ECONOMIC ANALYSIS OF STAPLE FOOD-GRAIN CROPS: VARIETIES' INPUT-OUTPUT COMPARISON, ECONOMIC PRACTICES AND SIGNIFICANCE IN THE ECONOMY OF DISTRICT SWAT

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ANWAR HUSSAIN

A dissertation submitted to the University of Peshawar in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY IN ECONOMICS

DEPARTMENT OF ECONOMICS
UNIVERSITY OF PESHAWAR
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2010

DEPARTMENT OF ECONOMICS
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Date: 6/10/10

APPROVAL CERTIFICATE

This dissertation entitled "ECONOMIC ANALYSIS OF STAPLE FOOD-GRAIN CROPS: VARIETIES' INPUT-OUTPUT COMPARISON, ECONOMIC PRACTICES AND SIGNIFICANCE IN THE ECONOMY OF DISTRICT SWAT" submitted by Anwar Hussain in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Economics is hereby approved.

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ABSTRACT

The present study aims to make economic analysis of staple food grain crops i.e. rice, wheat and maize in district Swat. Out of the total seven tehsils, three tehsils namely Kabal, Matta and Barikot were selected on the basis of purposive sampling technique. The selected tehsils were situated on the bank of river Swat where food grain crops were mainly grown. From each tehsil three villages each were randomly selected. The study is based on primary data which were collected through structured questionnaire using a sample of 200 farmers allocated proportionally. The respondents (farmers) were selected randomly from each village. Sample size for the selected villages was adequate because the villages were quite homogeneous in terms of land condition, cropping pattern, population and farming activities. For the analysis, benefit-cost ratios, log-linear Cobb-Douglas production functions, stepwise regression and Wald test were used. The findings of the study revealed that Fakhr-e-Malakand (rice variety with highest benefit-cost ratio of 3.41) was the most profitable variety as compared to all other rice varieties. Fakhr-e-Sarhad (wheat variety with highest benefit-cost ratio of 2.36) was the most profitable variety as compared to all other wheat varieties. Azam (maize variety with highest benefit-cost ratio of 2.24) was the most profitable variety as compared to all other maize varieties. For rice crop, the output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides were 0.24578, 0.6712, 0.0789123, 0.871245, 0.12487 and 0.004871 respectively. For wheat crop, the output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides were 0.61, 0.1220, 0.0789123, 0.871245, 0.12487 and 0.004871 respectively. For maize crop, the output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides were 0.64123, 0.124587, 0.55461, 0.31244, 0.5874 and 0.08248 respectively. Proportional increase in the output of rice, wheat and maize was faster than the increase in the inputs of rice, wheat and maize respectively. The major pre and post harvest agro-economic practices undertaken in food-grains crops cultivation were conservation of traditional varieties, land preparation, water management, transplanting, harvesting and drying, threshing and cleaning, transportation and straw management. The villagers used to derive their standard of living from agriculture in general and particularly from food grain cultivation. The food grains were most closely connected with sources of income, labour force and capital employment, woman participation,

labour distribution within the villages, food grain marketing, credit and financing, consumption pattern, price fluctuations, poverty alleviation, self-sufficiency, extension of markets, strengthening fertilizer business, mechanized farming, reduction in food grain shortages, children education, reduction in the social problems, extension in tractors and threshers market, increasing livestock production and reduction in the prices of those commodities which requires food grain as raw material. The per acre usage of labour for rice, wheat and maize was 55, 30 and 35 labours respectively. Majority of the food growers used to sell their produce in the village markets. The farmers mostly used non-institutional loans for farm activities. It is recommended that the government should launch policies for increasing cultivated area under food crops. Awareness should be given to the farmers to grow profitable varieties rather than traditional varieties. The farmers should only use recommended seed. Proper storage facilities should be provided to the food grain growers. Efforts should be made to increase farmers' income through improvements in food grain quality, plus better utilization of its by-products. As proportional increase in the output of food grain crops was higher than their inputs, therefore, the inputs should be properly and efficiently managed so as to ensure higher productivity.

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Chapter-1

INTRODUCTION

District Swat has been endowed by nature with vast potentialities for growing food grain crops, the relatively leveled terrain, congenial climatic conditions and abundant supply of farm labour. Food crops occupy a pivotal place in Swat's domestic food and livelihood security system and the prosperity of the majority of her people is closely bound up with food crops' production. The economic variables like capital and labour force employment, sources of income, consumption pattern, marketing activities, credit and financing, labour distribution, returns and surpluses are most closely connected with food crops productivity in district Swat.

A commodity on which the economy of a settlement or region concentrates much of its labour and capital is called staple commodity (Dolan and Vogt, 1984). There are two principal crop seasons namely the "Kharif", the sowing season of which begins in April-June and harvesting during October-December; and the "Rabi", which begins in October-December and ends in April-May. Rice, sugarcane, cotton, maize, mong, mash, bajra and jowar are "Kharif" crops while wheat, gram, lentil (masoor), tobacco, rapeseed, barley and mustard are "Rabi" crops.

The major staple food grains crops of district Swat are rice, wheat and maize. Different varieties of these crops are grown in different areas of the district as compared to bajra, jowar and barley which are not grown extensively. The main rice varieties grown in Swat are JP-5, Fakhr-e-Malakand, Basmati-385, Sara Saila, Swat-1, Swat-2, and Dil rosh-97. Basmati-385 is mostly grown in tehsil Barikot while Fakhr-e-Malakand and JP-5 are mainly grown in tehsil Matta. The major wheat varieties grown in the district are Saleem-2000, Haider-2002, Khyber-87, Nowshera-96, Tatara, Bakhtawar-92, Suleman-96, Auqab-200 and Fakhre-Sarhad. There are five main varieties of maize namely Azam, Pahari, Jalal, Babar, Ghori which are grown in district Swat (Cropping Reporting Services, Swat, 2004).

Food-grain crops mainly rice, maize and wheat, barley, jowar, bajra and gram are diverse in terms of cost and yielding on the same size of land.

There are various pre and post harvest operations involved in food grain production, which possess economic significance. To get maximum yields from various varieties of food grain crops, adoption of improved practices are indispensable.

The total area of the district is 506528 hectares[1] comprised on cultivated area of 98054 hectares, uncultivated area of 408474 hectares and area under forest is 136705 hectares. The total area under rice cultivation in 2002-03, 2003-04, 2004-05, 2005-06 and 2006-07 was 6872, 6848, 7019, 7083 and 7349 hectares respectively while the total rice production was 16533, 16710, 17092, 16922 and 17764 tones respectively. The total area under wheat cultivation in 2002-03, 2003-04, 2004-05, 2005-06 and 2006-07 was 62111, 59006, 61568, 62198 and 62137 hectares respectively while the total wheat production was 97060, 88185, 93467, 102707 and 103004 tones respectively. Remarkable improvement in production took place in 2005-06 due to favourable climatic conditions. The total area under maize cultivation in 2002-03, 2003-04, 2004-05, 2005-06 and 2006-07 was 61334, 63076, 59606, 61088 and 62513 hectares respectively, while the total maize production was 101412, 106431, 96769, 101109 and 103167 tonnes respectively. The production reduced in 2004-05 due to fall in the area under maize cultivation (Cropping Reporting Services, 2006-07).

In the context of economic analysis, it is important to study how food grain crops' production is related with labour and capital employment, marketing, credit and financing, sources of income, consumption pattern and net-returns. What are the socioeconomic profiles of the food crops' growers such as family size, occupation, cropping pattern, crop production, food availability, education level, livestock, size of land holding, variety-wise distribution of farmers, woman

1. See details of conversion units in appendix-A

participation, decision-making in the households and labour distribution within the villages? How different varieties of rice, wheat and maize differ in terms of costs and revenues from each other? What are the different pre and post harvest agro-economic practices carried out in food grains crops production process? How various inputs contribute towards output of these three crops? What are the different causes of low yield per acre in the district and what are appropriate suggestions? So, it is a researchable issue to analyze food grain crops from economic viewpoint in district Swat. The present study will answer such like questions.

Varieties' input-output comparison and economic practices undertaken in food-grain crop cultivation will provide a guideline for producers, lenders, agricultural economists, researchers, extension personnel, policy makers, and those involved in agriculture for future policy implementation. Linking food grain productivity with labor and capital employment, marketing, sources of income, credit and financing, consumption pattern and net-returns will benefit farmers, credit institutions, industrialists, and marketing personnel. Ultimately, the study will contribute towards overall development and growth of Swat economy and will be proved as a push towards balanced growth of the country.

1.1 Objectives of the Study

The objectives of this study are as under:

1) To compare the per acre cost and revenue of different varieties of rice, wheat, and maize in district Swat.

2) To quantify the contribution of various inputs towards output of rice, wheat and maize.

3) To identify the pre and post harvest agro-economic practices undertaken in food grain crops cultivation followed by identifying the factors responsible for low yield per acre in district Swat.

4) To explore the significance of food grain crop cultivation in economic activities mainly labour force employment, capital employment, marketing, sources of income, credit and financing.

1.2 Hypotheses tested

In this study, the following hypotheses have been tested.

1. Food grains' input-output relationship holds constant returns to scale.
2. Food grains production has positive impact on labour force employment, sources of income and consumption pattern of farmers.
3. Higher food grains production improves the standard of living of farmers.

1.3 Organization of the Study

The dissertation is organized into eight chapters. In first chapter, introduction about the study including its objectives and hypotheses have been given.

In second chapter, literature is reviewed. Literature about the economic analysis of the three crops i.e. rice, wheat and maize has been discussed. This chapter contains detailed information of past work on the problem.

In chapter three, data and methodology developed for the study is given. Details about the nature of data, its collection procedure, sampling design and analytical tools used are presented.

In chapter four, profiles of Swat economy and food grain cultivations are discussed. In this regard, study area description, climate, soil and water, population, occupations, variety-wise growing zones of food grain varieties, characteristics of food grain growers, and profiles of food grain varieties are discussed.

Comparison of cost and revenue of food-grain varieties is given in chapter five. In this connection, different cost and revenue components of rice, wheat and

maize have been identified. Benefit cost ratios for each variety of food crops have been calculated.

In chapter six, econometric analysis of food grain crops has been made. For each crop the log linear model has been estimated so as to find out the output elasticities and to determine the nature of returns to scale. For each crop, total product at mean, maximum and minimum values of the sample observations have been estimated. The average and marginal product has also been estimated for each crop.

In chapter seven, economic practices of food-grain crops cultivation and its significance in the economy of district Swat have been discussed. Pre and post harvest economic practices undertaken in food grain crops cultivation and causes of low yield per acre in the area under investigation have also been identified.

Conclusions and recommendations are presented in the last chapter.

Chapter- 2

LITERATURE REVIEW

2.1 Introduction

The review of the relevant literature provides basis for meaningful research. It highlights the background of the issue under research. In addition, valuable information on research techniques is gained from the earlier research reports. In this section a detailed review of the previous work done about the economic analysis of food-grins i.e. rice, wheat and maize is presented.

2.2 Literature on the Economics of Rice Crop

Kim (1993) studied the importance of rice as a staple crop. The study indicated that the number of farm households cultivating paddy rice had decreased, yet the proportion of total farm households had increased. He investigated that there were also many rice milling plants, facilities for rice storage, and rice wholesalers and retailers, which provided one of the most important source of employment, especially in the rural areas. Proposals were made for changes in government policy regarding rice production. He concluded that reducing production costs would be crucial for Korean rice to become competitive.

Jabber *et al* (1993) examined the level of hindrance to rice cultivation caused by shrimp culture, as well as the economic consequences of differential use of the land resource. Experimentation in growing rice and shrimp together was recommended, with selection of appropriate rice varieties to sustain productivity and farmers' profitability in the area.

Santha (1993) studied the economics of rice cultivation in India, in 1992. He compared the production cost, input use and profitability of rice production in three seasons: Viruppu (first crop), Mundakan (second crop) and Punja (third

crop). Rice was mainly grown as a transplanted crop during the Munkudan season and as a direct sown crop in the other seasons. Data were collected from a sample of 33, 60 and 27 farmers, respectively, for the first, second and third crops. Cultivation during the Mundakan season was the most profitable in terms of total returns and net income. The Viruppu crop performed best in terms of benefit cost ratio and cost of production. Hired labour was the most important input in all seasons.

Jones (1994) investigated that how any risk benefits for rice growers depended crucially on the extent their real incomes were linked (as taxpayers) to the financial flows of the storage scheme. That was because their real incomes and the financial flows were negatively correlated. Under recent arrangements that linkage was negligible, so price stabilization raised the share of the production risk they faced. Thus, recent increases in production were shown to result from larger expected profits for rice growers, and not from risk benefits. In addition to the profits from price stabilization, they had benefited from government subsidies on fertilizer, irrigation and plant research, and from increases in the average domestic price of rice.

Rebuffel (1994) studied that the development of smallholder rice production was supported by a number of projects in Ghana. The crop was grown for commercial purposes, with small farmers renting machinery from larger private farms. Research carried out had enabled crop sequences to be adapted to increase production without competing with food crops, and hydrological studies on the lowlands had also resulted in increased productivity. The economic conditions of access to credit and mechanization were evaluated, and a number of solutions were proposed.

Vichitkh (1994) studied the importance of rice production in the economies of South-East Asia, and the area playing a leading role in terms of sown area and volume of production. Between 1961 and 1992 the sown area increased by 25% to

37.8 million hectares, representing 25.6% of that worldwide. Gross yields rose to 112.7 m tones or 21.6% of world output. Despite yield increased per hectare of 80%, yields themselves remained 86.3% of world average, the highest in 1992 being in Indonesia. The rate of increase in output was just ahead of that in population; however, self-sufficiency indices in several countries (Lao, Malaysia, the Philippines, Cambodia and Indonesia) were less than 100%. The main factors influenced growth in output were introduction of high-yielding varieties and agrochemicals and improved irrigation. The region supplied 43% of worldwide exports in 1991, the leading exporter being Thailand, followed by Vietnam. Medium and long grain rice make up the greatest volume traded. Price fluctuations were much greater than for wheat. The main causes were monsoon-influenced weather conditions and technological changes.

Huang (1995) used a production function approach to assess per ha input levels in Chinese rice production at the provincial level using time-series data for 1984-91. The estimated coefficients were then compared with the price ratio of output and inputs. The results indicated a large misallocation of resources in rice production. For fertilizers, the poor allocation was mainly due to unequal fertilizer distribution between regions. For labour, overuse was observed in all production regions, indicating the importance of shifting the farm labour force into non-farming sectors.

Dash *et al* (1995) studied cost and return per hectare and level of input use in production for summer rice in Baharagora block of Singhbhum district in Bihar. From the analysis of data collected in 1991 from 32 sample farmers, it was observed that on average, per hectare cost of cultivation was Rs. 17 113. The average yield per hectare was about 56 quintals, which varied from 52.71 quintals to 58 quintals on the sample farms. The average gross and net returns per hectare were Rs. 18 923 and Rs. 1920, respectively.

Radziunas *et al* (1995) discussed the world importance of rice as a food crop which is grown and consumed in all ecologically suitable regions of the world, eclipsed only by wheat, though 96% of rice production was consumed locally. Concentration on the European Union was given, where rice was grown in all southern member states (especially Italy and Spain) and consumed throughout the EU. Production and consumption figures were compared with Colombia's. Southeast Europe, Russia and Ukraine as producers were also discussed briefly. Northern Europe and Portugal were the main consumers in Europe. The conclusion discussed changes in the rules for subsidies in the post-Uruguay Round era.

Dev and Hossain (1995) developed a model to estimate the farm specific technical efficiency of rice farmers under heterogeneous human resources and technological environment. The study concluded that, under heterogeneous human resources and technological conditions, farm specific technical efficiency could be assessed either through incorporation of farmers' education and technology directly into the production function or through a two stage analysis, estimating farm specific technical efficiencies first and then regressing the technical efficiencies on different explanatory variables including farmers' education and the technology index.

Kumar *et al* (1996) examined the cropping pattern in different agro-climatic zones of plateau region of Bihar, India. The growth rate in area, production and productivity (yield) during the same period was measured and the average productivity under the two periods was studied. There was a shift in cropping pattern in favour of wheat and potato crops after introduction of the Green Revolution in all zones of the plateau region. The yield of paddy per ha increased during the Green Revolution.

Jabati and Engelhardt (1996) assessed the impact on farm income of cultivating improved varieties using the full seed multiplication project (SMP)

package (improved seeds, fertilizer and mechanical ploughing and harrowing conditions) as well as using improved varieties alone for three rice growing environments of Sierra Leone. Self-sustainability of the project, macroeconomic effects of the project and the impact of price policy on the project itself, and on farmers' well being were examined. For farmers using the full SMP package, rice cultivation in the inland valley swamps was the most profitable (36.7% increase in income per hectare as compared to local varieties). For farmers using improved varieties alone, cultivation in the uplands was the most profitable (36.3% increase in income). If the prevailing price of rice was adjusted to reflect the actual value of inland production, farmers in the different rice growing zones could be increased their cultivated rice fields by average values ranging from 1 ha to 2.2 ha, provided the additional income was fully invested.

Kono (1996) used a Cobb-Douglas production function to identify the factors, which influence rice productivity in the national irrigation area, Taiwan. The economic performance of pump irrigation was also evaluated. Two factors, besides land, were found to influence rice productivity: tenurial status and water shortage. Tenants faced worse field conditions in rented fields and were located further away from the main and secondary canals. Water shortage in the dry season had a serious effect on rice productivity. Some progressive tenants have overcome water unavailability by adopting pump irrigation technology. That enabled them to achieve higher yields and income. Landlords and owner farmers of large-scale paddy fields also adopted their own pumps. They mainly used them to stabilize rice yield. It was concluded that pump irrigation had enhanced economic performance among farmers who had adopted it as a supplementary irrigation instrument.

Reddy *et al* (1996) studied a population of 126 farmers (twenty one small farms, 21 medium sized farms, and 21 large farms from one or the other of 2 selected villages in the Guntur district of India). The major factors influencing

yield gaps were identified as less use of all input levels except nitrogen on sample farms as compared to the demonstration farms. Therefore, the empirical findings implied that the yield on actual farms could be increased by 50 per cent over existing yield level (36 q/ha) by supply of key inputs at subsidized rates, providing the institutional credit at reasonable interest rates specially to small and medium farms, making available of irrigation at critical stages of crop growth based on regional crop planning, remunerative output pricing and streamlining existing extension system for efficient transfer of technology.

Gangwar and Dubey (1996) compared 10 different rice-based cropping systems in field trials in 1985-87 at Port Blair, Andaman Island. Maximum net returns/ha were obtained by rice/rice/black gram [Vigna mungo], rice/rice/sesame and rice/rice/green gram [Vigna radiata] sequences.

Yap (1996) examined the implications of the general agreement on tariffs and trade (GATT) Agreement on agriculture for the rice economy, and its impact on world rice production, trade, consumption and international prices. Considerable uncertainties, however, existed as to whether the full benefits will be realized, as they hinge mainly on the implementation of market access provisions in a limited number of countries. In assessing the impact of the agreement, it was assumed that there would be full compliance with the commitments made. Some alternative scenarios were also examined.

Zaffaroni *et al* (1996) undertook a survey in Brazil, to determine the main socioeconomic features of small and large scale rice producers. There was no significant difference between the two for the following parameters: communication systems; technical assistance; reasons for growing rice. Education, association, land ownership, cattle production, hired labour and machinery characterized larger producers.

Reddy (1997) assessed inter-regional variations in the performance of paddy rice production in Andhra Pradesh state, India, during the period 1981/82-

1991-92. Performance was assessed in terms of yield per ha, unit cost and total factor productivity. Data used in the analysis were collected from 400 holdings (from 40 villages) for the years 1981/82 and 1982/83 and from 600 holdings (from 60 villages) for the years 1983/84-1991/92, spread over five agro-climatic zones. The analysis revealed that the relatively lower prices for modern inputs compared to traditional inputs, partly due to subsidies, had enabled farmers to substitute modern inputs for traditional inputs and thereby obtained higher yields at lower costs.

Jabber and Palmer (1997) developed a model to estimate the growth of both production and adoption of modern rice varieties (MVs) in Bangladesh over the period 1972-94. The research suggested that (i) location-specific and insect and disease-resistant varieties need to be developed; (ii) credit facilities be provided on the basis of land devoted to MV of rice rather than farm size; and (iii) rice farmers are to be motivated to grow BR-28, BR29 in Boro season, replacing the previous Boro varieties.

Dipeolu and Kazeem (1997) studied the economics of rice production in the Itoikin irrigation project in Lagos State, Nigeria. Three functional forms, the linear, semi-logarithmic, and the double logarithmic (Cobb-Douglas production function) were estimated using data collected from 32 farms in 1991. The study revealed that the farmers lacked adequate experience in the improved farming technologies. They applied seed and fertilizer less intensively than expected and used agrochemicals and labour excessively. The results showed an average productivity of 0.994 t/ha, which was low, compared to potential rice yields of 2-3 t/ha. The average gross margin of the sampled farms was less than half that on the government demonstration farm.

Tejinder *et al* (1997) investigated the relative performance of individual states in India analyzing the data on area, production and yield of rice over the period 1969/70-1989/90. The states of Andhra Pradesh, Uttar Pradesh, Punjab and

Haryana showed an increasing share of total rice production over the period. On the other hand, Bihar, Tamil Nadu, Orissa, Assam, Karnataka, Kerala, Jammu and Kashmir, and Himachal Pradesh all recorded a decrease in their relative share of total rice production. West Bengal, Madhya Pradesh, Maharashtra, Gujarat and Rajasthan experienced a fluctuating share over time. Both area and yield increased over time in states showing an increase in their share of rice production. For states exhibiting a declining share of total rice production, the relative share of area declined, and yield increased, but the level of increase was small. Irrigation was found to be the most important factor influencing production and yield. The use of other inputs such as fertilizer, power, and credit were highly associated with irrigation level.

Vaidya (1997) surveyed management practices and the economics of rice production using a structured questionnaire. A survey of rice yield in the extension command area of Lumle Agricultural Research Centre estimated grain yields (not including post-harvest and processing losses) to be 2.59 t/ha in 1992 and 2.27 t in 1993. These yields, determined by cutting sample plots, were greater than average government estimates for the area but lower than farmers' estimates.

Ravikash (1997) modeled growth of the rice production area, total rice production and yield in Nagaland over 1966-95. Annual compound growth rate for each parameter was positive overall and for each of three periods of about ten years. Resource use efficiency and return on investment for different inputs (including labour), was also determined.

Sinha and Singh (1997) examined constraints of rice production in Bihar by surveying 80 randomly selected farmers of Patna and Gaya districts. On average, the yields were 1.4 t/ha lower than the potential yield of 4.0 t/ha. Credit problems, marketing problems, labour problems and tenancies of land were the main constraints in rice production.

Young *et al* (1998) described the Myanmar rice economy in the context of the current political situation and state of national economic development. Aspects covered include: policy, production systems (cultivation methods, variety use, production constraints), marketing, transport and storage, production costs and marketing margins, consumption, exports, capacity of land and water resources to increase production, and the comparative advantage of Myanmar rice production.

Sidibe (1998) characterized, identified and evaluated the economic benefits of fertilization practices for upland rice production in the Hounde region of Burkina Faso. A simple linear regression model was used to assess determinants of fertilizer use for a sample of 29 farmers and an on-farm economic analysis of fertilizer use was used to show the revenue, costs and net benefits of the two most common practices (combining urea and farmyard manure, and NPK fertilizer). Manure use was found to be highly dependent on the upland rice area, the rate of urea use and the number of on-farm workers, carts and cattle.

Jaikumaran (1998) discussed the sustainability of rice production in Kerala state, India, noting that conversion of paddy land to other cash crops as well as non-agricultural uses had severely affected the paddy land ecosystem, as well as rice production. Faced with this situation, it was considered that the solution lies in suitable mechanization. Experience with rice mechanization was described. In particular, the discussion reviewed uptake, constraints, performance and comparative economics of mechanized transplanting.

