume of 8 to 12 liters is about 20% [Sarwar and Saleem (1993)]. There is large room for improvement, including strengthening of feed base, diffusion of improved breed and measures against diseases such as cattle foot disease.

(3) Rural development

The emphasis of rural development policies is placed on solving poverty in India an Bangladesh and therefore measures such as offering employment opportunities through rural construction projects and promotion of self employment through small loan projects. However, these policies are not implemented at least in a systematic sense in Pakistan.

The rural development policies that are actually being adopted in Pakistan emphasize improvement of rural infrastructure and hardly have the characteristics of programs that are targeted for the poor. The greatest reason for this lies in the fact that poverty issue is insignificant in Pakistan compared to India and Bangladesh and that serious problems such as starvation do not exist to any significant extent.

Moreover, little significance is attached to infrastructure projects centering around improvement of rural roads in terms of creating employment. Rather, they have important meaning in diversification of rural economy (advancement of non-agricultural employment in particular) through promotion of farm product distribution.

2 Potential for International Cooperation and Its Direction

As mentioned above, the fundamental tasks of agriculture and rural villages in Pakistan can be summarized to three points: (1) improvement of productivity; (2) promotion of diversification; and (3) promotion of non-agricultural employment in rural villages. Therefore, international cooperation in these areas will be desirable.

Starting with the first point, improvement of productivity is of nature that requires support from various means. While it is basically achieved through cooperation for irrigation/drainage projects and for salt injury/waterlogging measures, everything including development and diffusion of new technology, financial assistance, improvement of infrastructure such as road construction and electrification of rural areas, and furnishing of input goods lead to improved productivity. In this sense, Japan has been providing assistance for improvement of productivity through granting of two-step loans for ADBP, rural road construction projects, groundwater development and assistance for increased food production. While these types of assistance need to be viewed in terms of their respective evaluation, their continuation in the future is basically justifiable.

Moving on to the second point of diversification, possible measures include support for diffusion of tubewell irrigation (e.g. furnishing tubewell, financial assistance) and technical cooperation for marketing as a measure for seeking advancement of fruit sector in Baluchistan Province, for instance. Construction of rural road is also effective.

Promotion of non-agricultural employment in rural villages should also be able to attain considerable goals through assistance in improvement of infrastructure such as rural roads and rural electrification.

Regarding cooperation for irrigation infrastructure

As can be seen in Chapter 2 Field Survey Report, irrigation projects that have decisive importance in agriculture of Pakistan are facing difficulties in various aspects. Financial difficulties experienced by the Pakistan Government have resulted in cutback of subsidies for irrigation and a series of policy changes including financial independence of competent authority for irrigation. The experience of Japan indicates that investment should b made from industrial sector to agricultural sector. Therefore, the negative impact such shift would have on agricultural production can be easily anticipated. Should financial independence of irrigation-related institutions be performed as scheduled, the funds for irrigation infrastructure will be significantly reduced.

Such changes will have serious impact on agriculture in Pakistan. Agricultural sector requires enormous investments in agricultural infrastructure such as irrigation and land improvement, especially when establishing a new farming method as represented by Green Revolution. It must be understood that the conditionality of the World Bank for Pakistani agriculture, as well as the accompanying shift in agricultural policy of Pakistan, will terminate the transfer of resources from industrial sector to agricultural sector. As have been examined through field survey, the infrastructure of agriculture in Pakistan is insufficient especially in the area of irrigation. If that were the case, a need would arise for transfer of resources to agricultural sector, which will be terminated within the country, to be covered partially by the assistance from international institutions for sustained growth of agriculture. Assistance to irrigation system shall be given the highest priority among them.

Equipping of irrigation facility is an important aspect that will determine the fate of agriculture in Pakistan Then what are the types of governmental development aid that can be offered? Roughly speaking, possible options are; 1) construction of dams and power plants; and 2) maintenance and operation including repair of irrigation facilities (lining of canals and construction of drainage facilities, to be exact). Either way, it will improve water supply to farm fields and contribute to increase in agricultural production, both of which are important policy tasks for Pakistani agriculture. However, maintenance and operation of irrigation facilities shall be given priority in view of the salt damage and waterlogging problem because when "construction of dams and power plants" and "maintenance and operation of irrigation facilities" are compared as subjects of investment (assistance), the former is an option that requires large-scale investment while the latter is an option accompanied by technological divisibility of investment (assistance). In other words, lining of canals can be financed by small amount of funds and implemented as accumulation of projects on a water course basis.

However, applying lining to all canals would require a large budget, which means that assistance resources will have to be distributed properly. In such a case, irrigation areas where mobilization of rural resources is possible and maintenance and operation through participation of farmers can be expected would be the ideal subject. From this viewpoint, investment to water courses is expected to have the highest cost benefit because its investment effect (including labor input) will be felt directly by the beneficiary farmers, making it relatively easy to mobilize rural resources and at the same time opening the way for long-term maintenance and operation.

In contrast, the direct benefit of investments will be felt less and less by the farmers as they are made further upstream from minors to main canals, and irrigation canals will increasingly assume a character of public goods rather than directly involving the interest of each and every farmer. As a result, it not only makes it difficult to mobilize rural resources but creates a subject that is incompatible with privatization of maintenance and operation. Therefore, priority shall be given to improvement of water courses for the time being.

Installation of tubewells is also a desirable method of water resource development in water courses although there are many obstacles to its diffusion. One of them is the slow rate of diffusion for electric tubewells (despite their mobility) owing to exceptionally high electric charges and lack of stable supply of electricity. Electric charges are predicted to skyrocket especially after the power generation sector of WAPDA is privatized, and it goes without saying what that would lead to. In addition, little can be expected from subsidy towards private tubewells due to financial difficulties. Solving the power shortage problem is important for industrial sector and agricultural sector alike. In addition, installation of tubewells will have to be restricted in regions where groundwater is saline, and such region-specific measures must be taken without delay. Furthermore, priority must be given to water course improvement projects so long as alternative source of water supply cannot be expected in saline water regions.

The following points will have to be taken into consideration with regard to the method of assistance. According to the field survey report:

1) The operation of irrigation system in Pakistan is currently shifting from centralization to decentralization, which means that the authority for making decisions related to irrigation is likely to be transferred to provincial governments and eventually to prefectural and county governments. If that were the case, assistance will have to be discussed at least on the provincial government level rather than on the national government level.
2) As reorganization of authorities governing irrigation in Pakistan is being planned, assistance will have to be provided after ascertaining how this will turn out.
3) The subject of irrigation projects will be limited to social groups such as water users' associations formed by villages and water courses, and participation of the farmers in mobilization of rural resources and in maintenance and operation will be the key to success of the project. In such a case, projects that take social science ideas into consideration will be required as discussed in relation to SCARP Transition Project.

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Chapter Four

Survey Members and Itinerary

1 Survey Member

(1) Committee in Japan

Shigeto Kawano	Professor Emeritus, the University of Tokyo
Yonosuke Hara	Professor, Institute of Oriental Culture, The University of Tokyo
Shigemochi Hirashima	Professor, Meiji Gakuin University
Seiichi Fukui	Associate Professor, Faculty of Agriculture, Kyushu University
Akihiko Ohno	Associate Professor, Faculty of Economics, Osaka City University
Koichi Fujita	Associate Professor, Faculty of Agriculture, the University of Tokyo
Tomomi Otsuka	Associate Professor, College of Humanity and Sciences, Nihon University

Hiroaki Sumida	Full Time Lecturer, College of Agriculture and Veterinary Medicine, Nihon University
Takashi Kurosaki	Development Studies Department, Institute of Developing Economies
Hisato Shuto	Graduate School, the University of Tokyo
Tsuguo Hirose	Executive Director, Secretary General, Asian Population and Development Association (APDA)
Masaaki Endo	Vice- Councillor, Asian Population And Development Association (APDA)
Osamu Kusumoto	Senior Researcher, Asian Population And Development Association (APDA)

(2) Preliminary Survey Member (July 3- July 9)

Osamu Kusumoto	Survey Team Member (See above)

(3) Survey Members (September 10- September 24)

Seiichi Fukui	Survey Team Leader (See above)
Akihiko Ohno	Survey Team Member (See above)
Hiroaki Sumida	Survey Team Member (See above)
Osamu Kusumoto	Survey Team Member (See above)

2 Cooperator

(1) The Embassy of Japan

Takao Kawakami	Ambassador
Hiroshi Fukada	Minister
Koji Yamada	First Secretary

(2) Governmant and Institutions

Hon. Mr. Syed Zafar Ali Shah, Deputy Speaker, National Assembly of Pakistan.