Pandey and Sanamongkhoun (1998) carried out the study to generate qualitative and quantitative understanding of the microeconomics of lowland rice systems in Laos. The analysis was based on data collected through a survey of 698 farmers from 15 villages in Saravane and Champassak provinces in 1996. Results covered: demographic characteristics and land use patterns; rice production practices, input use and economics; household income and expenditure; marketing of outputs; gender roles; sources and types of technology and information;

agricultural credit; and economics of technology adoption. Implications were drawn for research, extension and policy.

Xu-XiaoSong *et al* (1998) used a dual stochastic frontier efficiency decomposition model to estimate productive efficiency for Chinese hybrid and conventional rice production. Results revealed significant differences in technical and allocative efficiency between conventional and hybrid rice production, and indicated significant regional efficiency differences in hybrid rice production, but not in conventional rice production.

Fischer (1998) discussed that rice was an important agricultural commodity and a staple food crop for a large proportion of the developing country population. Challenges for the future of rice production included finding ways to grow enough rice for the expanding global population, sustaining higher rice production, and maintaining the natural resource base and protecting the environment. An overview of the way in which the International Rice Research Institute is approaching these challenges in terms of research was presented with particular reference to Asia.

Huang (1998) described the rice research system and recent technological change in rice production with reference to China. The determinants of rice technology adoption were identified and a review and discussion of the impacts of research and technological change on growth in rice yields was presented. The production constraints and the potential yield increase that could be achieved through research and technological change was then discussed, and policy implications and their impact on both the inputs and outputs of rice production were discussed.

Jha (1998) presented disaggregated data on rice production, yield and changes in total factor productivity across states (provinces) of India. Production trends, and the influencing factors were also traced. The extent to which increase

in rice yields and production could be attributed to the productivity of Indian rice research was assessed.

Ishida and Asmuni (1998) explored the changes in rice production and income distribution in a main granary area of Malaysia. Two rice producing sub-areas; Sawah Sempadan and Sungai Burong, of the Tanjong Karang Irrigation Area were chosen for the study. Data on incomes from farm as well as off-farm workers, farm expenses and practices, demographic characteristics etc., were collected in the survey. An economic analysis of rice production was presented so as to trace the impact of agricultural modernization on paddy income; the rural labour market was discussed with a view to gain some understanding of how different off-farm employment affects poverty alleviation and distributional equity among rice farmers; and the incidence of poverty and the situation of income distribution in the studied area was analyzed.

Dowling *et al* (1998) studied that the success in generating rapid growth in rice yields had given rise to excessive complacency on the part of national governments and international aid agencies. While on-farm yields have continued to increase, maximum yields at leading research centers had seen no change in the last 20 years.

Rajendra *et al* (1999) conducted a study on adoption of rice production technology during the kharif season of 1997 in 8 villages of 4 tehsils of Balaghat district. Results indicated that the adoption of scientific rice production technology in Balaghat was low. 95% of farmers in the district were not using improved varieties; 89% of farmers were not practicing seed treatment; 67% of farmers were transplanting rice in the late season (in August). No farmers were using recommended doses of fertilizer and 24% were only using FYM. 88% of farmers had adopted the transplanting method of rice cultivation. Only 7% were using balanced fertilizer, 73% of farmers using nitrogenous fertilizer only. About 70% had adopted chemical control of insect pests. 32% of farmers were getting

technical information from other farmers, 6% from Krishi Vigyan Kendra and 26% were not receiving any technical information. 41% of farmers had cited a lack of resources as the main reason for non-adoption of improved production technology.

Singh (1999) evaluated the effect of change in rice production technology on functional income distribution and determined the extent of change in the effects of factor specific technical bias on functional income distribution. He determined the nature and magnitude of biases of the change in technology of rice production from local varieties (LVs) to high-yielding varieties (HYVs) toward inputs used in different sizes of own and operational holdings. The study was conducted in Thoubal district of Manipur state during the year 1991-92. Based on Hicks' analytical model to evaluate the effects of technical change on functional income distribution, the analysis revealed that the new agricultural technology introduced in Manipur had been biased towards the use of labour and fertilizer and towards the saving of pesticide and insecticide in own holdings. Technical bias with respect to land was neutral and its estimated factor share remained unaltered under new technology.

Upendra (1999) studied that per ha cost of cultivation (cost C) was more for irrigated soils (Rs 8735.27) followed by rainfed lowland (Rs 6407.14), rainfed upland (Rs 6386.68) and deep water (Rs 3652.05). Per hectare net return was also comparatively higher in an irrigated rice ecosystem (Rs 3270.13) followed by rainfed upland rice (Rs 1424.42), rainfed lowland rice (Rs 521.56) and deep water (Rs 471.35). The average per tonne cost of production of rice was Rs 1898.2, Rs 2266.6, Rs 1601.1 and Rs 2202.5 under rainfed upland, rainfed lowland, irrigated and deep-water situations, respectively.

Katyal *et al* (1999) studied on-farm rice production trials in 25 villages in each year from 1990-93, making a total of 100 trials on irrigated kharif [monsoon] rice in about 100 villages in Samastipur, Bihar. Treatments included local

practices and cultivars, improved cultivars, and recommended NPK fertilizer application. Data on yields, sustainability index, cost benefit analysis and risk analysis were tabulated. Use of improved practices, cultivar and NPK application gave the highest yield, returns and profitability and the lowest risk.

Woo (1999) analyzed the economic impacts of alternative rice policy adjustments upon the rice market and the input structure of rice production in Taiwan. An econometric model was constructed to analyse the behaviour of rice supply and demand. The econometric rice model was then used to perform policy simulation analyses and evaluate the economic impacts of alternative policy scenarios. According to the empirical analysis results, the negative impacts on domestic rice production under trade liberalization could be less significant if the current government purchase programme for rice persists; but if the goal of policy adjustments is to pursue a higher level of total social welfare, it was recommended that the quantities of government purchases be reduced gradually; moreover, while minimized weighted impacts on interested groups is desired, optimal control techniques could be adopted to estimate the optimal quantities of government purchase, stocks.

Pandey (1999) argued that fine-tuning of policy and institutional innovations are important in further increasing rice yields and farmers' incomes. In the more intensive irrigated areas, where chemical fertilizer use was already high, a change in the paradigm from that of encouraging higher input use to achieving increased input-use efficiency was suggested.

Hanumarangaiah (1999) conducted a study in three taluks of Mandya district in Karnataka State to identify factors influencing the productivity [yield/unit area] of rice production (n=300, 1992/93). The 24 variables selected were classified into personal, motivational, behavioral, situational and extension participation factors. They pointed out significant variables responsible for

variations in productivity. Taken together, the 24 variables accounted for 74.38% of the variation in productivity.

Dante *et al* (2000) described the impact on the economic conditions of agriculture (in particular for rice production and trade) and on the fertilizer markets (fertilizer prices and consumption) of Indonesia, Malaysia, Philippines and Thailand during the economic crisis in 1997. Government agricultural policy initiatives focusing on food security and adequate resources to help farmers consume agricultural inputs were examined. The lessons learned from these experiences were: renewal of commitment and support was needed for sustainable agricultural development; the active participation of the private sector was imperative for food security and increased competitiveness under globalization; and precautions should be taken by the government in controlling the production and marketing of agricultural commodities through liberalization of agricultural markets that may result in low productivity and poor farm profitability.

Peng (2000) analyzed the efficiency of the use of chemical fertilizers in rice production in Xiantao, Hubei Province, China, using data for fertilizer use and other aspects of production collected in early 1998. The analysis included consideration of the fertilizer use and its efficiency but also included other aspects of production such as disease control, production costs, the introduction of new cultivars and yields. The distribution efficiency of chemical fertilizers was discussed.

Yang and Yang (2000) presented a discussion of the state of mechanization of rice (Oryza sativa) production in China. The prevailing level of mechanization was compared to that of other staple crops in China and particular problems highlighted. Efforts to increase the level of mechanization in double cropped rice, transplant production and the greater use of small-scale harvesters and processing machinery were described. The paper concluded with a discussion of the shorter-

term development of various aspects of mechanization in the rice producing industries.

Tian (2000) discussed changes in rice production patterns in China during the period 1978-95 and the factors affecting rice production. Results of the modelling of the relocation of rice production suggested that the adjustment of rice production during the reform period had been consistent with economic principles. Rice area had declined more rapidly in prosperous regions than in backward provinces. It was suggested that economic factors should be regarded as important determinants for the fluctuations and trends in rice production during the reform period. Important implications for policymaking were also discussed.

Kako *et al* (2000) investigated the process and prevailing situation of grain production in Heilongjiang Province, which was one of China's most important food supply bases, and discussed the province's future potential, focusing on rice production. Reflecting heightening demand, rice production had been rapidly increasing in Heilongjiang since the mid-1980s. The discussion looked at the development process of the rice industry in relation to both decentralization and marketization trends in China, while at the same time examined the prevailing situation and challenging issues faced by rice growers regarding production and distribution, and then offered suggestions about how policy could be improved in the future.

Hwang (2000) attempted to clarify two important aspects of rice trade faced by Taiwan when considering the necessary adjustments on food policy mechanisms. First, the reliability of rice export suppliers to meet both food security and consumer interests was assessed. Second, the potential rice imports to Taiwan were of serious concern for maintaining the future competitive position of domestic rice production. Two important rice import possibilities were considered as essential to Taiwan's rice supply control programme as well as to the level of food security. A theoretical model of import demand allocation was presented,

which allowed the derivation of empirical estimation and hypothesis tests. The estimation results for the major groups of rice import sources into Hong Kong and Singapore markets were presented, and their implications for food policy adjustments in Taiwan were discussed. It was concluded that reducing self-sufficiency was relatively safe with reliable export suppliers of rice and the promotion of high-quality rice production.

Kono and Somarathna (2000) carried out a study in a village of the dry zone during the 1997 and 1998 dry season (Yala season) to explore the possibility of crop diversification in paddy fields and to investigate the impact of pump irrigation on crop diversification. The study also investigated the existing traditional water management customs (Bethma) in the context of crop diversification. Statistical analysis showed that pump irrigation had had a significant impact on crop diversification in paddy lands. It had also influenced traditional water management customs of the village. Bethma customs were gradually changing and pump owning farmers were beginning to neglect traditional water management customs. The resulting heavy withdrawal of groundwater could cause serious problems that may threaten agricultural productivity in the future. Consequently emphasis was needed that new rules and regulations on water management should be established by both the government and farmers, and should be implemented as soon as possible.

Kundu and Kato (2000) presented an investigation into the extent of land infrastructure development and its effect upon rice production in terms of productivity and profitability with particular reference to the north west area of Bangladesh. The nature and extent of changes in land productivity in Bangladesh were determined and factors causing such changes were considered.

Tado (2000) studied that the current mechanization level of rice production in the Philippines was unsatisfactory. Lowering production costs was necessary to compete with neighbouring countries. Supportive government measures were the

goal in modernizing agriculture and improving the quality of life for the rural population. Besides increasing yields and reducing post harvest losses, innovations in rice production mechanization could act as a catalyst for rural areas. These developments must consider social and economic backgrounds, and nowadays, last but not least, environmental protection.

Imolehin and Wada (2000) highlighted problems that may help to explain the imbalance between rice production and consumption. They suggested areas of improvement that would boost local rice production to meet domestic demand. Prospects for increased rice production in Nigeria were discussed with regard to rice production ecologies and their potentials. Trends in rice production, imports and consumption during the 1980s and 1990s were described. Varietal improvement was discussed and informations were provided on the characteristics of recommended varieties and germplasm collection and conservation. Farmers had identified a number of constraints as limiting to rice production efforts. Those were discussed in the areas of: research; pest and disease management; soil fertility management; unavailability of simple and cheap farm implements; access to institutional and infrastructural support credit facilities; inadequate input delivery, marketing channels, irrigation facilities and extension services. Addressing these problems was a good first step towards attaining the target of rice self-sufficiency.

Gaytancioglu and Surek (2000) examined the use of inputs and determination production costs at farmer level in three rice growing regions in Turkey (n=294, 1996). Results showed seed, fertilizer, herbicide, labour and machinery use and credit requirement. Rice production costs were calculated by region. Further information was provided on rice marketing, reasons for growing rice, and problems faced in rice cultivation. The study found that there were great differences among the regions in terms of fertilizer use. In general, farmers applied nitrogen in excessive dosages, far in excess of the recommended rate. They also

used high rates of herbicides. Rice production was more costly than for many other crops, so the majority of rice farmers needed credit. Machinery was not used as widely in rice cultivation as for other crops. South Marmara region had the cheapest rice production cost ($0.30/kg) followed by Thrace and the Black Sea regions at $0.33/kg. Because of low grain yield per ha, the most expensive production cost was found in southeastern Anatolia.

Singh (2000) analyzed reasons for lower yields in farmers' fields compared with the potential yield levels realized at different research stations. Three types of yield gaps had been identified and analyzed: 1. Yield gap due to technology dilution from one production station (experimental plots, crop farms, demonstrations and farmers' fields) to another, 2. Technological gap within rice production stations and 3. Estimation gap. Experimental-cum-Survey data for the year 1988-89 obtained from diverse sources were used. Primary analysis of mean yields gave evidence of yield differentials for rice crops under upland and medium/lowlands between experimental plots, crop farm, demonstrations and farmers' fields. Maximum yield per hectare was observed on experimental plots on both types of land. Results of gap analysis indicated that a considerable gap exists due to technology dilution from one production station to another, particularly between experimental plots and farmers' fields. A significant gap in rice yield was due to differential adoption of technology on all rice production stations. Also, there was considerable reporting bias in rice productivity. It was suggested that efforts should be made by agricultural scientists and extension workers to minimize the observed yield gaps between the research farms and farmers' fields and demonstrations & farmers' fields, since those gaps were important to farmers. The yield obtained at experimental plots was generally not realizable by farmers. It was also suggested that agricultural strategies should be aimed at the proper utilization of resources along with transfer of technology in order to reduce the observed gaps and ultimately raise the yield levels of rice under rainfed situations.

Cheng and Cheng (2000) reviewed the extension to farmers of new rice technologies in China in the twentieth century. Since 1949, 80% of the increase in rice production had been attributable to the introduction of new technologies through an extension framework, which stretches from the national level through provincial and county levels to the village and includes agriculture and agricultural engineering departments, relevant research institutions and educational establishments. The roles of the extension services (including promoting the commercialization of transplant production, promoting new cultivation techniques, and the promotion of more diverse methods of extension) were summarized. Future requirements, developments and opportunities for extension were also discussed.

Fan and Fan (2000) estimated empirically the effects of technological change, technical and allocative efficiency improvement in Chinese agriculture during the reform period (1980-93). The results revealed that the first phase rural reforms (1979-84), which focused on the decentralization of the production system, had had significant impact on technical efficiency but not allocative efficiency. However, during the second phase reforms, which were supposed to focus on the liberalization of rural markets, technical efficiency improved very little and allocative efficiency had increased only slightly.

Ahloowalia (2000) addressed the problem of matching rice production to population growth through the further combinations of old and new plant breeding technologies. Targets at IRRI, Philippines, were: to increase rice grain yields to 15 t/ha; to improve the nutrient content and quality of rice; and to incorporate pest and disease resistance in new rice varieties. Achieving these targets will require novel genetic modification technology without radically altering the rice crop or the ecology where it is grown. A major development achieved by Swiss scientists had been the genetically engineered incorporation of provitamin A and iron into

rice, which was of potential benefit to the 800 million people in poor communities who were malnourished.

Alvarez and Datnoff (2001) described and quantified the beneficial effects of silicon fertilization on rice culture in numerous literature citations. They included yield increase, improved disease, insect and fertility management, and other benefits. Despite the scientific evidence, widespread silicon use was hindered by the high cost of the material and its application. The beneficial effects of silicon application on world rice production had been translated to monetary values using a yield and cost-price structure in the Everglades Agricultural Area of southern Florida, USA, and later changed to reflect conditions in other countries. Consequently, land would be liberated for the production of non-traditional, export-oriented crops. The additional benefits from silicon application may outweigh its cost in most rice-producing countries.

Islam and Molla (2001) conducted the study at the Bangladesh Rice Research Institute Regional Station, Comilla, during three rice-growing seasons. The experiment was consisted of six weeding treatments with three replications. The objective of the experiment was to determine an economic weeding method as well as to improve water management practices of paddy rice. The study indicated that the continuous ponding (100-150 mm) was not effective for weed control and high yield. Similarly, continuous ponding of 30-70 mm with one hand weeding was not economically sound. Two-hand weeding or one hand weeding plus herbicides could be recommended where labour was available. Otherwise only herbicides should be used to make weeding economic for profitable rice production. The study revealed that continuous ponding required about 1.5-2.0 times more water than intermittent irrigation.

Xue Zheng (2001) evaluated factors affecting rice yield per unit area in Shanghai during 1990-98. The major factors increasing rice yield were summarized as follows: modern rice cultivation techniques, new elite rice varieties

roduced through successful selection and breeding, a wheat-rice double cropping ystem with single-cropping late rice as the main crop (reducing adverse weather ffects on rice production), investment in farmland water conservation projects, nd raising the positivity of peasantry in planting grain crops by increasing the rice urchasing price and financial subsidy for rice purchasing.

Haq *et al* (2002) conducted a study in Shigar valley of Baltistan area to nvestigate the relationship of farm size and input use and its effect on production nd gross and net incomes of potato. Cobb-Douglas type of production function echnique was used to find out the contribution of each input towards output while ummy variable approach was used to compare the level of input used, cost of nputs, gross and net margins of the enterprise. Seed farmyard manure, nitrophos nd labors were the factors significantly contributed towards output. Among all he inputs, significantly contributing towards the output, labor is the more output lastic resource. Furthermore, among the farm size categories, the input use by nedium farms was significantly higher than large and small ones. Their output evel and form incomes too were higher than small and large farms. The analysis ndicated that medium forms were the most efficient in potato farming in the area.

Tey *et al* (2008) estimated the demand elasticities of rice in Malaysia, ocusing whether rice is an inferior good. By using data from Household Expenditure Survey 2004/2005, this study obtains demand elasticities of rice, as well as for other 11 food items via Linear Approximate Almost Ideal Demand System (LA/AIDS) and Quadratic Almost Ideal Demand System (QUAIDS). The mpirical results indicate that income elasticity of demand for rice (0.7104) is the ighest compared to other food items in the LA/AIDS model, while income lasticity of demand for wheat (0.5087) is higher than rice (0.4712). Both of the ncome elasticities of demand for rice suggest that rice is not an inferior good in Malaysia. However, by comparing both estimates of demand elasticities and

adjusted R^2s, the QUAIDS model provides more plausible results than the LA/AIDS model.

2.3 Literature on the Economics of Wheat Crop

Azhar and Ghafoor (1988) carried out a study of the effect of education on technical efficiency for four major crops in Pakistan. The crops considered were the high yielding varieties of wheat and rice and the two traditional crops in Pakistan, namely cotton and sugar. An engineering production function were estimated using the 1976/77 cross-sectional data for the entire irrigated region. A modified Cobb-Douglas function combined land, labour and intermediate inputs with farmer's education introduced as a shift variable. The least square estimates suggested that the effects on output of cross-farm variations in labour use were not significant; and that education became important only when the possibility of drawing from historical knowledge was remote, as was the case with Green Revolution crops.

Akhtar (1988) conducted a survey of wheat production in the district of Multan, Pakistan Punjab, in the 1984/85 seasons. The survey identified major factors limiting wheat productivity and the profitability of low and high-yielding wheat technologies in the cotton zone of the Punjab. Policy implications were identified for agricultural extension and research. Multan is one of the Punjab's leading cotton growing areas and 150 randomly selected farmers were involved in the study. Questions were posed regarding planting time, land preparation, fertilizer usage, irrigation and previous crops in specific fields. The main factors responsible for differences in wheat productivity were use of phosphorus fertilizers, certified seed and the planting of wheat after cotton cultivation. The net returns of low and average yielding fields barely covered variable costs and the net returns in high yielding fields were positive. Results emphasize the importance of cost-reducing technologies if wheat is to compete with alternative crops such as sunflowers, soyabeans and spring maize. Farmers in cotton areas normally obtain

average wheat yields of 2.5 t/ha but the average yield was 2.2 t/ha in 1984/85, which was a poor year. However, the feasible economic yields for the area were 3.5 t/ha. This implies a yield gap of some 30% to be filled by the application of known technologies. Developing appropriate recommendations for more homogeneous groups of farmers can reduce this gap. Recommendations should be based on crop rotations, access to irrigation water and the distribution of newer high yielding wheat varieties.

Bayri (1989) studied the effects of high-yielding wheat technology on functional income distribution in the spring wheat region of Turkey. The empirical model was used to test factor neutrality and to measure the biases of HYV wheat technology. The results showed that technical change in the region had favoured wheat in production and exhibited labour-saving and fertilizer-using biases. The labour-saving bias was contradictory to the general conviction that through greater needs for water control, threshing and harvesting HYV, technology would increase the demand for labour. Two explanations for this were offered: (1) HYV technology had favoured wheat to other crops in production. This implied a shift from producing labour-intensive crops such as tobacco and cotton to wheat; and (2) the demand for labour may be increasing without changing the real wage rate because the supply of labour in rural areas was ample. The real wage bill may be rising more slowly than returns to fixed factors, particularly land. These results were a typical example of the positive impacts of HYV technology on labour demand being offset by the high rate of population growth.

Hussain (1989) made an attempt to study the influence of the introduction of high yielding varieties of rice and wheat on cropping structure and crop combinations in India and the implications for large, medium and marginal farmers. An attempt was also made to assess the trend in Indian farming for a move towards market orientation. It was suggested that the introduction of high yielding varieties of wheat and rice had transformed the traditional subsistence

agriculture into a market-oriented sector and promoted monocultural practices. The production of staple cereals had improved but social tension had increased due to widening income disparity.

Vlasak (1990) studied in trials in 1984-85, 1985-87 and 1987-88 at the Research Institute of Plant Production in Ruzyne of 58 local and foreign varieties, Czech varieties Regina and Zdar consistently outyielded the foreign varieties (which attained the average yields of the Czech varieties only in some cases). High productivity combined with good quality was shown by Apollo (German Federal Republic), Gala (France) and Brokat (Austria). High fodder yields were produced by General, Granit and Jaguar (German Federal Republic) and Bert, Galahad, Gawain, Mercia and Rendezvous (UK). Data on plant height, 1000-grain weight, growth period, wet gluten content, gluten swelling and baking quality were tabulated.

Singh and Byerlee (1990) analyzed wheat yield variability in light of recent concern that rapid technological change had caused increased instability in world cereal production. The coefficient of variation of wheat yields was estimated for 57 countries from detrended data for various periods between 1951 and 1986. The coefficient of variation in wheat yields is shown to be determined by country size, moisture regime and temperature. Technological variables, such as level of adoption of high-yielding varieties and fertilizer dose, had no effect on difference in yield variability across countries. Analysis of yield variability for the same set of countries for three periods from 1951 to 1986 shows a general decline in yield variability since 1975 in developing countries. Analysis of wheat yield variability in India at the state and district levels confirms the analysis of country level data. The coefficient of variability of wheat yields in India in the period 1976-85 has fallen to less than half the level in the 1950s and this decline is statistically significant.

Tripathi (1993) examined the economics of high yielding variety (HYV) wheat cultivation for three farm size groups for middle hill and valley farms in Tehri Garhwal district, Uttar Pradesh, India. Data were collected from a sample of 120 farms for 1987/88. The average operational cost was Rs 2431/ha for middle-hills farms and Rs 2506/ha on valley farms. Bullock labour accounted for the highest percentage of operational cost followed by manure, fertilizer and seeds. The use of plant protection measures was not common. Human labour accounted for 34% and 29% of the total costs on middle-hill and valley farms, respectively. Net returns and the input-output ratio were highest for the large size group both for middle-hill and valley areas. All the input factors, except manure, showed a positive and highly significant impact on crop yield in valley areas, but no factor showed a significant influence in the middle-hills.