Mr. Abdul Rauf Khan Lughmani, Secretary of National Assembly, National Assembly Secretariat.

Mrs. Mahe Talat Naseem, Director, Center for Research and Library, National Assembly Secretariat.

Mr. Naim Uddin Siddiqi, Librarian, National Assembly Secretariat.

Mr. Murad Ali, Research Officer, National Assembly Secretariat.

Mr. Ch. Mukhtar Ahmed, Research Officer, National Assembly Secretariat.

Mr. Sayed Edam Shah Bukhari, Research Officer, National Assembly Secretariat.

Mr. Nasim Khalid, Protocol Officer, National Assembly Secretariat.

Dr. Zafar Altaf, Additional Secretary in Charge, Ministry of Food Agriculture and Livestock.

Dr. C.M. Anwar Khan, Chairman, Pakistan Agricultural Research Council (PARC)

Dr. Muhammad Akber, Director General, National Agricultural Research Center (NARC)

Mr. M.I. Nizami, Principle Scientific Officer, Land Resource Research Institute, NARC.

Dr. Shirif Zia, Director, Land Resource Research Institute, NARC.

Dr. Shahid Ahmad, Director, Water Resources Research Institute, NARC.

Dr. Muhammad Shafig, Principle Scientific Officer, Water Research Institute, NARC.

Mr. Muhammad Yasin, Senior Scientific Officer, Water Resources Research Institute, NARC.

Dr. Muhammad Amjad, Chairman Agricultural Price Commission (APCOM)

Dr. Aabdul Salam, Member (Economics), APCOM.

Dr. Muhammad Ramzan, Member (Agronomy), APCOM.

Mr. Mian Muhammad Mukhtar, Associate Chief, APCOM.

Dr. Sarfaz Khan Qureshi, Director, Pakistan Institute of Development Economy (PIDE).

Dr. Gaffar Chaudhry, Joint Director, Pakistan Institute of Development Economy (PIDE).

Mr. Saleem Murtza, Secretary, Department of Agriculture, Government of Punjab.

Mr. Mushtaq Ahmad Gill, Director General, Department of Agriculture, Government of Punjab.

Mr. Chaudhry Mohammad Ashraff, Director, On Farm Water Management, Department of Agriculture, Government of Punjab.

Mr. Shafqat Masood, Project Director, Second SCARP Transition Project, Department of Agriculture, Government of Punjab.

Mr. S. Zagham Abbas Shamsi, Director General, Bureau of Statistics, Government of Punjab.

Mr. Gulrez Akbar, Irrigation Agronomist, Department of Agriculture, Government of Punjab.

Mr. Muveed Hussaan, Director, Water Management Institute, Department of Agriculture, Government of Punjab.

Dr. Khalid Gill, Director, Soil Fertility, Department of Agriculture, Government of Punjab.

Mr. Mumtaz Ahmad, Project Director- Sheikhupura, Department of Agriculture, Government of Punjab.

Mr. M. Arshad, Management Chief, Department of Agriculture, Government of Punjab.

Mr. Zafar Javed Naqvi, Deputy Chief, Library and Documentation, PIDE.

Mr. Hussain B. Siyal, Research Demographer, PIDE.

Dr. Muhammad Jameel Khan, Director, Punjab Economic Research Institute (PERI).

Dr. Haq Nawaz Shah, Senior Research Economist, Punjab Economic Research Institute (PERI).

Mr. Shaukat Ali Shahid, Research Economist, Punjab Economic Research Institute (PERI).

Mr. Muhammad Arshad, General Manager, Public Relations Division, Water and Power Development Authority (WAPDA).

Dr. Riaz H. Qureshi, Professor, Fisalabad Agricultural University, Faculty of Agriculture.

Dr. Andrew P. Davidson, Department of Sociology, The University of New England.

Dr. Ed Barrett Lennard, Senior Research Officer, Department of Agriculture, Government of Western Australia.

Dr. Nico E. Marcar, Senior Research Scientist,The University of New England.