Krystof (1994) studied that the standard variety Viginta gave the highest grain yield (1037 g/m2). Stability was high for plant height and 1000-grain weight, while there was wide variability for grain weight and grain number/ear. Prjaspa had high values for 1000-grain weight and grain number/ear. Italian varieties were characterized by moderate to low 1000-grain weight but high grain number/ear. They had low winter hardiness, especially in one of the 3 years of the tests (1991). Lodging resistance in the varieties tested was seen to depend not only on straw length and stiffness but also on the root system. Midearly to midlate varieties gave highest yields; these included the Czech varieties Regina and Viginta. The varieties Florin, Mironovskaya 90, MV16-85, Berlioz and Real showed high yield potential on the basis of number of grains/ear and large grains.

Sharma and Bala (1994) examined trends in India's food grain production and consumption; decomposed the total yield increase into a yield effect and cropping pattern effect; investigated factors affecting food grain production; and forecasted future scenarios and presented policy implications. The study covered rice, wheat, coarse cereals and pulses for the period 1951/52-1988/89. Fertilizer

use and irrigation were important factors accounting for variations in yield levels, while the effect of high yielding varieties was not significant.

Tripathi (1995) presented results of a comparative study of performance of local and high yielding varieties (HYV) of wheat in the rainfed hills of India. The production costs for HYV were between 7-18% higher than for local wheat. Use of fertilizers and hired labour was also considerably higher. HYV showed poor performance in terms of net returns although gross returns were higher. The influence of fertilizer use on HYV returns was significant: the cultivation of HYV wheat can be made viable in hill farms through increased and balanced fertilizer use.

Roy and Talukder (1995) analyzed the relative economic performance of a potato- and a wheat-based cropping pattern in the Chandina Thana, Comilla District, Bangladesh. Two villages were studied which practised the cropping patterns of potato-Boro-T. Aman and wheat-T. Aus-T. Aman (Boro, Aman and Aus are varieties of rice planted in different seasons). A total of 40 farmers (20 from each cropping pattern) were surveyed during the crop year 1992/93. Total gross return per hectare from the potato cropping pattern was about twice that of the wheat cropping pattern.Profitability analysis of individual crops can be helpful in short run decision making but over the longer run account needs to be made for the profitability of crop combinations and rotations on specific plots of land in specific areas.

Barkley and Porter (1996) used regression analysis to quantify the relationship between planted varieties and wheat characteristics relating to production and end-use qualities. Results indicated that Kansas wheat producers consider end-use qualities, production characteristics, relative yields, yield stability, and past production decisions when selecting wheat varieties. Simulation results revealed potential tradeoffs facing wheat breeders and seed dealers. Time

paths of adoption are projected for potential improvements in wheat yields and quality characteristics.

Maredia (1996) employed an econometric approach using international and national yield trial data to estimate a spillover matrix for wheat varietal technology. The global spillover matrix was estimated based on international yield trial data from 1979-80 to 1987-88, that include 195 international trial locations and 209 wheat varieties. The locations were classified across countries using the CIMMYT's wheat megaenvironment system and varieties were classified by both their environmental and institutional origin. The model gave good explanatory power and confirmed the location specificity hypothesis, at least, for the varieties developed by national programmes (NARS). The spillover matrix shows that NARS varieties developed in the `home' environment generally perform better on average than varieties developed in other megaenvironments. The country-level analysis, however, indicated that CIMMYT germplasm did not did so well in some sub-environments, such as the irrigated short-duration environment. The results of the spillover matrix had implications for the design of crop breeding programmes both at the national and international levels.

Backman (1997) estimated three physical production functions, the quadratic, the linear response and plateau (LRP) and the exponential function. The models differed little in respect of the R2adj value (0.82-0.90) but the calculated optimum varied, depending on the production function. Data on a long-term field trial (21 years) were analyzed. The field trial was established in 1973 to demonstrate the effect of mineral fertilizer in crop production. The crops grown in the trial were barley, wheat and oats. Different varieties were included in the models.

Rost and Walther (1997) evaluated the results of the regional variety testing stations in Saxony-Anhalt obtained for winter wheat. As the process variable, the output not related to direct costs was chosen. The managerial analysis of the

variety test elucidated the importance of variety selection according to market situation and site conditions. If cropping was practised under conditions allowing no or only limited use of plant protection agents, only resistant varieties should be cultivated. The results demonstrated that a correct variety choice results in considerably higher production output free of direct costs.

Hartell (1997) made a study using the data on wheat production in the Punjab of Pakistan from 1979 to 1985 to examine patterns of varietal diversity in farmers' fields both at the regional and district levels and identify how and in what ways genetic resources had contributed to wheat productivity and yield stability. Five indicators were used to describe the system of wheat genetic resource use and diversity in farmers' fields. The contribution of farmers' previous selections is expressed as the number of different landraces appearing in the pedigree of a cultivar. Econometric results suggested that greater genealogical dissimilarity and higher rates of varietal replacement were likely to have positive pay-offs relative to aggregate yield stability, while in areas where production constraints inhibit farmers' ability to exploit the yield potential of their varieties, better production management was likely to have greater yield enhancing effects than the varietal attributes related to diversity.

Rejesus (1999) investigated sources of yield growth in wheat based on a stylized framework of technical change. Evidence suggested that the relative contribution of input intensification to yield growth had diminished in recent years and was likely to continue to decline in the future. One potential source of yield growth in wheat during the medium to long term was improved efficiency of input use, rather than input intensification, through sustainable wheat production practices rather than pure input increases. Other large gains could be made with continuous adoption of newer and better modern varieties based on advances in wheat breeding. Wide crossing and biotechnology could improve the stability of wheat yields in the intermediate term; their long-term impact on yield under

optimal conditions is less certain. World wheat demand was likely to grow more slowly over the next 30 years than it did in the past 30 years. At the same time, a wider variety of technological options will need to be tapped over the next three decades to achieve the necessary gains in wheat yields. Research costs per unit of increased wheat production were likely to be somewhat higher. Nonetheless, continued investment in wheat research was necessary to achieve production levels consistent with constant or slowly declining real world wheat prices.

Patras (1999) presented some production results from different farm types in order to outline the production potential and economic efficiency of different wheat varieties, maize and sunflower hybrids, under different conditions. A gap between households, in comparison with agricultural and trade societies was noted. Yield increases, which resulted after the use of crop rotation, fertilization, herbicide application, phytosanitary treatment application at the optimal time and high quality seed, were evident. With support from the Podu-Iloaiei Agricultural Research Station and from well-organized production units, demonstrative plots were set up for testing the agri-productive capacity of some wheat varieties and zoned maize hybrids. To ease the transfer of technical progress to farms, the paper considered it necessary to increase farm size to 30-50 ha, through land transfers or associations of landowners. It was argued that the State should support the formation of viable farms through e.g. cheap credit, and guaranteed prices.

Pandey (1999) conducted an experiment in Bihar, India during the 1993-95 rabi seasons to study the response of wheat cultivars K 8804, UP 262 and HUW 206 to seed rates (100, 150 and 200 kg/ha) and fertilizer levels (50% of the recommended rate of fertilizers; 100% of the recommended rate of fertilizers (100 kg N, 50 kg P and 25 kg K/ha) and 150% of the recommended rate of fertilizers). Wheat cultivars were at par in terms of grain and straw yields, protein content, economics and nutrient uptake. Yield-attributing characters, except effective tillers, were unaffected by seed rates. Grain yield, straw yield, net return and net

return per rupee invested increased significantly up to the seed rate of 150 kg/ha. Further increase in seed rate failed to produce any significant effect on these parameters. Treatment with 100% of the recommended rate of fertilizers significantly increased all yield-attributing indices, grain yield, straw yield and protein content in grain. The highest grain (41.93 and 43.57 q/ha) and straw (73.57 and 74.44 q/ha) yields were obtained upon treatment with 150% of the recommended rate of fertilizers for both years. Application of 150% of the recommended rate of fertilizers recorded significantly higher effective tillers, net return and nutrient uptake than the lower levels of fertilizers. However, the net return per rupee spent that resulted from the recommended rate and that from the 150% more than the recommended rate of fertilizers were at par. Seed rates had no effect on wheat protein content and nutrient uptake.

Gamba (1999) studied the best known wheat varieties by both small-scale and large-scale farmers were Mbuni, Nyangumi, Fahari, Kwale and Tembo, while Mbuni and Kwale were the varieties most widely grown. The recent varieties such as Duma, Mbege, and Ngamia were hardly known/grown by farmers reflecting the lack of seed of the new wheat varieties. The main sources of wheat seed (old and new) for both the small-scale and large-scale farmers were other farmers. Farmers' wheat seed management practices were on the whole similar between the small-scale and large-scale farmers. But significantly more large-scale farmers had separate fields for seed, selected seed at harvest and stored seed separately than did the small-scale farmers. The adoption of new wheat varieties was significantly higher in the high potential zone, in Uasin Gishu District and by large-scale farmers than in the low potential zone, in Nakuru/Narok districts and by small-scale farmers. The logit model showed that household size and seed retention period had a negative impact on adoption of new wheat varieties whereas farm size, commercial wheat price, years in wheat farming and seed selection had a positive impact.

Negatu (1999) analyzed to assess the impact of improved wheat varieties and their recommended fertilizer rate on small farmers' food status. The analysis was based on the primary data collected in 1995 from 192 farmers in two woredas in the central highlands of Ethiopia. The annual production of cereals, pulses and oilseed crops (all field crops) grown by the sample farmers were used to measure the food status of the households. This was done by comparing the total grain food production in calories with the recommended calorie consumption of 243 kg of cereal-equivalent per adult annually. The association of farmers' food status with the adoption of ET-13 wheat variety in Moretna-Jiru woreda and Israel wheat variety in Gimbichu woreda, and the use of their recommended fertilizer rate was analysed employing bivariate statistics. The analysis showed that food status of farm households in Moretna-Jiru was significantly associated with the adoption of ET-13, while in Gimbichu the association of the adoption of Israel with food status was not significant. In both woredas the users of the recommended fertilizer rate had significantly higher food status than the nonusers.

Kotu (1999) conducted a survey of 144 small-scale wheat farmers in Adaba and Dodola woredas of Bale highlands in Ethiopia. to determine the technical and socioeconomic factors affecting adoption of improved wheat technologies. About 42% of the farmers grew improved wheat varieties. The adopters (92%) applied significantly more chemical fertilizer than the nonadopters (72%). The adopters applied about 75 kg/ha of DAP and 36 kg/ha of urea, while the nonadopters applied about 48 kg/ha of DAP and 6 kg/ha of urea. The logistic regression model showed that credit for buying improved seeds and livestock ownership had positive and significant effects on probability of adopting improved wheat varieties. Credit for buying fertilizer, area under linseed, and use of hired labour significantly influenced farmers' decision to use fertilizer.

Hailye (1999) survey 200 farmers in Enebssie area. Zembolel (87%) and Enkoy (91%) were the wheat varieties mostly known in the intermediate and

highland zones, respectively. The most common source of wheat seed planted in the intermediate zone (57%) was seed from other farmers, 25% of the farmers retained seed from the previous year's grain crop, and 14% of the farmers purchased their seed from the local market. About 40% of the farmers in the highland zone got their seed from other farmers, 34% of the farmers retained seed from the previous year's grain crop, and 22% of the farmers purchased their seed from the local market. When farmers first obtained seed of new varieties, the most common source was other farmers in the intermediate zone (47%) and MOA (33%), while in the highland zone it was the local market (40%) or other farmers (38%). The farmers who retained their own seed sought to ensure its purity by cleaning it at planting, and storing the seed separately from the wheat grain used for consumption in a local container. The weighted average age of varietal turnover was about 11 years. This indicates the need to strengthen wheat breeding, extension service, formal seed production and distribution. With regard to seed policy it is important to note that farmer-to-farmer seed transfer remains the major means of diffusing seed.

Soni (2000) conducted a study of the impact of improved wheat production technology, including high yielding varieties with cultural practices, in Sagar district, Madhya Pradesh, India. Yield, input level and net return were compared for three technology options: (i) full package: national front line demonstration plots (FLD); (ii) progressive farming (adjacent plots of FLD participating farmers); and (iii) traditional farming (farmers in FLD villages). Data relate to the years 1993/94, 1994/95 and 1995/96. Demonstration fields produced significantly higher yields than the farmers' practices. Farmers harvested 29.81q/ha and 14.17 q/ha under irrigated and unirrigated conditions, respectively, with the traditional system of cultivation. The progressive farmers harvested 20% higher yield than the traditional system. However, farmers adopting advanced technology had 61.92%-76.07% higher yield as compared to the traditional system. The study

concludes that the investment in modern technologies proportionately enhanced output and net income.

Aklilu (2000) compared three promising bread wheat (Triticum aestivum) genotypes with two released check varieties by farmers' research groups using both researcher and farmer-selected crop management practices. Mean grain yields for the farmer- and researcher-managed plots were 1802 and 2148 kg/ha, respectively. One advanced line, HAR-2258, was high yielding and preferred by farmers on the basis of its crop stand, spike size, disease resistance, maturity class and crop uniformity. HAR-2258 and the check variety Abolla were both preferred by farmers for their quality in making staple food products. The improved crop management package for bread wheat was highly profitable for peasant farmers in N.W. Ethiopia: the researcher-managed production package increased wheat grain yields by an average of 19% across the four locations, and exhibited a marginal rate of return of 210% in comparison with the farmer-managed production practices.

Spink (2000) assessed the potential for reducing production costs in wheat, based on understanding how the crop grows and forms grain. The project assessed the value to the grower of choosing varieties according to their suitability to growing conditions, and then adjusting husbandry practices according to assessments of the crop's progress through the season. The total benefit from this approach was estimated to be pounds sterling 80-100 per hectare. The estimate was derived from four sub-projects: matching variety to sowing date; matching varieties and management to potential "finishing"; matching fungicide rate to crop nutrient status; and assessment of crop progress.

Ensermu and Hasana (2001) conducted a study in Chilalo area, southeastern Ethiopia, with the objective of explaining factors related to farmers' awareness and adoption of new wheat varieties. 18 peasant associations and 180 farmers were included in this study. The results indicate that the two stages of

variety adoption process (i.e., awareness and practical use) are influenced by different sets of factors. Human capital and information variables have more impact on creating awareness while the practical take up and use is influenced more by the nature of the location of the farm.

Qian *et al* (2009) conducted as study to forecast regional spring wheat (Triticum aestivum L.) yields on the Canadian Prairies, based on simulated daily water use and soil water contents derived from the National Drought Model. Empirical linear regression models were calibrated from 1976 to 2006 spring wheat yield data for this purpose.

2.4 Literature on the Economics of Maize Crop

Onstad and Guse (1999) studied that the same level of refuge for resistance management is used every year over 15-20 year and that no European corn borers immigrate into the region over the same period. When complete mixing across blocks between generations is assumed, the transgenic block significantly lowers damage to maize in the refuges. For most scenarios without toxin-titer decline during maize senescence, a 20% refuge is a robust, economical choice based on current value. At extremes of initial pest density or crop value (price × expected yield), refuge levels as low as 8% or as high as 26% can be superior. Nontransgenic maize can be planted as strips (at least 6 rows per strip) within a field or as separate but adjacent blocks to be effective at delaying resistance and providing economic returns at a 20% refuge level. With toxin-titer decline during senescence, the model results are sensitive to several biological parameters and assumptions with a 10% refuge level offering a robust, economic choice.

African Crop Science Society (1999) tested PREP-PAC, a soil fertility replenishment product specifically designed to ameliorate nutrient-depleted "patches" symptomatic of the worst maize-bean intercrops of smallholders' fields in western Kenya. PREP-PAC contains two kg Minjingu rock phosphate, 0.2 kg

urea, legume seed, rhizobial seed inoculant, seed adhesive and lime pellet, is assembled and is sold for Ksh. 42 (US $ 0.76) and is intended for 25 m^2 areas. PREP-PAC was tested on 52 farms in four districts of western Kenya during 1998 and compared with adjacent control plots. Farmers selected either a local bush or climbing variety (cv. Flora) of *Phaseolus vulgaris* as an intercrop with maize *(Zea mays)*. Use of the combined PREP-PAC and climbing bean package increased maize and bean yields by 0.72 and 0.25 t ha^{-1}, respectively ($P < 0.001$), resulting in a 161% return on investment. Total revenue from low pH soils (<5.2) was Ksh. 25 for the control and Ksh. 47 for PREP-PAC. In moderate soil pH >(5.3), total revenue was Ksh. 31 for control and Ksh. 68 for PREP-PAC ($P < 0.05$). Opportunity exists to distribute an affordable soil fertility restoration package among smallhold farmers but the profitability from its use is dependent upon soil conditions and accompanying legume intercrops.

Gustavo and Buckles (2002) compared the economics of the *abonera* maize production system, in which maize is grown in rotation with a green manure crop (velvetbean, *Mucuna deeringiana),* with traditional bush-fallow cultivation of maize in the Atlantic Coast area of Honduras. A probabilistic cost-benefit analysis of introducing velvetbean into the existing maize cropping pattern is carried out for the field, farm, and regional level. The probabilistic approach allows for a more comprehensive assessment of economic profitability, one which recognizes that farmers are interested in reducing production risk as well as obtaining increases in average net benefits. The analysis reveals that the *abonera* system provides significant returns to land and family labor over the six-year life cycle. The *abonera* is not only more profitable than the bush-fallow system but reduces the variability in economic returns, making second-season maize a less risky production alternative. Although the labor requirement per unit of land is smaller in the *abonera* system than that in the bush-fallow system, the larger area allocated to maize implies a net increase in labor requirements at the farm level. At the

regional level, widespread adoption of the *abonera* system appears to have increased the importance of the second season in total maize production. Although a causal link to adoption of the *abonera* system cannot be established conclusively from the data, adoption of the system remains a likely explanation for the changes observed in aggregate maize production in the Atlantic Coast region. Land rental prices for sowing second-season maize also reflect the widespread impact of the *abonera* system.

African Crop Science Society (2003) conducted experiments in western Kenya to determine the agronomic and economic benefits of applying Nitrogen (N) and Phosphorus (P) to maize. These factors were identified through an informal survey to be the main cause of low maize yield in the area. The experiments were conducted in 2 locations on farmers' fields in 1994,1995 and1996. Four levels of Nitrogen (0, 30, 60, 90-Kg ha-1) were combined with three levels of Phosphorus (0, 40, 80-Kg ha-1) to constitute twelve treatments which were tested on a randomized complete block design. Statistical analyses of yield data revealed that N application consistently affected grain yield significantly in all locations. Phosphorus had a significant effect on yield once in each location. There was significant nitrogen by phosphorus interaction (N*P) effects once in each location. Analysis across sites showed N and N*P interaction to be statistically significant. The statistically significant treatments of this experiment were subjected to economic analysis using the partial budget procedure to determine rates of N: P that would give acceptable returns at low risk to farmers. Economic analysis on the interaction across location showed that two N: P combinations i.e. 30:0 and 60: 40 kg ha-1 are economically superior and stable within a price variability range of 20%.

Andersen *et al* (2007) conducted experiments to study agro-ecological effects on the soil fauna and agro-economic implications of the technology. Bt-maize produced a higher grain yield and grain size than a near-isogenic non-Bt

variety or allowed a significant reduction in pesticide use. Concentrations of Cry1Ab in the Bt-varieties were sufficient to effectively control cornborer larvae.

Brookes (2007) studied that in maize growing regions affected by ECB and MSB, the primary impact of the adoption of Bt maize has been higher yields compared to conventional non genetically modified (GM) maize. Average yield benefits have often been +10% and sometimes higher; In 2006, users of Bt maize have, on average, earned additional income levels of between €65 and €141/ha. This is equal to an improvement in profitability of +12 to +21%; In certain regions, Bt maize has delivered important improvements in grain quality through significant reductions in the levels of mycotoxins found in the grain.

Wesseler *et al* (2007) observed that the EU-15 forgo several million Euros of net social benefits per year by postponing the introduction of Bt-maize, although this can be justified, if decision makers assume that the willingness-to-pay by household for not having those crops being introduced is about one Euro on average per year.

2.5 Summary

The aforementioned studies indicated different important aspects related to the economic analysis of food grain crops cultivation. The economics of rice cultivation including production analysis cost of input use and profitability of rice policies related to credit, mechanization, fertilizer and plant research were assessed. Inter-regional variations in the performance of paddy rice production and technological changes were explored. Econometric models were applied to assess per hectare input level and technical efficiency in rice production using time series as well as cross-sectional data. Cropping pattern under different climatic zones was observed. Constraints of rice production including credit problems, marketing problems, labor problems and tenancies of land were observed. The economic benefits of fertilization were identified. Besides, fluctuations in rice production, adoption of technology, varietal usage, rice marketing and factors influencing rice

productivity were studied. Efficiency of chemical fertilizer, state of mechanization, rice trade, consumption of rice, economic weeding methods and relationship of farm size and input use and its impact on rice productivity were analysed.

Focus has been made on the studies about factors limiting wheat productivity, performance of high yielding varieties, comparison of different wheat varieties, impact of recent technology on wheat production, determinants of wheat yield, impact of seasonal changes in wheat yield, economic analysis of different crops and the performance of national development strategies. In addition, Cobb-Douglas production function and regression analysis was also used to show the contribution of various inputs used.

Furthermore, studies were also conducted about the economic analysis of Transgenic Maize, on-farm evaluation of improved maize varieties, economic analysis of maize yield responses, economic analysis of Maize-Bean production, agricultural studies of genetically modified (GM) maize and the benefits of adopting genetically modified, insect resistant *bacillus thuringiensis* (Bt) maize.

2.6 Contribution of the Present Study

The present study is concerned with economic analysis of major staple food grain crops i.e. wheat, rice and maize in district Swat. Comparative analysis of the costs and revenue of different varieties of rice, wheat and maize has been made. Different pre and post harvest economic practices have been identified. Relationship between inputs and output of these crops has been analyzed using econometric techniques. The study establishes link between food grain crops' production and labour and capital employment, marketing, credit and financing, sources of income, consumption pattern and net-returns. Furthermore, causes of low yield per acre have been identified.

Chapter-3

DATA AND METHODOLOGY

3.1 Introduction

Data and methodology clearly depict the nature of the research to be carried out and provide tools to test the theories perceived. In this chapter information about nature, sources and collection of data, variables of the study, sampling procedure and analytical techniques are presented.

The study is confined to the economic analysis of major staple food grains crops i.e. wheat, rice and maize in three tehsils of district Swat namely Kabal, Matta and Barikot. The selected site was easily accessible and was situated on bank of river Swat where farmers mainly grow the selected staple food grains crops. Details about the data and methodology are given in the subsequent sections.

3.2 Nature of Data and Data Collection Procedure

The analysis is mostly based on primary data. However, to present facts and figures, secondary data on area and production of different food grain crops in Pakistan, NWFP and Swat have been documented from the following sources:

i. Agriculture Statistics of Pakistan (various issues)
ii. Economic Survey of Pakistan (various issues)
iii. District Census Report (1998)
iv. Mingora Agriculture Research Station, Takhta Band (Swat).
v. Cropping Reporting Services, Swat (2008)
vi. Internet World Wide Web, books and journals.

Primary data was collected from the respondents (farmers) through structured questionnaire (see appendix-B). The data was usually conducted in the farmer's fields, homes or in community centers (Hujras). Although the questionnaire was in English, yet a local language (Pashto) was used to collect the true information. The questionnaire was based on open and closed form questions about the following variables:

i. Per acre cost and revenue of different varieties of rice, wheat, and maize.

ii. Usage of various inputs of rice, wheat and maize mainly tractor hours, seed in maunds, fertilizer in bags, labour in man-days etc.

iii. Pre and post harvest economic practices in food grains production process.

iv. Labor and capital employment, marketing, sources of income, credit and financing, consumption pattern, decision-making, women participation and net-returns associated with food grains crops i.e. wheat, rice and maize.

v. Factors affecting per acre productivity in the study area and measures for its solution.