Dr. S. H. Mujtaba Naqvi, Director General, Nuclear Institute for Agriculture and Biology (NIAB),

Dr. Mumtaz Ali, Principal Scientific Officer, NIAB

Dr. Raziuddin Ansari, Principal Scientific Officer, Atomic Energy Agriculture Research Center, Tandojam, Pakistan.

Dr. Muhammad Jawaid Iqbal, Senior Rural Sociologist, Second SCARP Transition Project.

Mr. Malik Waggar Hussain, Deputy Director, Sheikhupura, Department of Agriculture.

Mr. Rana Khurram Mushtaq, Assistant Director, Directorate General Agriculture (Water Management), the Government of Punjab.

Mr. Zafar Ali Irshad, Extra Assistant Director of Agriculture, Ferogewala.

Dr. Munawar Mehdi, Soil Scientist, Sheikhupura, Department of Agriculture, Punjab.

Mr. Ashaiq Bhatti, Assistant Director (Marketing), Sheikhupura, Department of Agriculture, Punjab.

Mr. Muhammad Gsmial, Field Officer, Pakistan Oil Seed Development Board.

Mr. Khalid Mahmood Ahmad, Chief of Press, The Daily SHUHRAT, Karachi.

Mr. Manzur Ahmad Siddiqqui, Social Organizer, Second SCARP Transition Project.

Mr. Safdaar Ali, Head of the Government Elementary School of Village No. 166.

Mr. Saleem Ulhag, Teacher, the Government Elementary School of Village No. 166.

Mr. Maqbool Ahmad, Teacher, the Government Elementary boys School of Village No. 166.

Mr. Abdul Kareem, Teacher, the Government Elementary Boys School of Village No. 166.

Mrs. Safia Sleiman, Teacher, the Government Middle Girls School of Village No. 166.

Mrs. Shugfta Iqbal, Teacher, the Government Middle Girls School of Village No. 166.

Mrs. Khalida Parbeen, Teacher, the Government Middle Girls School of Village No. 166.

Mrs. Faarhat Unisa, Teacher, the Government Elementary Girls School of Village No. 166.

Mrs. Khalida Adeeb, Teacher, the Government Elementary Girls School of Village No. 166.

Mrs. Fazalit Akhtar, Teacher, the Government Elementary Girls School of Village No. 166.

Mrs. Mumtaz Begum, Teacher, the Government Elementary Girls School of Village No. 166.

Preliminary Survey Itinerary

3rd July - 9th July

3rd (Mon.)	12:00 Depart from Narita by PK 753-Arrive at Islamabad 19:35
4th (Tue.)	Visit to National Assembly Secretariat Discuss with Mrs. Mahe Talat Naseem, Director, Research and Library about the survey program. Discuss with Mr. Naim Uddin Siddiqi, Librarian about the Material Collection. Visit to the Embassy of Japan, discuss with Mr. Koji Yamada, Secretary.
5th (Wed.)	Visit to National Assembly. Pay courtesy to Mr. Abdul Rauf Khan Lughmani, Secretary of National Assembly of Pakistan. Visit to National Agricultural Research Center and Pakistan Agricultural Research Council(PARC), briefing from Mr. Syed Ghani Haider, Deputy Director, NARC. Visit to Pakistan Institute of Development Economy(PIDE), Briefing from Mr. Zafar Jayed Naqvi, Project Leader, PIDE
6th (thu.)	08:00(12:00) Depart from Islamabad 12:55 arrive at Lahore by PK 355 Visit to Department of Agriculture, Government of Punjab. Briefing of the Agricultural situation of Punjab and survey process from Mr. Salim Murtaza, Secretary, Department of Agriculture, Government of Punjab. Visit to the Water Management Section, discuss about survey point selection and data collection with Director General Agriculture, Mr. Mushtaq Ahmad Gill 20:55 Depart from Lahore 21:40 arrive at Islamabad by PK 382
7th (Fri.)	Visit to the mountainous rural area in Punjab Province. Look around the situation of mountainous rural area Report the survey result to Mr. Koji Yamada, First Secretary.
8th (Sat.)	Material Collection Report the survey result and discuss about main survey with Mrs. Mahe Talat Naseem, Director of Research and Library Center, National Assembly.
9th (San.)	Depart from Islambad 07:20(PK752) Arrive at Narita 21:00