It is important to note that while compiling the data, all items have been valued at market prices of 2008.

3.3 Sampling Design

For area selection, sample size and its allocation, the following procedure was adopted:

3.3.1 Area Selection

Out of the total seven tehsils, three tehsils namely Kabal, Matta and Barikot have been selected on the basis of purposive sampling technique because these areas were easily accessible. Further, these thesils qualify most of the characteristics favorable for food grain crops cultivation. The selected areas are situated on the bank of River Swat, where food grains in general and particularly rice crop is grown extensively. From each tehsil three villages each were randomly selected. From Tehsil Kabal, the three villages were Akhunkalay, Hazara and Dagai. From Tehsil Barikot, Parai, Aboha and Kota were selected while from Tehsil Matta, the three selected villages were Asharai, Durashkhela and Baidara.

3.3.2 Sample Size and its Allocation

A sample of size two hundred farmers was used and is logical and enough to use because the villages were quite homogeneous in terms of land condition (field, soil type and irrigation sources), cropping pattern, population and farming activities. Sample size was allocated to these nine villages on the basis of proportional allocation method, using the following formula:

$$SS = n_i (N_i/N)$$

Where

SS = Total sample size used (i.e 200).

N_i = population of particular village.

N = total population of the nine villages.

Accordingly, 66, 68 and 66 respondents were selected from tehsil Kabal, Barikot and Matta respectively. In tehsil Kabal, 66 respondents comprised on 22, 23 and 21 respondents from villages Akhunkalay, Hazara and Dagai were selected respectively. In tehsil Barikot, 68 respondents were comprised on 23, 23 and 22 respondents from villages Parai, Aboha and Kota respectively. In Tehsil Matta, 66 respondents were selected, comprised on 23, 21 and 22 respondents from Ashari, Dureshkhela and Baidara were selected respectively. Further, the respondents (farmers) have been selected randomly from each village, because the farmers possessed homogenous farming and socioeconomic condition.

3.4 Analytical Tools

For the analysis of the data, various techniques have been used. The details of the techniques are given as under:

3.4.1 Computation of Benefit-Cost Ratios (BCRs)

This is an easy technique to compare the cost and revenue of different crop varieties at a glance and is widely used (Ahmad, *et al*, 2005) and (Santha, 1993). For each of the three crops Benefit Cost Ratios have been calculated using the following formulas:

Benefit Cost Ratio for rice varieties = TRR / TCR ---------- eq. 3.1

Where TRR is the per acre total revenue in rupees generated from variety of rice and TCR is the total per acre cost in rupees of rice variety.

Benefit Cost Ratio for wheat varieties = TRW / TCW ---------- eq. 3.2

Where TRW is the per acre total revenue in rupees generated from variety of wheat and TCW is the total per acre cost in rupees of wheat variety.

Benefit Cost Ratio for maize varieties = TRM / TCM ---------- eq. 3.3

Where TRM is the per acre total revenue in rupees generated from variety of maize and TCM is the total per acre cost in rupees of maize variety.

According to the economic theory, higher and higher the values of benefit cost ratios, higher will be the return to the farmers. The most profitable variety is the one, which possess highest benefit cost ratio as compared to all other varieties.

3.4.2 Estimation of Cobb-Douglas Production Functions

The Cobb-Douglas production function technique was used to find out the contribution of various inputs towards food grain output. This model is widely used in agriculture for determining the nature of returns to scale. The log-linear Cobb-Douglas production function was applied for the three crop i.e. wheat, rice and maize separately. This approach has been used by Raviksh *et al* (1997), Haq, *et al* (2002) and Khattak & Anwar (2006), while in present study modified form of these models has been used.

Three different log linear models for rice, wheat and maize have been estimated. In these models, the included explanatory variables are rice area, tractor hours, fertilizer, seed, labour and pesticides/insecticides. The economic theory suggests that all the included explanatory variables have substantial effect on the response variable. Further, the sign of these coefficients are expected to be positive.

Furthermore, to check the potential of the included regressors, the forward stepwise regression analysis has been carried out for each crop. The stepwise regression analysis helps us in the development of a model and to identify the potential explanatory variables in terms of their exclusion and inclusion in the model. In forward regression analysis, the potential variable can be identified by the highest coefficient of determiantion, as proposed by Hocking (1976), Draper & Smith (1981), Rencher & Pun (1980) and Copas (1983).

Details of the econometric models are as under:

3.4.2.1. Estimation of Log Linear Cobb-Douglas Production Function for Rice

To show the input-output relationship of rice crop, the following log-linear model was estimated using the Method of Least Square.

$$\ln RP = \ln a_0 + a_1 \ln RA + a_2 \ln TRHR + a_3 \ln FERTR + a_4 \ln SDR + a_5 \ln LABR + a_6 \ln PSTR + e_1 \quad \text{---------- eq. 3.4}$$

The above model was then converted to the following general form:

$$RP = a_0 \times RA^{a_1} \times TRHR^{a2} \times FERTR^{a_3} \times SDR^{a_4} \times LABR^{a_5} \times PSTR^{a_6} \quad \text{----- eq. 3.5}$$

Where

RP = Total paddy production in kgs

RA = Area under rice crop in acres

TRHR = Tractor hours for cultivated area of rice

FERTR= Total fertilizer used for cultivated area of rice (in bags)

SDR = Seed used for cultivated area of rice (in kgs)

LABR = Total Labour used for cultivated area of rice (in man days)

PSTR= Total pesticides/insecticides used for cultivated area of rice (in Rs.)

Where

a_0 = Shows the impact of innovations or technology.

a_1, a_2, a_3, a_4, a_5 and a_6 are the output elasticities of RA, TRHR, FERTR, SDR, LABR and PSTR respectively.

e_1 = The residual term (absorbs the effect of those variables, which are not included in the model).

The equations 3.4 and 3.5 indicate that the rice production (RP) is dependent variable while RA, TRHR, FERTR, SDR, LABR and PSTR are the explanatory variables. Irrigation cost has been excluded from the set of explanatory variables because it was available free of cost in the study area.

3.4.2.2. Estimation of Log Linear Wheat Cobb-Douglas Production Function

To show the input output relationship of wheat crop, the Method of Least Square was used to estimate the following log-linear model:

$$\ln WP = \ln b_0 + b_1 \ln WA + b_2 \ln TRHW + b_3 \ln FERTW + b_4 \ln SDW + b_5 \ln LABW + b_6 \ln PSTW + e_2 \quad \text{---------- eq. 3.6}$$

or in the most general form

$$WP = b_0 \times WA^{b1} \times TRHW^{b2} \times FERTW^{b3} \times SDW^{b4} \times LABW^{b5} \times PSTW^{b6} \quad \text{-------- eq. 3.7}$$

Where

WP = Total wheat production (in kgs)

WA = Area under wheat crop in acres

TRHW = Tractor hours for cultivated area of wheat

SDW = Seed in Kgs used for cultivated area of wheat

FERTW= Total fertilizer used for wheat (in bags)

LABW = Total Labour used for cultivated area of wheat (in man days)

PSTW= Total pesticides/insecticides used for cultivated area of wheat (in Rs.)

b_1, b_2, b_3, b_4, b_5 and b_6 are the output elasticities of WA, TRHW, FERTW, SDW, LABW and PSTW respectively.

b_0 = Shows the impact of innovations or technology.

e_2 = The residual term (absorbs the effect of those variables, which are not included in the model).

3.4.2.3. Estimation of Log Linear Maize Cobb-Douglas Production Function

For maize crop, the following model was estimated:

$$\ln MP = \ln c_0 + c_1 \ln MA + c_2 \ln TRHM + c_3 \ln FERTM + c_4 \ln SDM + c_5 \ln LABM + c_6 \ln PSTM + e_3 \quad \text{---------- eq. 3.8}$$

or the most convenient form:

$$MP = c_0 \times MA^{c_1} \times TRHM^{c_2} \times FERTM^{c_3} \times SDM^{c_4} \times LABM^{c_5} \times PSTM^{c_6} \quad \text{---- eq. 3.9}$$

Where

MP = Total maize production in kgs

MA = Area under maize crop in acres

TRHM = Tractor hours for cultivated area of maize

SDM = Seed in Kg used by sample farmers

FERTM= Total fertilizer used for maize (in bags)

LABM = Total Labour used for cultivated area of maize (in man days)

PSTM= Total pesticides/insecticides used for cultivated area of maize (in Rs.)

c_1 c_2 c_3 c_4 c_5 c_6 are the output elasticities of MA, TRHM, FERTM, SDM, LABM and PSTM respectively.

c_0 = Shows the impact of innovations or technology.

e_3 = The residual term (absorbs the effect of those variables, which are not included in the model).

3.4.3 Determination of Returns to Scale

To check whether, the food crops are characterized by constant, increasing or decreasing returns to scale, Wald test has been used. The Chi-square statistic is equal to the F-statistic times the number of restrictions under test (Eviews, 1998). In this case, there is only one restriction i.e. the sum of exponents equal 1 for each crop. If the two test statistics are identical with the p-values of both statistics, this indicates that the null hypothesis of constant returns to scale can be decisively rejected.

If the sum of exponents of the explanatory variables in eq. 3.5 equals one, then the input-output relationship holds constant returns to scale for rice crop i.e. any proportional increase in rice inputs results in an equal increase in rice output. If the sum of exponents of the explanatory variables in eq. 3.5 is greater than one, then the input-output relationship holds increasing returns to scale i.e. rice output increases faster than rice inputs. If the sum of exponents on the explanatory variables in eq. 3.5 is less than one, then the input-output relationship holds decreasing returns to scale i.e. rice output increases slower than rice inputs.

In similar pattern, for wheat crop, if the sum of exponents in eq. 3.7 equals one, then the input-output relationship of wheat crop holds constant returns to scale. If the sum of exponents in eq. 3.7 greater than one, then the input-output relationship of wheat crop holds increasing returns to scale. If the sum of exponents in eq. 3.7 less than one, then the input-output relationship of wheat crop holds decreasing returns to scale.

To find out the nature of returns to scale for maize crop, if the sum of exponents in eq. 3.9 equals one, then the input-output relationship of maize crop holds constant returns to scale. If the sum of exponents in eq. 3.9 greater than one, then the input-output relationship of maize crop holds increasing returns to scale.

If the sum of exponents in eq. 3.9 less than one, then the input-output relationship of maize crop holds decreasing returns to scale.

3.4.4 Estimation of Total output at Mean, Maximum and Minimum Values of Inputs

Total productions were estimated at mean, maximum and minimum values of inputs for rice, wheat and maize.

Total rice production was estimated by substituting the mean, maximum and minimum values of rice inputs eq.3.5. Total wheat production was estimated by substituting the mean, maximum and minimum values of wheat inputs eq.3.7. Similarly, Total maize production was estimated by substituting the mean, maximum and minimum values of maize inputs eq.3.9.

3.4.5 Estimation of Average Product of each input at their Mean, Maximum and Minimum Values

To find out the rice production on 1 unit of rice input, average production at mean, maximum and minimum values of each rice input have been estimated, using the following formulas:

$AP_{RA} = ERP / RA$ ---------- eq. 3.10

$AP_{TRHR} = ERP / TRHR$ ---------- eq. 3.11

$AP_{FERTR} = ERP / FERTR$ ---------- eq. 3.12

$AP_{SDR} = ERP / SDR$ ---------- eq. 3.13

$AP_{LABR} = ERP / LABR$ ---------- eq. 3.14

$AP_{PSTR} = ERP / PSTR$ ---------- eq. 3.15

AP_{RA}, AP_{TRHR}, AP_{FERTR}, AP_{SDR}, AP_{LABR} and AP_{PSTR} are the average product of rice inputs i.e. RA, TRHR, SDR, LABR and PSTR respectively. ERP indicates the total estimated rice production. The average production of each input has been calculated for the mean, maximum and minimum values of rice inputs. The approach has been used by Wiens (2009).

The average product of wheat inputs have been estimated using the following formulas:

$AP_{WA} = EWP / WA$ ---------- eq. 3.16

$AP_{TRHW} = EWP / TRHW$ ---------- eq. 3.17

$AP_{FERTW} = EWP / FERTW$ ---------- eq. 3.18

$AP_{SDW} = EWP / SDW$ ---------- eq. 3.19

$AP_{LABW} = EWP / LABW$ ---------- eq. 3.20

$AP_{PSTW} = EWP / PSTW$ ---------- eq. 3.21

Where, AP_{WA}, AP_{TRHW}, AP_{FERTW}, AP_{SDW}, AP_{LABW} and AP_{PSTW} are the average product of wheat inputs i.e. WA, TRHW, SDW, LABW and PSTW respectively. The average production of each input has been calculated for the mean, maximum and minimum values of wheat inputs.

Similarly, the average product of maize inputs have been estimated using the following formulas:

$AP_{MA} = EMP / MA$ ---------- eq. 3.22

$AP_{TRHM} = EMP / TRHM$ ---------- eq. 3.23

$AP_{FERTM} = EMP / FERTM$ ---------- eq. 3.24

$AP_{SDM} = EMP / SDM$ ---------- eq. 3.25

$AP_{LABM} = EMP / LABM$ ---------- eq. 3.26

$AP_{PSTM} = EMP / PSTM$ ---------- eq. 3.27

AP_{MA}, AP_{TRHM}, AP_{FERTM}, AP_{SDM}, AP_{LABM} and AP_{PSTM} are the average product of maize inputs i.e. MA, TRHM, SDM, LABM and PSTM respectively. The average production of each input has been calculated for the mean, maximum and minimum values of maize inputs.

3.4.6 Estimation of Marginal Product of each Input at their Mean, Maximum and Minimum Values

Marginal Product of each input at mean, maximum and minimum values of rice inputs have been estimated to show the responsiveness of the scale of rice production due to change in the quantity of one rice input and other stay unchanged. The approach has been applied by Wiens (2009). These have been calculated by taking the first derivative of eq. 3.5 with respect to RA, TRHR,

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FERTR, SDR, LABR and PSTR respectively and then substituting the mean, maximum and minimum values of these inputs in the newly obtained equation.

Marginal product of each input at mean, maximum and minimum values of wheat inputs have been estimated to show the responsiveness of the scale of wheat production due to change in the quantity of one wheat input and other stay unchanged. These have been calculated by taking the first derivative of eq. 3.7 with respect to WA, THRW, FERTW, SDW, LABW and PSTW respectively and then substituting the mean, maximum and minimum values of these inputs in the newly obtained equation.

Marginal Product of each input at mean, maximum and minimum values of maize inputs have been estimated to show the responsiveness of the scale of maize production due to change in the quantity of one maize input and other stay unchanged. These have been calculated by taking the first derivative of eq. 3.9 with respect to MA, THRM, FERTM, SDM, LABM and PSTM respectively and then substituting the mean, maximum and minimum values of these inputs in the newly obtained equation.

3.4.7 Marginal Rate of Substitution among Inputs

The Marginal Rate of Substitution among inputs have been calculated, to show how the scale of production respond if quantity of one input is changed while others stay unchanged. These have been calculated using the following formula:

$$MRS_{(X/Y)} = L/M \times YX^{-1} \quad \text{---------- eq. 3.28}$$

Where $MRS_{(X/Y)}$ represents marginal rate of substitution of input X for Y.

L is the output elasticity of X and M is the output elasticity of Y. This formula has been applied for the three crops i.e. rice, wheat and maize. The approach has been adopted by Fisk (1996). The formulas used for calculating the Marginal Rate of Substitution among rice inputs are given in Appendix-C (1). The inputs substitution formulas for wheat and maize are given in Appendix-C (2) and Appendix-C (3) respectively.

Statistical package, Eviews has been used for deriving the results.

Chapter -4

SWAT ECONOMY AND FOOD-GRAIN CROPS CULTIVATION

4.1 Introduction

Swat is one of the important districts of Pakistan, which has been selected for the study because no such work has been undertaken in this area so far. The soil of the study area is well suited for food grain cultivation. It is considered one of the important rice growing areas of N.W.F.P. In this chapter, agrarian features of the district including study area description, its climates, soil and water, population, occupation, family size, education level, size of land holding, variety and area wise distribution of food growers have been discussed.

4.2 Profiles of Food Grain Economy of District Swat

4.2.1 Study Area Description

Swat is a district of geographical diversity. The district lies from 34" 34' to 35" 55' north latitudes and 72" 08' to 72" 50' east longitudes. It is bounded on the north by Chitral district and Ghizer district of northern areas, on the east by Kohistan and Shangla district on the south by Buner district and Malakand protected area and on the west by Lower Dir and Upper Dir districts (District Census Report, 1998). The total area of the district is 506528 hectares; cultivated area 98054 hectares; uncultivated area 408474 hectares and area under forest is 136705 hectares (Cropping Reporting Services, 2006-07).

4.2.2 Climate, Soil and Water

Swat food crops are grown under a Mediterranean climate. The climate is endowed by warm, dry, clear days, and a long growing season favorable to high crops yields. The weather is usually clear with immense solar radiation during the reproductive and ripening periods, which is very much conducive for good yield.

The summer season is short and moderate. It is warm in lower Swat valley, but cool and refreshing in the upper northern part. The hottest month is June with maximum and minimum temperature of 33◦ C and 16◦ C respectively. The coldest month is January and the maximum and minimum temperature of 11◦ C and -2◦ C respectively. The amount of rainfall received during winter season is more than that of summer season. Paddy and maize are mostly grown in the Kharif season while heat is Rabi crop. It is grown mostly on fine-textured, poorly drained soils with impervious hardpans or claypans (Cropping Reporting Services, 2006-07). Most of the irrigation water for Swat rice comes from River Swat. The irrigation potential of the district is very satisfactory. Its transplanting coincides with the onset of monsoon rains, which meet the major portion of its water requirements. If heavy rain falls just when the paddy is ready for reaping it may be beaten down into the flooded fields and completely ruined. The water canals are community/jointly owned.

4.2.3 Population

According to 1998 census, district Swat has a total population of about 125760 of which approximately 648008 are males while the remaining 522248 are females (NIPS, 2002). The total area of the district is 5337 square kilometer having population density 235.6 persons per square kilometer in March 1998, which was 140.3 persons per square kilometer in 1981. The average household size for the district has increased to 8.8 persons in 1998 from 7.00 persons in 1981 irrespective of the fact that the average annual growth rate has declined from 3.83 percent in 1981 to 3.37 percent in 1998. The average annual growth rate of the district is quite higher than the national growth rate of 2.61 percent (District Census Report, 1998).

Economically active population of the Swat district among the population aged 10 years and above to the total population is 19.38 percent which is about 244 thousands souls with 97.90 percent males and 2.10 percent females. The

remaining 80.62 percent economically inactive population consists of 34.34 percent children below 10 years, 33.36 percent domestic workers including 64.68 percent females amongst the total females and 3.91 percent males workers amongst total males (District Census Report, 1998).

4.2.4 Occupations

Most of the people living in the research area are farmers. Other occupations in the district included teaching, fishing and daily wage earners but these activities also supported farming. It was also observed that people engaged in those activities only after they had completed their seasonal farming duties. Agricultural sector is the main stay of the local community and most of population was related with it. Food grains cultivation occupied a pivotal place in Swat's domestic food and livelihood security system.

4.2.5 Variety-Wise Growing Zones in district Swat

In district Swat different varieties of rice, wheat and maize are grown. All the varieties do not suit for all the areas. This depends upon the nature of the variety and climatic conditions of that particular region. The major rice varieties like IRRI-6, KS 282, and Basmati-385 are well suited for plain areas of the district. While for hilly areas the varieties JP-5, Swat-1, Swat-2, Dil Rosh 97, Basmati-385, Pakhal and Kashmir Basmati are recommended by the agriculture research stations in district Swat (Table 4.1).

Wheat varieties like Salim-2000, Tatara, Auqab-2000 are suggested for Barani areas of the district while the varieties Fakhre-Sarhad, Pir Sabak-2004, Pir Sabak-2005, Nowshera-96, Bakhtawar-92, Haider-2002, Khyber-87 and Suleman-96 are recommended for irrigated areas (Table 4.2).

All maize varieties like Azam, Pahari, Jalal, Babar, Ghori are recommended by the agriculture research station for irrigated rather Barani areas (Table 4.3).

Table 4.1

Variety Wise Growing Zones for Rice Cultivation

Growing Zones	Varieties
Plain Areas	IRRI-6, KS 282, and Basmati-385
Hilly Areas	JP-5, Swat-1, Swat-2, Dil Rosh 97, Basmati-385, Pakhal and Kashmir Basmati

Source: Agriculture Research Station (North), Rice Botany Section, Mingora, Swat.

Table 4.2

Variety Wise Growing Zones for Wheat Cultivation

Growing Zones	Varieties
Barani areas	Salim-2000, Tatara, Auqab-2000
Irrigated areas	Fakhre-Sarhad, Pir Sabak-2004, Pir Sabak-2005, Nowshera-96, Bakhtawar-92, Haider-2002, Khyber-87, Suleman-96

Source: Cropping Reporting Services Swat, Amankot, 2008.

Table 4.3

Variety Wise Growing Zones for Maize Cultivation

Growing Zones	Varieties
Barani areas	----------
Irrigated areas	Azam, Pahari, Jalal, Babar, Ghori

Source: Cropping Reporting Services Swat, Amankot, 2008.

4.3 Area and Production of Wheat in District Swat

Total area under wheat crop in 1999-00 was 56015 hectares, decreased to 53519 hectares in 2000-01. In next five years from 2001-02 to 2005-06, total area under wheat crop increased for two years by 6.19% and 9.28% in 2001-02 and 2002-03 respectively, decreased in third year by 5.00% in 2003-04 and increased again in last two years by 4.34% and 1.02% in 2004-05 and 2005-06 respectively. In 2006-07, the total area under wheat crop reached to 62137 hectares. Total wheat production in district Swat was 65038 tons in 1999-00 and decreased to 47649 tons in 2000-01. In next six years from 2001-02 to 2006-07, total wheat production in district Swat increased consecutively for first two years by 62.62% and 25.26% in 2001-02 and 2002-03 respectively, decreased in third year by 9.14% in 2003-04 and increased successively 5.99%, 9.89% and 0.29% in 2004-05, 2005-06 and 2006-07 respectively. The statistics are given in Table 4.4.

Table 4.4

Area and Production of Wheat in district Swat

Year	Area (Hectares)	Production (tones)
1999-00	56015	65038
2000-01	53519	47649
2001-02	56834	77486
2002-03	62111	97060
2003-04	59006	88185
2004-05	61568	93467
2005-06	62198	102707
2006-07	62137	103004

Source: Cropping Reporting Services Swat, Amankot, 2008.

4.4 Area and Production of Maize in District Swat

Total area under maize crop in 2001-02 was 60791 hectares. In next five years from 2002-03 to 2006-07 total area under maize crop increased for two years consecutively by 0.89% and 2.84% in 2002-03 and 2003-04 respectively, decreased in third year by 5.50% in 2004-05 and increased again by 2.49% and 2.33% in 2005-06 and 2006-07 respectively. Total maize production in district Swat was 104883 tons in 2001-02. In next five years from 2002-03 to 2006-07 total maize production in district Swat decreased by 3.31% in 2002-03, decreased by 4.95% in 2003-04, decreased again by 9.08% in 2004-05 and increased by 4.48% and 2.04% in 2005-06 and 2006-07 respectively, as given in Table 4.5.

Table 4.5

Area and Production of Maize in district Swat

Year	Area (Hectares)	Production (tones)
2001-02	60791	104883
2002-03	61334	101412
2003-04	63076	106431
2004-05	59606	96769
2005-06	61088	101109
2006-07	62513	103167

Source: Cropping Reporting Services Swat, Amankot, 2008.