Survey Itinerary

From September 11th to 24th

Sep 11 (Mon)	12:00 Depart from Narita by PK 753 Arrive at Islamabad 20:00
Sep 12 (Tue)	Visit to National Assembly Pay Courtesy to Mr. Abdul Rauf Khan Lughmani, Secretary of National Assembly. Discuss about the survey schedule with Mrs. Mahe Talat Naseem, Director, Research and Library Center, National Assembly. Visit to the Embassy of Japan. Pay courtesy to Ambassador Takao Kawakami Discuss about survey program with Mr. Koji Yamada, First Secretary.
Sep 13 (Wed)	Visit to the National Agricultural Research Center (NARC) briefing on the agricultural and rural development in Pakistan from Dr. Muhammad Akber, Director General, NARC. Visit to Ministry of Food Agriculture and Livestock briefing on the agricultural production in Pakistan from Dr. Zafar Altaf, Additional Secretary Incharge.
Sep 14 (Thu)	Visit to Pakistan Institute of Development Economy (PIDE) Discuss with Mr. Gaffar Chaudhry, Joint Director PIDE on the economic situation, agricultural development and population in Pakistan. Visit to Pakistan Agricultural Research Council (PARC) Briefing on Pakistan Agricultural Research System from Dr. C.M. Anwar Khan, Chairman, PARC. Visit to Agricultural Price Commission (APCOM), briefing on the agricultural price policy from Dr. Muhammad Amjad, Chairman APCOM.
Sep 15 (Fri)	Free (Islamic Holiday)
Sep 16 (Sat)	Move from Islamabad to Lahore.
Sep 17 (Sun)	Visit to the Government of Punjab. Briefing on the agricultural situation and rural population in Punjab Province by Mr. Saleem Murtza, Secretary, Department of Agriculture, Government of Punjab Visit to office of Director General, Department of Agriculture, discuss about the field survey point and study mission in Punjab with Mr. Mushtaq Ahmad Gill, Director General, Department of Agriculture.

	Visit to Water and Power Development Authority (WAPDA), briefing on Water management of Pakistan from, Mr. Muhammad Arshad, General Manager, Public Relations Division, WAPDA (Mr. Ohono and Dr. Sumida). Visit to Punjab Economic Research Institute (PERI), briefing on Punjab Agricultural Economy Study of Punjab from Dr. Muhammad Jameel Khan Director, PERI (Dr. Fukui and Mr. Kusumoto) Visit to Statistic Bureau of Punjab Briefing on the agricultural statistics of Punjab by Mr. S. Zagham Abbas Shamsi, Director General, Bureau of Statistics, Government of Punjab. Visit to Punjab Economic Research Institute, briefing on the Punjab Agricultural survey by Dr. Muhammad Jameel Khan, Director, Punjab
Sep 18 (Mon)	Move from Lahore to Faisalabad (Dr. Sumida and Mr. Kusumoto). Visit to Nuclear Institute for Agriculture and Biology (NIAB), briefing of seed research from Dr. S. H. Mujtaba Naqvi, Director General, NIAB. Visit to Faisalabad Agricultural University, briefing of salinity soil problem and agricultural development issues in Punjab from Prof. Riaz H. Qureshi Go around the Sheikhupura District and find the survey site. (Dr. Fukui and Mr. Ohono)
Sep 19 (Tue)	Visit the rural village and observe the field survey, Kopy Village, Sheikhupura district
Sep 20 (Wed)	Visit the Deputy Director office of Sheikhupura, discuss about agricultural extension in this area. Visit the No. 166 village at Sheikhupura and observe the Field Survey Visit the SCARP Transition Project Field Office.
Sep 21 (Thu)	Visit the No. 166 village at Sheikhupura and observe the field survey. Report the field survey result to Mr. Mustaq Ahmad Gill, Director General, Water Management, Department of Agriculture, Government of Punjab.
Sep 22 (Fri)	Depart from Lahore by PK 378 (17:20) Arrive at Islamabad (18:30). Free (Islamic Holiday) Report the Survey result to Mr. Koji Yamada
Sep 23 (Sat)	Report the survey result to Mr. Abdul Rauf Khan Lughmani, Secretary of National Assembly (Mrs. Mahe Talat Naseem).

	Report the survey result to H.E. Mr. Takao Kawakami, Ambassador of Japan
Sep 24 (Sun)	07:20 Depart from Islamabad 21:55 arrive at Narita

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