4.5 Area and Production of Rice in District Swat

Total area under rice crop in 1993-94 was 8432 hectares, increased to 8913 hectares in 1994-95. In next five years (from 1995-96 to 1999-00), total area under rice crop decreased by 1.87% and 15.22% in 1995-96 and 1996-97 respectively, increased by 2.67% in 1997-98 and decreased again by 0.17% and 10.37% in 1998-99 and 1999-00 respectively, as given in Table 4.9. In 2000-01,

total area under rice crop in Swat reached to 7527 hectares. The total area under rice crop decreased by 4.05%, 4.85% and 0.35% in 2001-02, 2002-03 and 2003-04 respectively and increased by 2.5%, 0.91% and 3.76% in 2004-05, 2005-06 and 2006-07 respectively.

Table 4.6

Area and Production of Rice in District Swat

Year	Area (Hectares)	Production (tones)
1993-94	8432	17180
1994-95	8913	18771
1995-96	8746	18637
1996-97	7415	15991
1997-98	7613	16560
1998-99	7600	16720
1999-00	6812	15422
2000-01	7527	17717
2001-02	7222	16775
2002-03	6872	16533
2003-04	6848	16710
2004-05	7019	17092
2005-06	7083	16922
2006-07	7349	17764

Source: Cropping Reporting Services Swat, Amankot, 2008.

Total rice production in district Swat was 17180 tons in 1993-94 and reached to 18771 tons in 1994-95. In next four years (from 1995-96 to 1998-99), total rice production in district Swat decreased consecutively by 0.71% and 14.20% in 1995-96 and 1996-97 respectively and increased successively by 3.56% and 0.97% in 1997-98 and 1998-99 respectively. In 1999-00, total rice

production decreased and reached to 15422 tons. In the next five years (from 2000-01 to 2005-06), the total production of rice in Swat, increased by 14.88% in 2000-01, decreased consecutively by 5.32% and 1.44% in 2001-02 and 2002-03 respectively and increased again by 1.07% and 2.29% 2003-04 and 2004-05 respectively. In 2005-06 and in 2006-07, the total rice production in Swat decreased by 0.99% and 4.98% respectively (Table 4.6).

Variety-wise rice area and production in district Swat has been presented Table 4.7. Total area under rice crop was 6812 hectares in 1999-00 and increased to 7019 hectares in 2004-05. Total production of rice was 15422 tons in 1999-00 and increased to 17092 tons in 2004-05. Total area under Irri Pak rice crop was 4 hectares in 1999-00 and decreased to 3 hectares in 2004-05. Total production of Irri Pak rice was 6 tons in 1999-00 and decreased to 4 tons in 2004-05. Total area under Basmati rice crop was 2702 hectares in 1999-00 and increased to 2927 hectares in 2004-05. Total production of Basmati rice was 6125 tons in 1999-00 and increased to 6290 tons in 2004-05. Total area under JP-5 rice crop was 2989 hectares in 1999-00 and increased to 3830 hectares in 2004-05. Total production of JP-5 rice was 6826 tons in 1999-00 and increased to 10246 tons in 2004-05. Total area under other rice varieties was 1117 hectares in 1999-00 and decreased to 259 hectares in 2004-05. Total production of other rice varieties was 2465 tons in 1999-00 and decreased to 552 tons in 2004-05.

Table 4.7

Variety-wise Rice Production and Area under Cultivation in District Swat

Year	Irri Pak		Basmati		JP-5		Other		Total	
	Area (hectares)	Production (tones)	Area (hectares)	Production (tones)	Area (hectares)	Production (tones)	Area (hectares)	Production (tones)	Area (hectares)	Production (tones)
1999-00	4	6	2702	6125	2989	6826	1117	2465	6812	15422
2000-01	5	7	2971	6302	3326	8865	1225	2543	7525	17717
2001-02	4	6	2852	5970	3295	8665	1071	2134	7222	16775
2002-03	4	6	2830	6076	3145	8571	893	1880	6872	16533
2003-04	4	5	2850	6080	3150	8590	500	2035	6972	16710
2004-05	3	4	2927	6290	3830	10246	259	552	7019	17092

Source: Cropping Reporting Services Swat. Amankot, 2008.

4.6 Characteristics of Food Grain Growers

4.6.1 Family Size

The average family size was found 9 per household. They used to live in joint family system. Due to the increasing trend of population, the research area may face socioeconomic problems.

4.6.2 Education Level

In district Swat the number of male Primary, Middle, High and Higher Secondary Schools are 1017, 69, 65 and 10 respectively. The female Primary, Middle, High and Higher Secondary Schools are 601, 29, 17 and 1 respectively (District Census Report, 1998). Among the two hundred farmers 21 % were found educated while the remaining 79 % were uneducated which showed high degree of illiteracy level. The education level of sample farmers has been represented in Table 4.8.

Table 4.8

Distribution of Sample Farmers by Level of Education

Village	Educated	Uneducated	Total
Akhunkalay	4	18	22
Hazara	3	20	23
Dagai	6	15	21
Parai	4	19	23
Aboha	5	18	23
Kota	4	18	22
Asharai	6	17	23
Durashkhela	5	16	21
Baidara	5	17	22
Total	**42**	**158**	**200**

Source: Field Survey

4.6.3 Size and Nature of Land Holding

The process of passing land from one generation to another was a complicated one. Households possessed different sizes of land ownership. Some households have both lowland and upland food grain fields. But the lowland fields were limited in comparison to upland fields. In the field survey it was observed that most of the farmers were tenants and they don't possess their own land. In the research area 16.5%, 28% and 55.5% were found owner, owner-cum tenant and tenant respectively as given in Table 4.9.

Table 4.9

Distribution of Sample Farmers by Size of Land Holding

Village	Owner	Owner-cum-tenant	Tenant	Total
Akhunkalay	3	6	13	22
Hazara	4	7	12	23
Dagai	3	5	13	21
Parai	4	7	12	23
Aboha	5	5	13	23
Kota	4	6	12	22
Asharai	3	8	12	23
Durashkhela	3	5	13	21
Baidara	4	7	11	22
Total	**33**	**56**	**111**	**200**

Source: Field survey

4.6.4 Area Wise Distribution of Rice Farmers

In the research area the average size of land holding of food grain growers was 1.5 acres. Larger households generally cultivated more food crops land primarily because more labour was likely to be available. They are helped by family members so as to avoid employing outside labour. The information obtained from the field study about the nature of area possessed by sample farmers have been presented in Table 4.10 in detail.

Table 4.10

Area Wise Distribution of food growers

Village	Average Size of Land Holding (acre)	No. of Respondents
Akhunkalay	1.0	22
Hazara	2.0	23
Dagai	1.5	21
Parai	1.5	23
Aboha	2.5	23
Kota	3.0	22
Asharai	1.5	23
Durashkhela	1.5	21
Baidara	2.2	22
Total	-	**200**

Source: Field survey

4.6.5 Variety Wise Distribution of Sample Farmers

Choice of variety depended on environment, planting date, quality, marketing, and harvest scheduling. JP-5 was dominated and well-known variety of the district and its growers were 40% of the total rice growers. The share of Basmati-385 rice was 7.5%. The share of Sara Saila, Dil Rosh-97, Swat-1, Swat-2 and Fakhr-e-Malakand was 12.5%, 7.5%, 7.5%, 12.5% and 12.5% respectively. All these figures are shown in Table 4.11.

Table 4.11

Variety Wise Distribution of Sample of Rice Farmers

Variety	Number of Growers	% age Variety Growers
JP-5	80	40.0
Basmati-385	15	7.5
Sara Saila	25	12.5
Dil Rosh-97	15	7.5
Swat-1	15	7.5
Swat-2	25	12.5
Fakhr-e-Malakand	25	12.5
Total	**200**	**100.0**

Source: Field survey

In the study area different varieties of wheat were grown in different areas. Fakhre-Sarhad was the most well known variety of the district. The variety-wise distribution of wheat growers is given in Table 4.12. The growers of variety Salim-2000, Haider-2002, Khyber-87, Nowshera-96, Tatara, Bakhtawar-92, Auqab-2000, Suleman-96, Fakhre-Sarhad, Pir Sabak-2004 and Pir Sabak-2005 were 11%, 13%, 8%, 13%, 8%, 7%, 5%, 6%, 19%, 6% and 4% of the total wheat growers respectively. This indicates that Fakhre-Sarhad is the dominant variety in the district.

The variety-wise distribution of maize growers is given in Table 4.13. The table indicates that the growers of variety Azam, Pahari, Jalal, Babar and Ghori are 24%, 16%, 12%, 39% and 9% of the total maize growers respectively. The share of variety Babar grower is the highest as compared to all other varieties growers.

Table 4.12

Variety Wise Distribution of Sample of Wheat Farmers

Wheat Variety	Number of Growers	% age Variety Growers
Salim-2000	23	11
Haider-2002	26	13
Khyber-87	15	8
Nowshera-96	26	13
Tatara	16	8
Bakhtawar-92	14	7
Auqab-2000	10	5
Suleman-96	12	6
Fakhre-Sarhad	38	19
Pir Sabak-2004	12	6
Pir Sabak-2005	8	4
Total	200	100

Source: Field survey

Table 4.13

Variety Wise Distribution of Sample of Maize Farmers

Wheat Variety	Number of Growers	% age Variety Growers
Azam	48	24
Pahari	32	16
Jalal	24	12
Babar	78	39
Ghori	18	9
Total	200	100

Source: Field survey

4.7 Profiles of Major Food Grain Varieties in the District

4.7.1 Profiles of Major Rice Varieties of the District

JP-5, Basmati-385 and Sara Saila are the most popular varieties of the district. JP-5 is a thick grain rice variety. It is sown in a high altitude of about more than 1000 meters. It is very common in the district. It gives production of 5 to 7 tons per hector, and takes 140 days from sowing to harvesting. Fakhr-e-Malakand is a new variety grown in the District. It is a high yielding variety as compared to all other varieties of the district. Swat-1 is a medium grain type. It is comparatively sown in low altitude areas. From cooking point of view, it is considered a good variety. It also gives more production like JP-5 in cold areas. Swat-2 is also a medium grain and productive variety. It gives production 10% more than that of JP-5. It is sown in low altitude areas but it is a still a cold resistant variety. It is recommended for those areas where JP-5 is sown in district Swat. Dil Rosh 97 is also a medium grain variety and from production point of view, it is considered a good one. It matures from 10-15 days quickly than JP-5. For cooking it is also considered a good quality. Just like JP-5, it is also

recommended in cold areas of district Swat. Basmati-385 is a good and long grain variety and is grown in various parts of the district.

4.7.2 Profiles of Major Wheat Varieties of the District

In district Swat, various varieties of wheat are grown. Saleem-2000, Haider-2002, Khyber-87, Noshera-96, Tatara, Bakhtawar-92, Auqab-200, Suleman-96, Pir Sabak-2004, Pir Sabak-2005 and Fakhri-Sarhad are the most popular and major varieties grown in the district. The varieties Saleem-2000, Tatara, Auqab-200 are also grown in barani areas of the district whereas all the remaining varieties are mainly cultivated in irrigated areas. Further, all these are the improved varieties and are grown in various areas of the district.

4.7.3 Profiles of Major Maize Varieties of the District

In district Swat different varieties of maize are grown. The major and popular varieties of the district are Azam, Pahari, Jalal, Babar (White), Ghori (Yellow). The first three varieties are synthetic varieties while the last two varieties are hybrid varieties. All these varieties are grown in irrigated areas of the district.

4.8 Summary

District Swat is well suited area for food grain crops' cultivation. Major occupations were teaching, fishing and daily wage earners but most of them were farmers. They grow different varieties of rice, wheat and maize. The total production of wheat, maize and rice in 2006-07 was 103004 tones, 103167 tones and 17764 tones respectively. The average family size of the farmers was 6 per household. Most of the farmers were uneducated and tenants, cultivating 1.5 acre area on average. The major rice varieties grown in the district were JP-5, Basmati-385, Sara Saila, Dil Rosh-97, Swat-1, Swat-2 and Fakhr-e-Malakand. JP-5 was widely grown variety as compared to other rice varieties. The major wheat varieties grown were Salim-2000, Haider-2002, Khyber-87, Nowshera-96, Tatara,

Bakhtawar-92, Auqab-2000, Suleman-96, Fakhre-Sarhad, Pir Sabak-2004 and Pir Sabak-2005. Fakhr-e-Sarhad was dominant as compared to all other wheat varieties. The major maize varieties grown were Azam, Pahari, Jalal, Babar and Ghori in which Babar variety was extensively grown.

Chapter-5

COST AND REVENUE COMPARISON OF FOOD-GRAIN VARIETIES

5.1 Introduction

Information about the revenue and cost of food grain crops i.e. rice, wheat and maize are presented in this chapter. The perceptions of the farmers about cost and revenue items were noted and have been converted to the size of one acre area. In practice, the farmer himself, assisted by members of his family, often co-operating on a labour exchange basis with other farmers, performs the bulk of the work. Whenever a "day's labour" is referred to it means a working day of approximately eight hours.

Bullocks were necessarily used alongwith tractor by the farmers for rice cultivation because in standing water in the fields, ploughing was impossible with tractor. Whereas for maize and wheat there was no need to use the bullock and tractor collectively. In the study area almost all of the land preparation for food grins cultivation was done with the help of tractor except for some operations in rice cultivation. Besides, there was no cost of water (irrigation) except labour usage in it.

The per acre costs and revenues of rice, wheat and maize are given in subsequent sections.

5.2 Per Acre Cost and Revenue of Different Rice Varieties

In district Swat, different varieties of rice are grown namely JP-5, Basmti-385, Sara Saila, Dil Rosh -97, Swat-1, Swat-2 and Fakhre-Malakand. Details about the cost and revenues of these different varieties are presented in appendix-D:

5.2.1 Cost and Revenue of Variety JP-5

The figures in appendix-D (1) indicate that the land preparation charges were Rs. 1100 per acre comprised on tractor charges of Rs. 600 and bullock's charges of Rs. 500 per acre. The usage of labour for one acre rice area was 55 man

days for various operations i.e. nursery bed preparation, maintenance, pulling and transport; transplanting, cleaning/handling and harvesting. The land rent charges were Rs. 5500 per acre. The total cost for variety JP-5 was Rs. 16385 per acre. The total and net revenue was Rs. 44, 000 and Rs. 27, 615 per acre respectively as given in appendix-D (2).

5.2.2 Cost and Revenue of Variety Basmati-385

For variety Basmati-385, 28 kg seed was used amounting to Rs. 336 per acre. The total cost for various operations was Rs. 16271 per acre, as given in appendix-D (3). The total and net revenue from one acre area was Rs. 54900 and Rs. 38629 respectively. The total revenue is comprised on Rs. 50400 (paddy production) and Rs. 4500 (rice straw), as presented in appendix-D (4).

5.2.3 Cost and Revenue of Variety Sara saila

In the cultivation of variety Sara Saila, 30 Kg seed was used amounting to Rs. 300 per acre. The total cost for various activities was Rs. 16235 per acre, given in appendix-D (5). The total and net revenue of this variety was Rs. 42500 and Rs. 26265 respectively, as presented in appendix-D (6).

5.2.3 Cost and Revenue of Variety Dil Rosh-97

In the cultivation of variety Dil rosh-97, 25 Kg seed was used amounting to Rs. 250 per acre. The total cost for various activities was Rs. 16185 per acre, given in appendix-D (7). The total and net revenue of this variety was Rs. 33700 and Rs.17515 respectively, as presented in appendix-D (8).

5.2.4 Cost and Revenue of Variety Swat-1

In the cultivation of variety Swat-1, 30 Kg seed was used amounting to Rs. 300 per acre. The total cost for various activities was Rs. 16235 per acre, given in appendix-D (9). The total and net revenue of this variety was Rs. 35300 and Rs.19065 respectively, as presented in appendix-D (10).

5.2.5 Cost and Revenue of Variety Swat-2

In the cultivation of variety Swat-2, 30 Kg seed was used amounting to Rs. 360 per acre. The total cost for various activities was Rs. 16295 per acre, given in appendix-D (11). The total and net revenue of this variety was Rs. 35300 and Rs.19005 respectively, as presented in appendix-D (12).

5.2.6 Cost and Revenue of Variety Fakhr-e-Malakand

In the cultivation of variety Fakhr-e-Malakands, 30 Kg seed was used amounting to Rs. 360 per acre. The total cost for various activities was Rs. 16295 per acre, given in appendix-D (13). The total and net revenue of this variety was Rs. 55500 and Rs.39205 respectively, as presented in appendix-D (14).

5.2.7 Average Cost and Revenue of all varieties

The average per acre cost for all varieties is Rs. 16, 272, which comprised on cost of seed Rs. 337, fertilizers Rs. 655, labour usage (man days) Rs. 6600, transplanting 1800, harvesting Rs. 1200 and threshing Rs. 1260, as given in table 5.1 (a). The average paddy production is 36 maunds acre area amounting to Rs. 38556. The average amount of rice straw is Rs. 4357 per acre, while the total and net revenue is Rs. 42913 and Rs. 26647 respectively, given in Table 5.1 (b).

Table 5.1 (a)

Average Per-acre Cost and Revenue of all Rice Varieties

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation				
i) Ploughing with tractor	Hr	3	200	600
ii) Puddling with bullocks	Day	1	500	500
Raising nursery				
i) Seed	Kg	29	12	337
ii) Nursery bed preparation	Day	2	120	240
iii) Nursery maintenance	Day	1	120	120
iv) Nursery pulling, transport	Day	4	120	480
Fertilizers				
i) DAP	Kg	25	9	225
ii) Urea	Kg	50	8.6	430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides				
i) Furadan (Insecticides)	Kg	16	50	800
ii) Machety (weedicides)	ml	800	300	300
iii) labour charges	Day	3	120	360
Harvesting	Day	10	120	1200
Threshing				
i) Tractor charges	Hr	1	300	300
ii) Labour charges	Day	8	120	960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16, 272

Source: Field survey

Table 5.1 (b)

Average Total and Net Revenue of all Rice Varieties

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy	36	1071	38556
ii) Straw		4357	4357
Total Revenue (gross)			42913
Net Revenue			26647

Source: Field survey

5.3 Benefit Cost Ratios of Different Rice Varieties

To compare the cost and revenues of different rice varieties, Benefit Cost Ratios (BCRs) for each variety have been calculated. The BCR for varieties JP-5, Basmati-385, Sara saila, Dil rosh-97, Swat-1, Swat-2 and Fakhr-e-Malakand were 2.69, 3.37, 2.62, 2.08, 2.17, 2.16 and 3.41 respectively (Table 5.2). It is evident from this table that variety Fakhr-e-Malakand possesses the highest BCR value, indicting that it is the most profitable variety of rice as compared to all other rice varieties, coinciding on the economic theory.

Table 5.2

Benefit Cost Ratios for Different Varieties of Rice

Rice Variety	Total Rice Revenue (Rs.) (TRR)	Total Cost of Rice (Rs.) (TCR)	Benefit Cost Ratios BCR = TRR/TCR
JP-5	44, 000	16385	2.69
Basmati-385	54, 900	16271	3.37
Sara saila	42, 500	16235	2.62
Dil rosh-97	33700	16185	2.08
Swat-1	35, 300	16235	2.17
Swat-2	35, 300	16295	2.16
Fakhr-e-Malakand	55, 500	16295	3.41

Source: Personal calculations

5.4 Per Acre Cost and Revenue of Different Wheat Varieties

Saleem-2000, Haider-2002, Khyber-87, Noshera-96, Tatara, Bakhtawar-92, Auqab-200, Suleman-96, Pir Sabak-2004, Pir Sabak-2005 and Fakhri-Sarhad were the most popular and major varieties of the district. These varieties differ from each other in terms of cost and revenues. Their details are presented in appendix-E.

5.4.1 Cost and Revenue of Variety Saleem-2000

In the cultivation of variety saleem-2000, 50 Kg seed was used amounting to Rs. 1500 per acre. The total cost for various activities was Rs. 17960 per acre, given in appendix-E (1). The total and net revenue of this variety was Rs. 39000 and Rs.21040 respectively, as presented in appendix-E (2).

5.4.2 Cost and Revenue of Variety Haider-2002

In the cultivation of variety Haider-2002, 50 Kg seed was used amounting to Rs. 1250 per acre. The total cost for various activities was Rs. 17710 per acre, given in appendix-E (3). The total and net revenue of this variety was Rs.29700 and Rs.11990 respectively, as presented in appendix-E (4).

5.4.3 Cost and Revenue of Variety Khyber-87

In the cultivation of variety Khyber-87, 50 Kg seed was used amounting to Rs. 1000 per acre. The total cost for various activities was Rs. 17460 per acre, given in appendix-E (5). The total and net revenue of this variety was Rs.36500 and Rs.19040 respectively, as presented in appendix-E (6).

5.4.4 Cost and Revenue of Variety Nowshera-96

In the cultivation of variety Nowshera-96, 50 Kg seed was used amounting to Rs. 1400 per acre. The total cost for various activities was Rs. 17860 per acre, given in appendix-E (7). The total and net revenue of this variety was Rs.34000 and Rs.16140 respectively, as presented in appendix-E (8).

5.4.5 Cost and Revenue of Variety Tatara

In the cultivation of variety Tatara, 50 Kg seed was used amounting to Rs. 1250 per acre. The total cost for various activities was Rs. 17710 per acre, given in appendix-E (9). The total and net revenue of this variety was Rs.31400 and Rs.13690 respectively, as presented in appendix-E (10).

5.4.6 Cost and Revenue of Variety Bakhtawar-92

In the cultivation of variety Bakhtwar-92, 50 Kg seed was used amounting to Rs. 1400 per acre. The total cost for various activities was Rs. 17860 per acre, given in appendix-E (11). The total and net revenue of this variety was Rs.39800 and Rs.21940 respectively, as presented in appendix-E (12).

5.4.7 Cost and Revenue of Variety Auqab-2000

In the cultivation of variety Auqab-2000, 50 Kg seed was used amounting to Rs. 1250 per acre. The total cost for various activities was Rs. 17710 per acre, given in appendix-E (13). The total and net revenue of this variety was Rs.37600 and Rs.19890 respectively, as presented in appendix-E (14).

5.4.8 Cost and Revenue of Variety Suleman-96

In the cultivation of variety Suleman-96, 50 Kg seed was used amounting to Rs. 1250 per acre. The total cost for various activities was Rs. 17710 per acre, given in appendix-E (15). The total and net revenue of this variety was Rs.34000 and Rs.16290 respectively, as presented in appendix-E (16).

5.4.9 Cost and Revenue of Variety Fakhri-Sarhad

In the cultivation of variety Fakhri-Sarhad, 45 Kg seed was used amounting to Rs. 1125 per acre. The total cost for various activities was Rs. 17585 per acre, given in appendix-E (17). The total and net revenue of this variety was Rs.41500 and Rs.23915 respectively, as presented in appendix-E (18).

5.4.10 Cost and Revenue of Variety Pir Sabak-2004

In the cultivation of variety Pir Sabak-2004, 50 Kg seed was used amounting to Rs. 1250 per acre. The total cost for various activities was Rs. 17710 per acre, given in appendix-E (19). The total and net revenue of this variety was Rs.30600 and Rs.12890 respectively, as presented in appendix-E (20).

5.4.11 Cost and Revenue of Variety Pir Sabak-2005

In the cultivation of variety Pir Sabak-2005, 50 Kg seed was used amounting to Rs. 1250 per acre. The total cost for various activities was Rs. 17710 per acre, given in appendix-E (21). The total and net revenue of this variety was Rs.31500 and Rs.13790 respectively, as presented in appendix-E (22).

5.4.12 Average Cost and Revenue of All varieties

The average per acre cost for all varieties is Rs. 17, 760, which comprised on land preparation cost of Rs. 1300, seed Rs. 1300, fertilizer Rs. 4360, labour usage (man days) Rs. 3600, threshing Rs. 1260, as given in Table 5.3 (a). The average wheat production is 26 maunds from one acre area amounting to Rs. 26000. The average amount of wheat Boosa is Rs. 9045 per acre, while the total and net revenue is Rs. 35045 and Rs. 17285 respectively, given in Table 5.3 (b).

Table 5.3 (a)

Average Per-acre Costs of all Wheat Varieties

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	26	1300
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 760

Source: Field survey

Table 5.3 (b)

Average Total and Net Revenue of all Wheat Varieties

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	26	1000	26000
Boosa		9045	9045
Total Revenue (gross)			35045
Net Revenue			17285

Source: Field survey

Table 5.3 (a)

Average Per-acre Costs of all Wheat Varieties

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	26	1300
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 760

Source: Field survey

Table 5.3 (b)

Average Total and Net Revenue of all Wheat Varieties

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	26	1000	26000
Bhoosa		9045	9045
Total Revenue (gross)			35045
Net Revenue			17285

Source: Field survey

5.5 Benefit Cost Ratios of Different Wheat Varieties

To compare the cost and revenues of different wheat varieties, Benefit Cost Ratios (BCRs) for each variety have been calculated. The BCR for varieties Saleem-2000, Haider-2002, Khyber-87, Noshera-96, Tatara, Bakhtawar-92, Auqab-200, Suleman-96 and Fakhri-Sarhad were 2.17, 1.68, 2.09, 1.90, 1.77, 2.23, 2.21, 1.92, 2.36, 1.71 and 1.78 respectively (Table 5.4). It is evident from this table that variety Fakhr-e-Sarhad possesses the highest BCR value, indicting that it is the most profitable variety of wheat as compared to all other varieties, coinciding on the economic theory.

Table 5.4

Benefit Cost Ratios for Different Wheat Varieties

Wheat Variety	Total Revenue (Rs.) (TR)	Total Cost (Rs.) (TC)	Benefit Cost Ratios BCR = TRW/TCW
Salim-2000	39, 000	17, 960	2.17
Haider-2002	29, 700	17, 710	1.68
Khyber-87	36, 500	17, 460	2.09
Nowshera-96	34, 000	17, 860	1.90
Tatara	31, 400	17, 710	1.77
Bakhtawar-92	39, 800	17, 860	2.23
Auqab-2000	37, 600	17, 710	2.21
Suleman-96	34, 000	17, 710	1.92
Fakhre-Sarhad	41, 500	17, 585	2.36
Pir Sabak-2004	30, 600	17, 710	1.71
Pir Sabak-2005	31, 500	17, 710	1.78

Source: Personal calculations

5.6 Per Acre Cost and Revenue of Different Maize Varieties

In district Swat different varieties of maize are grown. The major and popular varieties are Azam, Pahari, Jalal, Babar, Ghori. These varieties differ from each other in terms of costs and revenues. Their details are given in appendix-F:

5.6.1 Cost and Revenue of Variety Azam

In the cultivation of variety Azam, 20 Kg seed was used amounting to Rs. 800 per acre. The total cost for various activities was Rs. 18960 per acre, given in appendix-F (1). The total and net revenue of this variety was Rs.42500 and Rs.23540 respectively, as presented in appendix-F (2).

5.6.2 Cost and Revenue of Variety Pahari

In the cultivation of variety Pahari, 20 Kg seed was used amounting to Rs. 720 per acre. The total cost for various activities was Rs. 18880 per acre, given in appendix-F (3). The total and net revenue of this variety was Rs.24200 and Rs.5320 respectively, as presented in appendix-F (4).

5.6.3 Cost and Revenue of Variety Jalal

In the cultivation of variety Jalal, 20 Kg seed was used amounting to Rs. 700 per acre. The total cost for various activities was Rs. 18860 per acre, given in appendix-F (5). The total and net revenue of this variety was Rs.22500 and Rs.3640 respectively, as presented in appendix-F (6).

5.6.4 Cost and Revenue of Variety Babar

In the cultivation of variety Babar, 20 Kg seed was used amounting to Rs. 780 per acre. The total cost for various activities was Rs. 18940 per acre, given in appendix-F (7). The total and net revenue of this variety was Rs.35800 and Rs.16860 respectively, as presented in appendix-F (8).

5.6.5 Cost and Revenue of Variety Ghori

In the cultivation of variety Ghori, 20 Kg seed was used amounting to Rs. 680 per acre. The total cost for various activities was Rs. 18840 per acre, given in

appendix-F (9). The total and net revenue of this variety was Rs.26600 and Rs.7760 respectively, as presented in appendix-F (10).

5.6.6 Average Cost and Revenue of all varieties

The average per acre cost for all varieties is Rs. 18, 900, which comprised on land preparation cost of Rs. 1200, seed Rs. 740, fertilizers Rs. 4360, labour usage (man days) Rs. 4200, threshing with tractor Rs. 1500, as given in table 5.5 (a). The average maize production is 26 maunds from one acre area amounting to Rs. 24700. The average amount of stalk is Rs. 5000 per acre, while the total and net revenue is Rs. 29700 and Rs. 10800 respectively, given in Table 5.5 (b).

Table 5.5 (a)

Average Per-acre Costs of All Maize Varieties

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	20	37	740
Fertilizers i) DAP ii) Urea	 Bag Bag	 1 2	 3000 680	 3000 1360
Weedicides	-	-	600	600
Threshing (with tractors)	Hour	1	1500	1500
Labour charges from sowing to threshing	Day	35	120	4200
Bags charges	Bag	20	40	800
Land rent	--	-	5500	5500
Total Cost				18, 900

Source: Field survey

Table 5.5 (b)

Average Total and Net Revenue of all Maize Varieties

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Maize grain Stalk	26	950 5000	24700 5000
Total Revenue (gross)			29700
Net Revenue			10800

Source: Field survey

5.7 Benefit Cost Ratios of Different Maize Varieties

To compare the cost and revenues of different maize varieties, Benefit Cost Ratios (BCRs) for each variety have been calculated. The BCRs for varieties Azam, Pahari, Jalal, Babar, Ghori were 2.24, 1.28, 1.19, 1.89 and 1.41 respectively (Table 5.6). It is evident from this table that variety Azam possesses the highest BCR value (2.24), indicting that it is the most profitable variety of maize as compared to all other varieties, coinciding on the economic theory.

Table 5.6

Benefit Cost Ratios for Different Maize Varieties

Maize Variety	Total Revenue of Maize (Rs.) (TRM)	Total Cost of Maize (Rs.) (TCM)	Benefit Cost Ratios BCR = TRM/TCM
Azam	42, 500	18, 960	2.24
Pahari	24200	18, 880	1.28
Jalal	22500	18, 860	1.19
Babar	35800	18, 940	1.89
Ghori	26600	18, 840	1.41

Source: Personal calculations

5.8 Summary

In this chapter, the per acre cost and revenue of different rice, wheat and maize varieties have been assessed. The major cost components for rice crop cultivation were land preparation, raising nursery, fertilization, transplanting, cleaning, pesticides, harvesting, threshing and land rent. Variety Fakhr-e-Malakand was the most profitable variety in terms of net revenue as compared to other rice varieties. The major heads of revenue of rice were paddy and rice straw.

The major cost components for wheat crop cultivation were land preparation, seed, fertilizer, threshing, labour and land rent. Variety Fakhr-e-Sarhad was the most profitable variety of wheat in terms of net revenue as

compared to all other wheat varieties. The major heads of revenue of wheat were wheat grain and boosa.

The major cost components for maize crop cultivation were land preparation, seed, fertilizer, threshing, labour and land rent. Variety Babar was the most profitable variety in terms of net revenue as compared to all other maize varieties. The major heads of revenue of maize were maize grain and stalk.

Chapter-6

ECONOMETRIC ANALYSIS OF FOOD GRAIN CROPS

6.1 Introduction

This chapter intends to furnish information about the econometric analysis of the input output relationship of food grain crops i.e. rice, wheat and maize. For each crop the log linear model has been estimated so as to find out the output elasticities and to determine the nature of returns to scale. For each crop, total product at mean, maximum and minimum values of the sample observations have been estimated. The average and marginal product has also been calculated for each crop. Details are given in subsequent sections.

6.2 Econometric Analysis of Rice Input-Output Relationship

This section provides information about the sample statistics and econometric analysis of rice crop. The analysis is based on primary data collected and valued at the market prices of 2008. Details are given as under:

6.2.1 Sample Statistics of Rice Input-Output

The sample statistics based on the field survey information indicates that the average, maximum and minimum produce of rice farmers was 2750 Kgs, 4500 Kgs and 550 Kgs respectively. The average size of area of rice farmers was 1.5 acres. On average 5 tractor hours, 3 bags of fertilizer, 40 Kgs seed and 3 bottles of sprays for pesticides/insecticides were used by rice farmers. On average, the farmers used 75 labours (man days) for cultivating the rice crop. The average, maximum and minimum amount of inputs used by the farmers are given in Table 6.1.

Table 6.1
Sample Statistics of Rice Farmers

	RP	RA	TRHR	FERTR	SDR	LABR	PSTR
Mean	2750	1.5	5	3	40	75	3
Maximum	4500	3.6	6	4	45	80	4
Minimum	550	0.2	2	1	30	50	1
Observations	200	200	200	200	200	200	200

Source: Personal calculations

6.2.2 Estimation of Log Linear Production Function for Rice

The estimated log linear Cobb-Douglas production function is:

ln RP = 2.876+ 0.245781*ln RA+ 0.6712*ln TRHR + 0.0789123*ln FERTR + 0.871245*ln SDR+ 0.12487*ln LABR + 0.004871*ln PSTR ---------- eq. 6.1

or in the most general form:

$$RP = 17.74316 \times RA^{0.245781} \times TRHR^{0.6712} \times FERTR^{0.07891} \times SDR^{0.871245} \times LABR^{0.12487} \times PSTR^{0.004871}$$ ---------- eq. 6.2

Where $a_o = e^{2.4708} = 17.74316$

The results indicate that RA, TRHR, LABR and SDR are statistically significant at both 10% and 5% level of significance. FERTR is significant at 5% level of significance only. PSTR is not statistically significant variable. Usage of fertilizer was also at minimum level because the land was too fertile and suitable for rice crop cultivation.

According to eq. 6.1 and 6.2, the value of the rice area elasticity of production (0.24578) indicates that if rice area increases by 1% and all other inputs remain unchanged, the rice production will increase by 0.24%. If TRHR increases by 1%, the rice production increases by 0.67% taking all other variables unchanged. The output elasticities of FERTR, SDR, LABR and PSTR are 0.0789123, 0.871245, 0.12487 and 0.004871 respectively which can be interpreted in the same way. Further, the signs and size of the coefficients are according to the expectation and are in line with the economic theory. Value of Durbin Watson

statistic (1.91) shows that there does not exist any problem of autocorrelation. The results are given in table 6.2.

Table 6.2

Regression Results of Log Linear Production Function for Rice

Dependent Variable: ln RP				
Included observations: 200				
Sample: 1 200				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.876	0.12487	23.032	0.0000
ln RA	0.245781	0.012457	19.73	0.0083
ln TRHR	0.6712	0.09871	6.7997	0.0034
ln FERTR	0.07891	0.0045781	17.237	0.0468
ln SDR	0.871245	0.012481	69.806	0.0008
ln LABR	0.12487	0.003458	36.11	0.0463
ln PSTR	0.004871	0.0009124	5.3387	0.8523
R-squared	0.718713	Durbin-Watson stat		1.912121
Adjusted R-squared	0.724029			

The R-square and adjusted R-square values show that the fit is good. The high value of R^2=0.72 shows that 72% of the variations in the (log of) total rice production is explained by the (log of) included explanatory variables. Most of the explanatory variables have a strong relationship with the dependent variable. The stepwise regression supported the statement. The stepwise regression results are given in appendix-G. In appendix-G (1), rice production has been regressed on rice area only. RA is not only statistically significant at 10% and 5% level of significance but also responsible for changes in the rice production, as indicated by R^2=0.61.

In appendix-G (2), RA and TRHR have been included. The value of R-square (0.64) favours the good fit. In appendix-G (3), RA, TRHR and FERT have been included and the value of R-square is 0.72. This also indicates that these variables are also responsible for changes in dependent variable (RP). Appendix-G (4) shows that 77% of the variations in the (log of) total rice product is explained by the (log of) included explanatory variables. Here the included explanatory

variables are RA, TRHR, FERTR and SDR. In appendix-G (5), the included explanatory variables are RA, TRHR, FERTR, SDR and LABR. This indicates that 89% of the variations in the (log of) total rice product is explained by the (log of) included explanatory variables. The inclusion of each explanatory variable and the values of R-square have a strong coordination in these regression results.

6.2.3 Determination of Returns to Scale for Rice Crop

In the context of input-output relationship, it is necessary to show how the inputs and output go side by side. The log linear Cobb-Douglas production function (eq. 6.2) clearly depicts the nature of returns to scale. The sum of all the output elasticities equals 1.9969 (i.e. > 1), indicates that rice production is characterized by increasing returns to scale. The Wald-Test (Table 6.3) also support the result. The test has the null hypothesis that the rice production is characterized by constant returns to scale and has only one restriction i.e. $a_1+a_2+a_3+a_4+a_5+a_6=1$. As, the Chi-square statistic is equal to the F-statistic times the number of restrictions under test, so the null hypothesis of constant returns to scale is decisively rejected.

Table 6.3

Wald Test Results for Rice Crop

Wald Test: Sample: 1 200			
Null Hypothesis:	$a_1 + a_2 + a_3 + a_4 + a_5 + a_6 = 1$		
F-statistic	8.689398	Probability	0.007222
Chi-square	8.689398	Probability	0.007201

Where a_1, a_2, a_3, a_4, a_5 and a_6 are the coefficients of RA, TRHR, FERTR, SDR, LABR and PSTR respectively.

6.2.4 Total Estimated Rice Production at Mean, Maximum and Minimum Values of Rice Inputs

The total rice production at the mean, maximum and minimum values of rice inputs in the sample have been estimated in Table 6.4, by using eq. 6.2.

Putting the mean rice inputs, the total estimated rice production is 2700 Kgs. For maximum and minimum values of rice inputs, the total estimated rice production is 4330 Kgs and 600 Kgs respectively.

Table 6.4

Total Estimated Rice Production at Mean, Maximum and Minimum Values of Rice Inputs

	Rice Inputs						Total Estimated Rice Production (Kgs)
	RA	TRHR	FERTR	SDR	LABR	PSTR	
Mean	1.5	5	3	40	75	3	2700
Maximum	3.6	6	4	45	80	4	4330
Minimum	0.2	2	1	30	50	1	600
Observations	200	200	200	200	200	200	

Source: Personal calculations

6.2.5 Estimated Average Production at Mean, Maximum and Minimum Values of Rice Inputs

To find out the rice production on 1 unit of rice input, average production at mean, maximum and minimum values of each rice inputs have been estimated in Table 6.5, using eq. 3.10 to 3.15. The average product of RA, TRHR, FERTR, SDR LABR and PSTR at their mean values are 1800, 540, 900, 67.5, 36 and 900 Kgs respectively. The averages product of each input for their maximum and minimum values is given in Table 6.5.

Table 6.5

Estimated Average Production of inputs at Mean, Maximum and Minimum Values of Rice Inputs

	Average product of Inputs (Kgs)					
	AP_{RA}	AP_{TRHR}	AP_{FERTR}	AP_{SDR}	AP_{LABR}	AP_{PSTR}
Mean	1800	540	900	67.5	36	900
Maximum	1202.778	721.667	1082.5	96.2222	54.125	1082.5
Minimum	3000	300	600	20	12	600

Source: Personal calculations

6.2.6 Marginal Product Estimation at Mean, Maximum and Minimum Values of Rice Inputs

To show the responsiveness of the scale of rice production due to change in the quantity of one rice input and other stay unchanged, the marginal product of each input has been estimated. These have been calculated by taking the first order partial derivatives with respect to each rice input of eq. 6.2 one by one. The marginal product at the mean value of RA is 443.56 Kgs indicating that if rice area increases by one acre (over 1.5 acre) and all other variables constant, the production will increase by 443.56 Kgs. On similar pattern, if the tractor hours for rice are increased by one unit (over 5 hours) and all other variables constant, the rice production will increase by 299.10 Kgs. The marginal product of FERTR, SDR LABR and PSTR are 71.20, 50.55, 3.86 and 3.56 respectively, as given in appendix-J (1).

The marginal product at maximum values of each rice inputs has been estimated in appendix-J (2). The marginal product at the maximum values of RA, TRHR, FERTR, SDR, LABR and PSTR are 281.84, 461.77, 81.42, 79.92, 6.44 and 5.03 respectively.

The marginal product at the minimum values of RA, TRHR, FERTR, SDR LABR and PSTR are 726.87, 198.50, 46.67, 17.18, 1.48 and 2.88 respectively, as given in appendix-J (3).

6.2.7 Marginal Rate of Substitution of Inputs at Mean Values of Rice Inputs

To show how the scale of production respond if quantity of one input is changed while others stay unchanged, the marginal rate of substitutions have been calculated using eq. 3.28 and equations given in appendix C(1). To this end, the ratios of output elasticities are needed which have been presented in Table 6.6.

Table 6.6

Rice Output Elasticities' Ratios

	Output Elasticities' Ratios					
Output Elasticities' Ratios	a_1=0.245781	a_2=0.6712	a_3=0.07891	a_4=0.871245	a_5=0.12487	a_6=0.004871
a_1=0.245781	1	2.7308	0.32106	3.5448	0.5080	0.0198
a_2=0.6712	0.3662	1	0.11756	1.2980	0.1860	0.00726
a_3=0.07891	3.1147	8.5058	1	11.0417	1.5824	0.06173
a_4=0.871245	0.2821	0.7704	0.09057	1	0.1433	0.00559
a_5=0.12487	1.9683	5.3752	0.63193	6.9772	1	0.03901
a_6=0.004871	50.458	137.7951	16.19996	178.8637	25.635	1

Source: Personal calculations

The marginal rate of substitution of RA for LABR is 98.41, indicating that one unit of rice area (one acre area) can be substituted for 98 units of labour without changing the product scale. Similarly, the marginal rate of substitution of RA for FERTR is 6.23, indicating that one unit of rice area (one acre area) can be substituted for 6 units of fertilizer bags without changing the product scale. The marginal rate of substitutions between various rice inputs has been presented in Appendix-M.

6.3 Econometric Analysis of Wheat Input-Output Relationship

This section provides information about the sample observations and econometric analysis of wheat crop. The econometric analysis includes estimation of log linear wheat production function, stepwise regression, determination of returns to scale, estimation of total, average and marginal product. The marginal rate of substitution between wheat inputs has also been estimated. The details are given in subsequent sections.

6.3.1 Sample Statistics of Wheat Input-Output

The sample observations of wheat input-output, indicate that the average wheat production of 200 farmers was 1950 Kgs while the maximum and minimum wheat production was 4000 and 350 Kgs respectively. The average size of land holding was 1.5 acre. The usage of TRHW, FERTW, SDW, LABW and PSTW are 4 hours, 3 bags, 50 Kgs, 30 labours and 3 bottles respectively. The statistics are given in Table 6.7.

6.7

Sample Statistics of Wheat Input Output

	WP	WA	TRHW	FERTW	SDW	LABW	PSTW
Mean	1950	1.5	4	3	50	30	3
Maximum	4000	3.6	6	4	55	35	4
Minimum	350	0.2	2	1	40	20	1
Observations	200	200	200	200	200	200	200

Source: Personal calculations

6.3.2 Estimation of Log Linear Production Function for Wheat

The estimated log linear Cobb-Douglas production function is:

$$\ln WP = 4.9900 + 0.6104 * \ln WA + 0.1220 * \ln TRHW + 0.1479 * \ln FERTW + 0.2991 * \ln SDW + 0.2124 * \ln LABW + 0.1041 * \ln PSTW \quad \text{----------eq. 6.3}$$

or in the most general form:

$$WP = 146.936424 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041} \quad \text{---------- eq. 6.4}$$

Where

$b_o = e^{4.9900} = 146.936424$

The results indicate that WA, TRHW, LABW, FERTR and SDW are statistically significant at both 10% and 5% level of significance. PSTR is not statistically significant variable.

According to eq. 6.3 and 6.4, the value of the Wheat Area (WA) elasticity of production (0.6104) indicates that if wheat area increases by 1% and all other

inputs remain unchanged, the wheat production increases by 0.61%. If TRHW increases by 1%, the wheat production increases by 0.12% taking all other variables unchanged. The output elasticities of FERT, SDR, LABR and PSTR are 0.0789123, 0.871245, 0.12487 and 0.004871 respectively which can be interpreted in the same way. Further, the signs and size of the coefficients are according to the expectation and are in line with the economic theory. Value of Durbin Watson statistic (2.14) shows that there does not exist any serious problem of autocorrelation. The results are given in Table 6.8.

Table 6.8

Regression Results of Log Linear Production Function for Wheat

Dependent Variable: ln WP				
Sample: 1 200				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.9900	0.12487	39.96156	0.0018
ln WA	0.6104	0.012457	49.00056	0.0003
ln TRHW	0.1220	0.009871	12.35964	0.0003
ln FERTW	0.1479	0.0045781	32.31035	0.0058
ln SDW	0.2991	0.012481	23.96443	0.0000
ln LABW	0.2124	0.003458	61.42568	0.0063
ln PSTW	0.1041	0.91124	0.11424	0.8862
R-squared	0.65713	Durbin-Watson stat		2.14457
Adjusted R-squared	0.65840			

The R-square and adjusted R-square values are showing that the fit is good. The value of R^2=0.66 shows that 66% of the variations in the (log of) total wheat product is explained by the (log of) included explanatory variables. Most of the explanatory variables have a strong relationship with the dependent variable. To

this end, the stepwise regression has been carried out. The results are shown in appendix-H.

In appendix-H (1), wheat production has been regressed on wheat area only. WA is not only statistically significant at 10% and 5% level of significance but also responsible for changes in the total wheat production, as indicated by $R^2 = 0.65$.

In appendix-H (2), WA and TRHW have been included. The value of R-square increased to 0.70 favours the good fit. In appendix-H (3), WA, TRHW and FERTW have been included and the value of R-square is 0.75 and also indicates that these variables are also responsible for changes in dependent variable (WP). Appendix-H (4) shows that 79% of the variations in the (log of) total wheat product are explained by the (log of) included explanatory variables. Here the included explanatory variables are WA, TRHW, FERTW and SDW. In appendix-H (5), the included explanatory variables are WA, TRHW, FERTW, SDW and LABW. This indicates that 81% of the variations in the (log of) total wheat product is explained by the (log of) included explanatory variables. The inclusion of each explanatory variable and the values of R-square have a strong coordination in these regression results.

6.3.3 Determination of Returns to Scale for Wheat Crop

To explore the input-output relationship, the log linear Cobb-Douglas production function (eq. 6.4) was estimated which also clearly depicts the nature of returns to scale. The sum of all the output elasticities equals 1.50 (i.e. > 1), indicates that wheat production is characterized by increasing returns to scale. The Wald-Test (Table 6.9) also supports the result. The test has the null hypothesis that the wheat production is characterized by constant returns to scale and has only one restriction i.e. $b_1+b_2+ b_3+ b_4+ b_5 + b_6 =1$. As, the Chi-square statistic is equal to the F-statistic times the number of restrictions under test, so the null hypothesis of constant returns to scale is decisively rejected.

Table 6.9

Wald Test Results for Wheat Crop

Sample: 1 200			
Null Hypothesis:	$b_1+b_2+ b_3+ b_4+ b_5 + b_6 =1$		
F-statistic	12.354678	Probability	0.00674
Chi-square	12.354678	Probability	0.00675

Where b_1, b_2 , b_3, b_4, b_5 and b_6 are the coefficients of ln WA, ln TRHW, ln FERTW, ln SDW, ln LABW and ln PSTW respectively.

6.3.4 Estimation of Total Wheat Production at Mean, Maximum and Minimum Values of Wheat Inputs

The total wheat production at the mean, maximum and minimum values of wheat inputs in the sample has been estimated in Table 6.10, by using eq. 6.4. Putting the mean values of wheat inputs, the total estimated wheat production is 1950.44 Kgs. For maximum and minimum values of wheat inputs, the total estimated wheat production is 3996.06 Kgs and 341.19 Kgs respectively.

Table 6.10

Total Estimated Wheat Production at Mean, Maximum and Minimum Values of Wheat Inputs

	Wheat Inputs						Total Wheat Output (Kgs)
	WA	TRHW	FERTW	SDW	LABW	PSTW	
Mean	1.5	4	3	50	30	3	1950.44
Maximum	3.6	6	4	55	35	4	3996.04
Minimum	0.2	2	1	40	20	1	341.19

Source: Personal calculations

6.3.5 Average Estimated Wheat Production at Mean, Maximum and Minimum Values of Wheat Inputs

The wheat production on 1 unit of wheat input (Average Production) at mean, maximum and minimum values of each wheat inputs have been estimated in Table 6.11, using eq. 3.16-3.21. The average product of WA, TRHW, FERTW,

SDW LABW and PSTW at their mean values are 1300, 488, 650, 39, 65 and 650 Kgs respectively. The average product of each input for their maximum and minimum values is also given in Table 6.11.

Table 6.11

Average Estimated Production at Mean, Maximum and Minimum Values of Wheat Inputs

	Average product of Inputs					
	AP_{WA}	AP_{TRHW}	AP_{FERTW}	AP_{SDW}	AP_{LABW}	AP_{PSTW}
Mean	1300	488	650	39	65	650
Maximum	1110	666	999	73	114	999
Minimum	1706	171	341	9	17	341

Source: Personal calculations

6.3.6 Marginal Product Estimation at Mean, Maximum and Minimum Values of Wheat Inputs

To show the responsiveness of the scale of wheat production due to change in the quantity of one wheat input and other stay unchanged, the marginal product of each input has been estimated. These have been calculated by taking the first order partial derivatives with respect to each wheat input of eq. 6.4 one by one. The marginal product at the mean value of WA is 794 Kgs indicating that if wheat area increases by one acre (over 1.5 acre) and all other variables constant, the production will increase by 794 Kgs. Similarly, if the tractor hours for wheat is increased by one unit (over 4 hours) and all other variables constant, the wheat production will increase by 59 Kgs. The marginal product FERTW, SDW LABW and PSTW are 96, 12, 14 and 68 respectively, as given in appendix-K (1).

The marginal product at maximum values of each wheat inputs has been estimated in appendix-K (2). The marginal product at the maximum values of WA, TRHW, FERTW, SDW, LABW and PSTW are 678, 81, 148, 22, 24 and 104 Kgs respectively.

The marginal product at the minimum values of WA, TRHW, FERTW, SDW LABW and PSTW are 1041, 21, 50, 3, 4 and 36 Kgs respectively, as given in appendix-K (3).

6.3.7 Marginal Rate of Substitution of Inputs at Mean Values of Wheat Inputs

To show how the scale of production respond if quantity of one input is changed while others stay unchanged, the marginal rate of substitutions between wheat inputs have been calculated using eq. 3.28 and equations given in appendix C(2). To this end, the ratios of output elasticities are needed which have been presented in Table 6.12.

Table 6.12
Wheat Output Elasticities' Ratios

	Output Elasticities' Ratios					
Output Elasticities' Ratios	b_1= 0.6104	b_2= 0.122	b_3= 0.1479	b_4= 0.2991	b_5= 0.2124	b_6= 0.1041
b_1= 0.6104	1	0.1998689	0.242300131	0.49000	0.34796	0.1705
b_2= 0.122	5.0032787	1	1.212295082	2.45163	1.74098	0.8532
b_3= 0.1479	4.1271129	0.8248817	1	2.02231	1.43610	0.7038
b_4= 0.2991	2.040789	0.4078903	0.49448345	1	0.71013	0.3480
b_5 = 0.2124	2.873823	0.5743879	0.696327684	1.40819	1	0.4901
b_6= 0.1041	5.8635927	1.17195	1.42074928	2.87319	2.04034	1

Source: Personal calculations

The marginal rate of substitution of WA for LABW is 57.48, indicating that one unit of wheat area (one acre area) can be substituted for 57 units of labour without changing the product scale. Similarly, The marginal rate of substitution of WA for FERTW is 8.25, indicating that one unit of wheat area (one acre area) can be substituted for 8 units of fertilizer bags without changing the product scale. The marginal rate of substitutions between various wheat inputs has been presented in appendix-N.

6.4 Econometric Analysis of Maize Input-Output Relationship

This section provides information about the sample observations and econometric analysis of wheat crop. The econometric analysis includes estimation of log linear maize production function, stepwise regression, determination of returns to scale, estimation of total, average and marginal product. The marginal rate of substitution between maize inputs has also been estimated. The details are given in subsequent sections.

6.4.1 Sample Statistics of Maize Input-Output

The sample observations of maize input-output indicate that the average maize production of 200 farmers was 1920 Kgs while the maximum and minimum maize production was 4600 and 230 Kgs respectively. The average size of land holding was 1.5 acre. The usage of TRHM, FERTM, SDM, LABM and PSTM are 4 tractor hours, 3 fertilizer bags, 20 Kgs seed, 35 labours and 1 bottle of pesticides respectively. The statistics are given in Table 6.13.

Table 6.13

Sample Statistics of Maize Input-Output

	MP	MA	TRHM	FERTM	SDM	LABM	PSTM
Mean	1920	1.5	4.0	3	20	35	1
Maximum	4600	3.5	4.8	4	25	40	1
Minimum	230	0.2	2.0	1	15	32	1
Observations	**200**	**200**	**200**	**200**	**200**	**200**	**200**

Source: Personal calculations

6.4.2 Estimation of Log Linear Production Function for Maize

Following is the estimated log linear Cobb-Douglas production function:

ln MP = 3.51008+ 0.64123*ln MA + 0.124587*ln TRHM+ 0.55461*ln FERTM +

0.31244*ln SDM + 0.5874*ln LABM + 0.08248*ln PSTM ---------- eq. 6.5

or in the general form:

$$MP = 33.45094375 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$$ ---------- eq. 6.6

Where $c_o = e^{3.51008} = 33.45094375$

The results indicate that MA, TRHM, LABM, FERTM and SDM are statistically significant at both 10% and 5% level of significance. PSTR is not statistically significant variables. Due to good climatic conditions the farmers rarely used pesticides/insecticides.

According to eq. 6.5 and 6.6, the value of the Maize Area (MA) elasticity of production (0.64) indicates that if maize area increases by 1% and all other inputs remain unchanged, the maize production will increase by 0.64%. If TRHM increases by 1%, the maize production will increase by 0.12% taking all other variables unchanged. The output elasticities of FERTM, SDM, LABM and PSTM are 0.55461, 0.31244, 0.5874 and 0.08248 respectively which can be interpreted in the same way. Further, the signs and size of the coefficients are according to the expectation and are in line with the economic theory. Value of Durbin Watson statistic (1.78), which is closer to 2, shows that there does not exist any problem of autocorrelation. The R-square and adjusted R-square values are showing that the fit is good. The value of R^2=0.73 shows that 73% of the variations in the (log of) total maize product is explained by the (log of) included explanatory variables. The results are given in Table 6.14.

Table 6.14

Regression Results of Log Linear Production Function for Maize

Dependent Variable: ln MP				
Sample: 1 200				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.51008	0.12487	28.10987	0.0000
ln MA	0.64123	0.012457	51.47548	0.0000
ln TRHM	0.124587	0.012	10.38225	0.0003
ln FERTM	0.55461	0.045781	12.11441	0.0011
ln SDM	0.31244	0.012481	25.03325	0.0068
ln LABM	0.5874	0.0248	23.68548	0.0063
ln PSTM	0.08248	0.08124	1.015263	0.73623
R-squared	0.732153	Durbin-Watson stat		1.7758
Adjusted R-squared	0.738987			

The output elasticities values indicate that most of the explanatory variables have a substantial effect of the response variable. The stepwise regression has been carried out for maize crop. The results are given in appendix-I.

In appendix-I (1), maize production has been regressed on maize area (MA) only. MA is not only statistically significant at 10% and 5% level of significance but also responsible for changes in the maize production, as indicated by R^2 = 0.61.

In appendix-I (2), MA and TRHM have been included as explanatory variables. The value of R-square turned out to be 0.67 showing that 67% of the variations in the (log of) total maize product is explained by the (log of) included explanatory variables. In appendix-I (3), MA, TRHM and FERTM have been included yielding the value of R-square equal to 0.71 and also indicates that these variables are also responsible for changes in dependent variable (MP). Appendix-I (4) shows that 77% of the variations in the (log of) total maize product is explained by the (log of) included explanatory variables. Here the included explanatory variables are MA, TRHM, FERTM and SDM. In appendix-I (5), the included explanatory variables are MA, TRHM, FERTM, SDM and LABM which indicates that 80% of the variations in the (log of) total maize product are explained by the (log of) included explanatory variables. The inclusion of each explanatory variable and the values of R-square have a strong correlation with each other.

6.4.3 Determination of Returns to Scale for Maize Crop

To explore the input-output relationship, the log linear Cobb-Douglas production function (eq. 6.6) has been estimated which also clearly depicts the nature of returns to scale. The Sum of all the output elasticities equals 2.50 (i.e. > 1), indicates that maize production is characterized by increasing returns to scale. The Wald-Test (Table 6.15) also supports the result. The test has the null hypothesis that the maize production is characterized by constant returns to scale and has only one restriction i.e. $c_1+c_2+ c_3+ c_4+ c_5 + c_6 = 1$. As, the Chi-square

statistic is equal to the F-statistic times the number of restrictions under test, so the null hypothesis of constant returns to scale is determinedly rejected.

Table 6.15

Wald Test Results for Maize Crop

Sample: 1 200			
Null Hypothesis:	$c_1+c_2+c_3+c_4+c_5+c_6=1$		
F-statistic	17.184579	Probability	0.02354
Chi-square	17.184579	Probability	0.02355

Where c_1, c_2, c_3, c_4, c_5 and c_6 are the coefficients of ln MA, ln TRHM, ln FERTM, ln SDW, ln LABM and ln PSTM respectively.

6.4.4 Estimation of Maize Production at Mean, Maximum and Minimum Values of Maize Inputs

The total maize production at the mean, maximum and minimum values of maize inputs in the sample has been estimated in Table 6.16, by using eq. 6.6. Putting the mean values of maize inputs, the total estimated maize production is 1932 Kgs. For maximum and minimum values of maize inputs, the total estimated maize production is 4698 Kgs and 232 Kgs respectively.

Table 6.16

Total Estimated Maize Production at Mean, Maximum and Minimum Values of Maize Inputs

	Inputs						Total Output (Kgs)
	MA	TRHM	FERTM	SDM	LABM	PSTM	
Mean	1.5	4.0	3	20	35	1	1932
Maximum	3.6	4.8	4	25	40	1	4698
Minimum	0.2	2.0	1	15	32	1	232

Source: Personal calculations

6.4.5 Estimation of Average Maize Production at Mean, Maximum and Minimum Values of Maize Inputs

The maize production on 1 unit of maize input (Average Production) at mean, maximum and minimum values of each maize inputs have been estimated in Table 6.17, using eqs. 3.22-3.27. The average product of MA, TRHM, FERTM, SDM, LABM and PSTM at their mean values is 1288.24, 483.09, 644.12, 96.6186, 55.21 and 1932.37Kgs respectively. The average product of each input for their maximum and minimum values is also given in Table 6.17.

Table 6.17

Average Production of of Maize Inputs at their Mean, Maximum and Minimum Values

	Average product of Inputs					
	AP_{MA}	AP_{TRHM}	AP_{FERTM}	AP_{SDM}	AP_{LABM}	AP_{PSTM}
Mean	1288.24	483.09	644.12	96.6186	55.21	1932.37
Maximum	1304.96	978.72	1174.46	187.9149	117.44	4697.87
Minimum	1160.88	116.09	232.18	15.478	7.255	232.18

Source: Personal calculations

6.4.6 Estimation of Marginal Product at Mean, maximum and minimum Values of Maize Inputs

To show the responsiveness of the scale of wheat production due to change in the quantity of one maize input and other stay unchanged, the marginal product of each input has been estimated. These have been calculated by taking the first order partial derivatives with respect to each maize input of eq. 6.6 one by one. The marginal product at the mean value of MA is 800 Kgs indicating that if maize area increases by one acre (over 1.5 acre) and all other variables constant, the production will increase by 800 Kgs. Similarly, if the tractor hours for maize is increased by one unit (over 4 hours) and all other variables constant, the maize

production will increase by 60 Kgs. The marginal product FERTM, SDM LABM and PSTM are 357, 30, 32 and 158 respectively, as given in appendix-L (1).

The marginal product at maximum values of each maize input has been estimated in appendix-L (2). The marginal product at the maximum values of MA, TRHM, FERTM, SDM, LABM and PSTM are 744, 123, 650, 58, 69, and 385 Kgs respectively.

The marginal product at the minimum values of MA, TRHM, FERTM, SDM, LABM and PSTM are 875, 14, 69, 5, 4 and 19 Kgs respectively, as given in appendix-L (3).

6.4.7 Marginal Rate of Substitution between Wheat Inputs at their Mean, Maximum and Minimum Values

To show how the scale of production respond if quantity of one input is changed while others stay unchanged, the marginal rate of substitutions between maize inputs have been calculated using eq. 3.28 and equations given in appendix C(3). To this end, the ratios of output elasticities are needed which have been presented in Table 6.18.

Table 6.18

Maize Output Elasticities Ratios

Output Elasticities Ratios	Output Elasticities Ratios					
	c_1= 0.64123	c_2= 0.12458	c_3= 0.55461	c_4= 0.31244	c_5= 0.5874	c_6= 0.08248
C_1= 0.64123	1	0.1943	0.8649	0.4872	0.9161	0.1286
C_2= 0.12458	5.1468	1	4.4516	2.5078	4.7148	0.6620
C_3= 0.55461	1.1562	0.2246	1	0.5633	1.0591	0.1487
C_4= 0.31244	2.0523	0.3988	1.7751	1	1.8800	0.2639
C_5 = 0.5874	1.0916	0.2121	0.9442	0.5319	1	0.1404
C_6= 0.08248	7.7743	1.5105	6.7242	3.7880	7.1217	1

Source: Personal calculations

The marginal rate of substitution of MA for TRHM is 13.72, indicating that one unit of maize area (one acre area) can be substituted for 14 units of labour without changing the product scale. Similarly, the marginal rate of substitution of MA for LABR is 25.47, indicating that one unit of maize area (one acre area) can be substituted for 25 units of labour (man days) without changing the product scale. The marginal rate of substitutions between various maize inputs has been presented in appendix-O.

6.5 Summary

This chapter states that the output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides for rice crop were 0.24578, 0.6712, 0.0789123, 0.871245, 0.12487 and 0.004871 respectively. Proportional increase in the output of rice was faster than the increase in the inputs of rice (increasing returns to scale). The total estimated rice production for mean, maximum and minimum values of rice inputs were 2700, 4330 and 600 kgs respectively. The average product of area, tractor hours, fertilizer, seed, labour and pesticides at their mean values were 1800, 540, 900, 67.5, 36 and 900 kgs respectively. At the mean values of the sample, the marginal product of area, tractor hours, fertilizer, seed, labour and pesticides were 443.56, 299.10, 71.20, 50.55, 3.86 and 3.56 kgs respectively.

For wheat crop, the output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides were 0.61, 0.1220, 0.0789123, 0.871245, 0.12487 and 0.004871 respectively. Proportional increase in the output of wheat was faster than the increase in the inputs of wheat (increasing returns to scale). The total estimated wheat production for mean, maximum and minimum values of wheat inputs were 1950.44, 3996.06 and 341.19 kgs respectively. The average product of area, tractor hours, fertilizer, seed, labour and pesticides at their mean values were 1300, 488, 650, 39, 65 and 650 kgs respectively. The marginal product at the mean values of area, tractor hours, fertilizer, seed, labour and pesticides were 794, 59, 96, 12, 14 and 68 kgs respectively. The marginal product at the maximum values

of area, tractor hours, fertilizer, seed, labour and pesticides were 678, 81, 148, 22, 24 and 104 kgs respectively.

For maize crop, the output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides were 0.64123, 0.124587, 0.55461, 0.31244, 0.5874 and 0.08248 respectively. Proportional increase in the output of maize was faster than the increase in the inputs of maize (increasing returns to scale). The total estimated maize production for mean, maximum and minimum values of maize inputs were 1932, 4698 and 232 kgs respectively. The average product of area, tractor hours, fertilizer, seed, labour and pesticides at their mean values were 1288.24, 483.09, 644.12, 96.6186, 55.21 and 1932.37Kgs respectively. The marginal product at the mean values of area, tractor hours, fertilizer, seed, labour and pesticides were 800, 60, 357, 30, 32 and 158 kgs respectively.

Chapter-7

ECONOMIC PRACTICES, SIGNIFICANCE AND CAUSES OF LOW YIELD OF FOOD-GRAIN CROPS CULTIVATION

7.1 Introduction

District Swat has been endowed by nature with vast potentialities for growing food-grains. Farmers are generally satisfied with traditional late-maturing food-grains varieties. These soils are well suited for crop cultivation. Paddy and maize is mostly grown in the Kharif season and is harvested in November and December. While wheat is Rabi crop grown in October-November and harvested in June-July. This chapter intends to highlight the major economic practices undertaken in food grins cultivation followed by its significance in the economy of district Swat. Economic practices implies all those practices relevant to food grain crops cultivation which can make food grain crops economic and profitable if practiced properly.

7.2 Economic Practices in Food Grain Crops Cultivation

Food-grains production practices differ from place to place but it is tried to state all those activities, which are generally practiced in the study area. These practices possess economic significance and if managed properly, the crops can be made most profitable. The important pre and post harvest economic practices undertaken in food-grains crops cultivation are detailed as under:

7.2.1 Usage of land for food grains

Having studied the research area it was observed that most of land was rented on IJARA basis. The payments were paid either at the beginning of production process or after harvesting rice production. Payments were also used to make in the form of grain production. In the research area, usually the rent of land was charged as half of the total production. Due to the existence of chances of

floods, it was negotiated between the owners and tenants in some areas. The actual rent paid varied from place to place but on average Rs.5500 for six months were paid for one acre of land, which is a large share out of total costs.

7.2.2 Conservation of Traditional Varieties

There have been some changes in the methods of farming and the high yielding varieties are now being grown with the traditional food grain varieties. However, apart from the traditional emotional attachment to these inherited varieties, the local farmers are aware that the local varieties have some advantages. They believe it is superior in taste and nutritive value. The old varieties are more resistant to pests and diseases as well as droughts and floods. They do not need more chemical fertilizer or pesticides and insecticides and are therefore quite viable economically as well when the cash input and output are compared. It is quite clear that the local people are aware of the importance of conserving these traditional varieties. Besides, the use of high yielding varieties, which are tolerant to the agro-climatic conditions of Swat, is one avenue by which production and productivity can be increased. Some farmers were found to use certified seed material for cultivation. When seeds are retained from the previous crop, the crop is found to be contaminated with seeds from other varieties and weed seeds. Sowing of mixed varieties often result to loose fair market prices for these crops.

7.2.3 Raising Nursery and Maintenance

High yielding rice cultivation starts from a suitable nursery. Healthy seedlings of a good nursery are tough, have short but erect leaves, and vigorous roots, recover quickly after transplanting, of highly uniform size easy to pull and transplant, and free of diseases and pests. All these characteristics can be obtained through pure seed of improved varieties, seeding density, fertility level of nursery bed, and time of sowing, water management and pest control. As far as the nursery sowing is concerned, the land is ploughed with tractor 2-3 times and the field is irrigated. The weeds germinated after a week is eradicated through ploughing and

planking. During this process water remains in the fields. The field is puddled well and harrowed thoroughly so as to retain equal level of water in the seedbed. The sprouted seed is spread over the puddle bed. During the early few days of growth the water is drained out daily at night. Afterwards, water is kept 2-4 cm deep to suppress weeds. Just enough water should be added to the seedbed to saturate the soil during the first 5-7 days. Afterwards, water should be increased gradually up to 5 cm depending on the height of the seedling to control weeds. These practices are done for rice only rather for maize and wheat.

7.2.4 Land Preparation and Water Management

The methods of land preparation affect food grain yield. Inefficient land preparation was one of the most important causes of poor yields. Through better land preparation of lands weed control becomes possible. It also facilitates easy sowing which is helpful to establish good seed and soil contact. Through effective land preparation easy absorption of moisture, water holding capacity and provision of sufficient aeration is ensured. For rice cultivation, deep ploughing 2-3 times followed by planking is enough to get well-pulverized soil. Mixing of organic matter (rice straw, stubbles, and farmyard manure) improves the soil structure and fertility. After the land is prepared in dry condition, field should be divided in suitable plots for better water management and other operations. It is essential also that an appropriate height of water be maintained in relation to the stage of growth of the crop. To this end, the field is leveled in order to have an even stand of water, to control weeds and to facilitate the complete drying out at harvest time.

Land preparation and water management is necessary for maize and wheat cultivation. There are some stages where water is necessary for maize crop mainly these are seedling, knee- height, tasseling, silking and grain filling stage. Fertile land and timely and balanced water management can increase the efficiency of land to produce more.

7.2.5 Transplanting

When the main field is puddled and leveled thoroughly, transplanting is done. In rice cultivation, the levees (bunds) are properly made and plastered to avoid water loss. During transplanting the water nursery seedlings are brought and distributed throughout the field in small bundles. In wheat and maize cultivation, the final grins are transferred manually in the fields and then proper arrangements are made for channalizing the water in future.

7.2.6 Weed Control

For healthy food grains production hand weeding is a significant factor. Through proper and effective weeding, high rice productivity is ensured. Farmers performed that activity by themselves and in some cases hired labour are used. In rice cultivation, the plant produces seeds by the millions and is usually introduced through the irrigation water as the seeds are small and floats. The seeds will germinate when the water is deep and clear. The duckweed seedlings germinate and grow very slowly and then rapidly expand leaf size, suckers and branches. This process smothers all other vegetation including cultivated rice.

In case of wheat and maize cultivation, this practice is also necessary so as to protect the grain crops from wild plants.

7.2.7 Insect and Disease Control

It is common practice that agricultural productivity is mostly sensitive to pests and diseases. However in the relevant area, it was observed that such like possibility was minimum. In case if it occurs the services of research stations are utilized. Generally, sprays are recommended for this purpose.

The paddy bug attacks the rice grain at two stages. Firstly at the milk stage and secondly at the dough stage. The damage during the milk stage results in unfilled or underfilled grains while damage during the dough stage causes discolored and broken grains after milling. Rice blast was the most important

disease of rice in Swat. This disease caused severe yield reductions whenever it occurred. To follow the situation, the farmers in District Swat used to spray as directed by the agricultural research station. Generally in rice cultivation, Furadan (insecticide) and Machety (weedicides) were used by the farmers.

In wheat and maize cultivation, special insecticides and weedicides were also used by the farmers so as to protect the food grain crops.

7.2.8 Fertility Management

Fertilizer application is considered an important factor for increasing rice productivity. The use of chemical fertilizer has been proven increased rice yield up to 50% when given on proper time and in proper dosage. The major elements required by the crops are nitrogen, phosphorus, and potash, while among the minor elements zinc is the most important. The practices of using farmyard manure or rice straw during puddling economizes the use of chemical fertilizers. Green manuring can reduce the dependence of rice crop on artificial fertilizers. Immediately after rice harvest, green manuring crops like shaptal berseem can be sown and then can be ploughed in by the end May before transplantation. The farmers also use DAP and Urea for rice cultivation. In wheat and maize cultivation, apart from DAP and Urea, NPK was also used by the farmers.They were generally available with the village shopkeepers minimizes the transportation cost. In most villages it was seen that this facility was provided by Karigars (peoples having horses as occupation).

The farmyard manure used at the farm was valued at the village average rate, and for the purchased quantities, actual prices paid were charged. In all the villages, the average price of animal manure was Rs.40 per Horse Bag.

7.2.9 Harvesting and Drying

To get higher paddy yields, it should be harvested just in time. The appropriate time for harvesting ranges from 30-35 days after flowering. This is the stage at which 85-90% of the upper portion of the panicle is straw colored and the moisture content is 20-23%. The water should be stopped from 10-15 days before harvesting. Standing water in the field deteriorates grains if the crop lodges, and also the grain quality are affected. The crop is harvested at the time when there is no dew in the field. Peak grain quality occurs at harvest. Care is taken during the subsequent steps to preserve these quality characteristics in order to meet the high quality standard demanded by domestic and international processors as well as consumers. Maintenance of milling quality during harvesting and drying was a major consideration because value was based on quality. When maize and wheat grains fully matures, dried in the sun light, are then harvested by the farmers.

7.2.10 Threshing and Cleaning

In old days threshing of rice bullocks, obtained on exchange basis, performed paddy but nowadays tractors were used for this purpose in all the research area. Those were easily available and time saving. It finishes all the rice paddy of one acre within one or two hours.

The recommended time for threshing is 2-4 days after paddy harvesting. Threshing methods were included manual and mechanical. Tractors instead of bullocks nowadays practice threshing the paddy. To improve product quality and marketing, proper cleaning played significant role in the research area. This activity was generally performed through the experienced members of the family. In case if it was not available then the required labours were hired. The activity required smooth air to clean the paddy. Maize and wheat crops are also threshed with the help of tractors and are then carefully separated good quality from poor quality. The broken grains are also separated so as get fair prices for their product.

7.2.11 Transportation

The food grains were generally carried through horses of corresponding village Karigars taking their wages in terms of paddy at 20% rate of the total production. During the cropping process of rice, seedlings were properly distributed in small plot for transplanting.

7.2.12 Milling

After cleaned the paddy, it was carried to the local mills and was milled to make it fresh for consumption. At milling time care was taken to voide from broken rice in return. The milling facilities were available at each village level for rice farmers in district Swat. However the mill were not in good conditions rather were badly ventilated, infested with rice and paddy weevil. The mills were also lacking storage and drying spaces. There were on average 1 mill in the villages where rice was grown. Peoples used to prefer small mills because they could mill their production with their own will and interference. The small mills thus were able to produce marketable grades of rice.

The wheat and maize grains were also carried to the floor mills on a fixed milling rate. In district Swat there was a certain amount of competition, and a few mills were willing to mill at lower cost as compared to other mills. The mill owners thus used to advance loans interest-free to farmers.

7.2.13 Storage

Farmers seldom used to store paddy. However, rice mills used to store it for a short period. Milled rice was also stored by the rice farmers rarely. Rice undergoes certain changes during storage in the first 3 to 4 months after harvest. These changes improve rice quality, making it more acceptability to consumers. For satisfactory storage of rice the moisture content is kept before 9%. Fumigation in storage, insect proofing of bags, and dis-infestation with inorganic salts are all measures, which can successfully be applied under our conditions. However

efforts were made by the owners to ensure that the warehouse/store was in good condition for storage of the grain. Warehouse/storage areas were be properly cleaned. All refuse were removed and burnt. Areas around the warehouse/storage area were cleaned with care taken to remove vegetation, refuse, and discarded machinery which only served as breeding ground for rodents and insects.

7.2.14 Record Keeping/Stock Control

In case of surplus production, the food grains were transferred to warehouses either private or government. Checks were made to have proper record of food grains bags so s to avoid any theft or loss. Domestic shopkeepers generally performed this activity. No food grain was allowed to leave the warehouse before taking proper permission from the manger.

7.2.15 Straw Management

Rice straw can be used for various purposes. In district Swat rice straw was mostly used for livestock as well as for commercial purposes. It has a good market in local economy. The farmers also used the wheat straw (Boosa) and maize straw (stalk) mainly for livestock.

7.2.16 Marketing of Food Grain Crops

Effective marketing provides food production to users when, where and in them form they want. The produce of food grain crops was used to sell by the food growers mainly in small markets. However, some of Beoparis, commission agents and Arthiyas used to purchase the farmers produce and then re-selled in big markets. The poor farmers did not get fair prices for their products due their requirement of cash for day-to-day consumption. The farmers also used to keep some portion of their produce in their homes and then sell to village shopkeepers for their daily requirement.

7.3 Economic Significance of Food Grains Crops Cultivation

Food grains played a vital role in the economy of District Swat. Food grains is most closely connected with capital and labour employment, sources of income, marketing activities, credit and financing, labour distribution, returns and surpluses and decision-making. The subsequent sections will provide knowledge about the assessment of rice cultivation in connection with economic variables of food grain economy of district Swat.

7.3.1 Food Grains Cultivation as a Sources of Income

Agriculture was the largest sector of the district economy. The topography of the district was such that not all the land was suitable for cultivation. Most of the cultivation was carried out in the southern areas of the district, mainly in Mingora, Barikot, Kabal, Matta and Khwazakhela.

For the rural population, agriculture was the main source of livelihood. Rice maize and wheat grains alongwith straw were the source of farmers' income. They used these products at home or sold them to supplement their cash income.

Food sustenance by the villagers is generally derived by their own farm products. However, some families lived mainly on food obtained from other occupations. Primary food supplies such as rice, wheat, onion or vegetables were in short supply there. Natural threats to the food supply included floods, droughts and insect plagues.

For the rice farmers, animal husbandry was another subsidiary income and also provided a good source of the family's dietary needs. Cattle, buffalo, cow and poultry were the major livestock there. Villagers occasionally sold but rarely consumed those animals. For villagers, to feed their livestock on free grazing lands was common practice.

The average food grain grower has cow, goats, sheep or poultry as secondary source of income. When he is not engaged in agriculture activities, he

sells his labor locally or outside of the area. But apart from it, agriculture was the main source of income of the rice farmers. Some rice farmers had their own shops in the villages while some were found investing their incomes in animal trade. They were relying on subsistence level of farming. Some members of the family were carpenters, masons, and public school teachers and very few of them were Govt. servants. Foreign remittances were also the main component of non-agriculture incomes.

As most of the villagers derive their food sustenance from farm products so they were thus dependent on nature for their livelihood because there was chances of natural threats like floods, droughts and insect plagues Agriculture products like rice, wheat, maize, onion or vegetables were in short supply there. "Roti" made of wheat or maize flour was the staple diet of the local people in district Swat. The green tea in general and particularly milk tea was very popular in the district.

The major crops cultivated in the villages were onion, wheat, maize, tomato and vegetables. However, in Kharif season rice was mainly grown on area situated near river Swat. After the harvesting of the rice onion and/or wheat were cultivated. Some fruit trees like grape, mango, plum, watermelon, apricot, pear and walnut were also grown in the study area. Due to the lack of precipitation during the dry season and the lack of any irrigation system, local people tend to rely on rain-fed agriculture.

7.3.2 Labour Force Employment in Food Grain Cultivation

Food grains cultivation was of great social significance precisely because it was organized on the basis of small forms rather than large and it provided the largest share of total labour employment to the local community. Food grains were labour intensive crops, which included hired and family labour. On average Rs.120 per day was given to that particular skilled labour.

Food grains cultivation in district Swat mobilized family labour for certain operation, and was in many cases a part-time activity, there were no reliable figures on the size or composition of the labour force employed. However, in the field survey, informations were obtained about the average amount of labors employed on the cultivation of one acre of the three major crops namely rice, maize and wheat. Many of those farmers spent a part of their time working in other areas, but it is not false that food grains cultivation absorbed a large proportion of the total labour force of the local community. At the period of peak activities like transplanting and harvesting, it took local as well as non-local labors into account. At transplanting stage Rs.120 was paid to each labour for his services of eight hours approximately. All the transplanting activities were done at morning. The average age of labour force involved in the production activities was ranging from 12-45 years.

A normal working day was about eight hours. Women used to help in some of the operations like transplanting and reaping out. In case they worked, they used to return home earlier than men, as they must cook the meal. Their working day was therefore a little shorter, but on average this was balanced by men who sometimes work more than eight hours. Sons who had left school used to assist their fathers for various operations in food grains cultivation like ploughing, raking, preparing seed beds and threshing. Because they were still living in their father's home and they must act upon the orders of their fathers. For both male and female tasks it was customary for groups of workers to cooperate by working on each other's land in turn. This method was used for ploughing, raking, reaping, threshing and even work connected with milling. In the study area a straight wage labour system as well as labour exchange system was existed. The amount of time or number of persons available for work also depended on some social factors. On Friday they necessarily had to attend the mosque.

In rice crop cultivation on average 55 labours (man days) costing Rs. 6600 per acre were used for various activities in its cultivation. The activities alongwith man-days are given in Table 7.1.

As the total area under rice crop in district Swat is 18372 acres in 2006-07, it means that it takes into account approximately 1010487 labour man-days for its cultivation.

Table 7.1

Average Amount of Labour for Various Operations in Rice Crop Cultivation

Operation	Quantity	Total Cost (Rs.)
Land Preparation	1	120
Raising nursery	7	840
Transplanting	15	1800
Irrigation	4	480
Cleaning/handling	7	840
Pesticides	3	360
Harvesting	10	1200
Threshing	8	960
Total cost (Rs.)	55	6600

Source: Field survey

In wheat crop cultivation, on average 30 labours (man days) costing Rs. 3600 per acre for various operations (from sowing to threshing) were used. As the total area under wheat crop in district Swat is 155342 acres in 2006-07, it means

that it takes into account approximately 1864110 labour man-days for its cultivation.

In maize crop cultivation, on average 35 labours (man days) costing Rs. 4200 per acre for various operations (from sowing to threshing) were used

As the total area under maize crop in district Swat is 156282 acres in 2006-07, it means that it takes into account approximately 5469887 labour man-days for its cultivation.

7.3.3 Capital Employment in Food Grain Cultivation

Majority of farmers owned at least one pair and those who do not have used rented oxen pairs. Oxen were considered the chief source of power. In case when there were heavy rain the tractors could not work satisfactorily, and the farmers then necessarily used oxen pairs. The oxen were used for various operations like ploughing, short haulage, harrowing and threshing. But nowadays the tractors are used for ploughing and threshing. The price of rented oxen pair was observed Rs. 500 per pair. On the other hand cost of tractor was found Rs. 200/hr for ploughing and for threshing rice paddy it charges Rs. 300/hr.

In food grains cultivation, the farmers used light hand-ploughs, drawn by oxen. Harrows are made from a long plank studded with large nails, and the farmer stands on this as it is drawn across the field by oxen. The farmers were threshing their paddy by driving over the straw with a tractor rather to use bulls to tread out the grain. Cutlasses, forks and sickles were normal equipment in most households. The sickles were used for reaping food grains.

7.3.4 Woman Participation in Food Grain Cultivation

None of the women folk of the household worked for wages in district Swat. They used to help with the family in some operations of food grains cultivation. They helped the family to sew the children's clothes, cook, wash and keep the home scrupulously clean.

7.3.5 Labour Opportunities and Decision Making in the Households

Women in the agrarian economy of district Swat had less opportunity than men in availing labour opportunities. Some women belonging to the most ethnic group were engaged in craft production for family use and sometimes for sale. Beyond that household maintenance and childcare was the primary duty of Swati women. Though female children and grand parents participate in various activities but men were considered the undisputed heads. They made all the important decisions about their families. Decisions about expenditures were made by men but in various cases like saving money and dealing traditions, women generally used to take the decisions.

7.3.6 Labour Distribution within the Villages

The distribution of labour in the district depends upon the nature of occupation and skill. Some people performed their services on permanent jobs. Some were working on daily wages basis. Some workers were found working together in groups' forms. Coordination and mobilization of laborers was the responsibility of the head who served as a conduit for the transfer of information and to arrange and select appropriate workers. Those of labours were seen in agriculture sector and lantering as well. In the process of rice production it was seen at transplanting and harvesting stage. Cooperation and mutual help was the strong traditions of the villagers. They used to contribute each other when somebody requires assistance in food grain cultivation process.

7.3.7 Food Grain Marketing

The majority of the small and medium size farmers sold their produce in the village markets, while the big growers with heavy surpluses preferred to sell their produce outside the village markets including commission agent and big shop keepers. The produce was then routed to the terminal markets, which were generally situated in large urban centers. In those markets, big wholesalers

operated, who provided products to the millers, retailers and exporters. The marketing of all food grains produce in District Swat was controlled by local markets. The farmers used to retain small quantity for home consumption. Some of farmers used to sell their produce to the mill owners, because those owners used to provide loans on soft conditions to the farmers. The production was then reselled in big cities where they get some fair prices for their products. The food grain production ensures effective marketing structure in the district economy. Lot of intermediaries will not only be employed there but also be the source of income for these market functionaries. This will not only extend the existing food markets but will also be proven as a push for motivating the terminal markets.

7.3.8 Credit and Financing for Food Grain Cultivation

Credit facilities available to food grain growers were inadequate in district Swat. The farmers mostly used non-institutional loans for farm activities mainly purchasing seed, fertilizer and pesticides. The farmers also used to utilize such loans for house construction or repairs, for domestic consumption or to finance weddings and some was used to buy oxen. If more adequate agricultural extension services were available it would be desirable to offer more closely supervised credit, and to tie it to the provision of better seed, fertilizer or livestock improvement. There had been an increase in the prosperity of the local community in recent years, and that was partly reflected in the number of new houses, which have been built. Provision of agriculture credit and utilization of loans will not only strengthen the banking structure but will also have a positive impact on the economy of district Swat. The disbursement of agriculture credit for small farmers on soft conditions will increase food grain productivity.

7.3.9 Consumption Pattern of Food Grain Growers

Most of the villagers derive their food sustenance from food grain cultivation and the revenue generated thus has a strong relation with consumption pattern of food grains growers' internal economy. The pattern of expenditures also

indicates the true picture of standard of living of a particular community. Whatever is earned from food grain cultivation, are then used for various heads of daya-to-day expenses. The heads of expenditures of food growers were mainly food items, clothing, education, health, electricity and housing. The expenditures on these items depend upon the health of food grain production. In subsequent sections, the consumption pattern of food grains growers of the district has been discussed.

7.3.9.1 Food Item Expenditures of Food Grain Growers

Food items included beef, mutton, tea, chicken, sugar, ata, vegetables, eggs, and fruits. The average expenditures on this head were Rs.4000 per month, which is 47% of the total expenditures as given in figure 7.1. The total expenditures on this head were low indicating that the farmers were mostly belonging to low income families. Household food consumption is more sensitive to price fluctuations and severely affect the family budget.

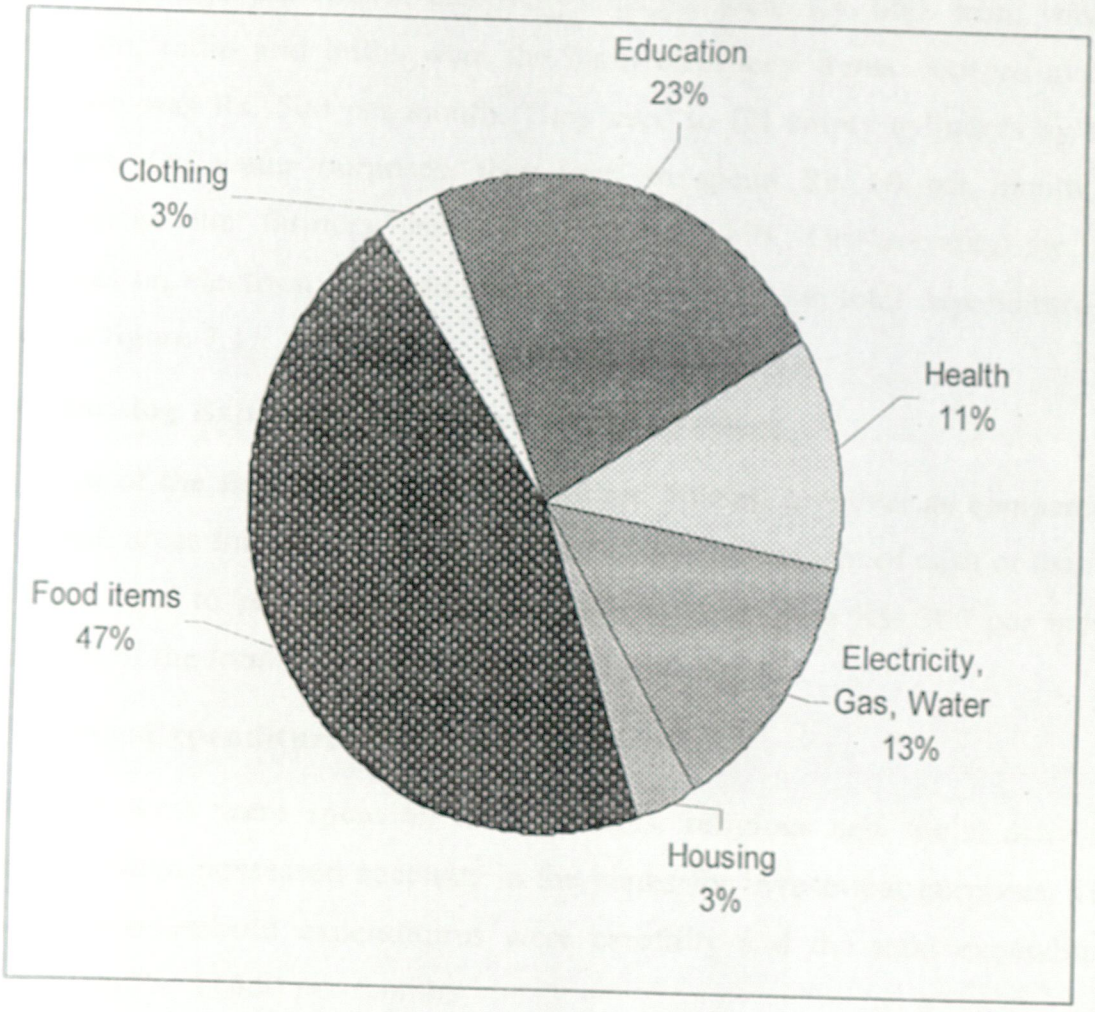
7.3.9.2 Clothing Expenditures of Food Grain Growers

Clothing expenditures are not regularly done. However, for their families, before Eid they used to buy new clothes. The average consumption was Rs. 300 per month, which is 3% of the total expenditure, as given in figure 7.1. Simple garments are worn by most of Swati people. However, in some special occasions they wear special dresses like in the days of Eid and marriages.

7.3.9.3 Educational Expenditures of Food Grain Growers

Most of the farmers were not able to admit them due to financial constraints. Therefore, they used to admit children in government schools rather private schools. Education expenditures were included on textbooks, uniforms and transportation. On average, Rs. 2000 per month, which is 23% of the total expenditure, was used to spend on this head, as given in figure 7.1.

Figure 7.1: Food Grain Growers Consumption Pattern (per month)



7.3.9.4 Health Expenditures of Food Grain Growers

Health expenditures was not a regular component however it has been tried to find average monthly amount spent on this head. Headache, toothache, cold, fever, stomachache and soar throat were the main component in health expenditures. Total average expenditures were estimated as Rs. 1000 per month, which is 11% of the total family expenditures, as given in figure 7.1.

7.3.9.5 Electricity, Gas and Water Expenditures of Food Grain Growers

The average per month electricity charges were Rs. 600. Iron, washing machine, fan, radio and bulbs were the main electricity items. Sui-gas average consumption was Rs. 500 per month. They used to fill empty cylinders by town shopkeepers. On water purposes, they used to spend Rs. 60 per month. On monthly basis, the farmers used to pay water bill. On average, the total expenditures on electricity, gas and water were 13% of the total expenditures, as depicted in figure 7.1.

7.3.9.6 Housing Expenditures of Food Grain Growers

Most of the farmers used to live in hired houses; however as compared to that of urban areas they were less expensive. Either in the form of cash or manure, the farmers used to pay rent. House rent expenditures were Rs. 300 per month, which is 3% of the total expenditures, as given in figure 7.1.

7.3.9.7 Other Expenditures of Food Grain Growers

Large sums were spent on the marriages, religious and social activities. Very few of them possessed accounts in the banks for investment purposes. They used to plan household expenditures were carefully and the total expenditures recorded were Rs. 11460 per month.

7.3.10 Food Grain Production and Price Fluctuations

The food grain prices were sensitive to its production in the district. As food grain production is nature-dependent, may be high or low, extremely affect and food grain prices. In some cases, there may be shortage of food grain and can also affect the prices of other commodities in the district.

7.3.11 Food Grain Cultivation and Poverty Alleviation

Food grain cultivation represents the way of life for most of the rural rice farmers in district Swat. It is agriculture sector in general and particularly food

grain cultivation from which the poor farmers derive their food sustenance from farm products. Any improvement in food grain productivity leads towards improvement in the standard of living of the poor farmers. Expenditures are financed through revenue generated from food grain crops. In case, when natural calamities exist, food grain productivity becomes low which creates socioeconomic problems for the farmers. The productivity in bulk leads reducing the poverty in the district. The farmers used to start small businesses especially animal trade and small shops. Each of the farmer gave the perception to construct houses for themselves if got sufficient resources. Further, most of the farmers expressed their views to extend their agriculture activities to other crops, vegetables and horticulture. Having sufficient food grain productivity, most of the farmers intended to repay the debts to village shopkeeper and relatives who were waiting for their products to be harvested as early as possible. The food crops also affect the style of the farmers

7.3.12 Food Grain and Self-sufficiency

Food items were he major heads of expenditures of the food growers in the district. When nature favours the food grain productivity becomes high and thus save the resources of the farmers. The farmers used to retain some food grain for their own consumption in homes while the rest was sold in the local markets. The health of food diets of the farmers depended on revenue generated from food grain cultivation. It was hard for the poor farmers to purchase food grain for their own consumption if not provide by themselves.

7.3.13 Food Grain and Extension of Markets

It was also observed that the farmers having sufficient productivity were willing to purchase various products like bicycle, Television, radio, sewing machines, fans, hand cart, telephone and other commodities used in day-to-day life. Mostly, the farmers intended to purchases Chinese products available in local markets in district Swat. The farmers mostly purchase the day-to-day commodities

from the village shopkeepers and they were also depended upon the revenue generated to the farmers. The revenue thus obtained has a strong impact on local markets of the district to be further extended.

The maize productivity further creates good market for locally so-called "Poli Market" whose products are sold within streets of the villages in the district. Further, from yellow and white grain, some of the people "locally called BUT" used to derive their food sustenance from it.

7.3.14 Strengthening Fertilizer Business

In the district, there were lot of fertilizer shops, which used to provide fertilizer to the farmers like DAP, Urea and NPK, which are the key inputs for food grain productivity. The high yield of food grain crops will increase the purchasing power for fertilizer and so the fertilizer industry and fertilizer businesses will further be motivated.

7.3.15 Impact on Food Grain Maden Commodities

In the district there were small-scale industries like backers shops, small biscuits firms, bread maker firms whose prices mostly depended on food grain production. Any shortages in food grain production, will lead severe fluctuation in the products of these small-scale industries. This burden will further be transferred to the village shopkeeper and ultimately the village consumers in the district.

7.3.16 Impact on Farm Mechanization

Higher and higher food grain productivity higher will be the income of the farmers and ultimately higher will be their purchasing power. Most of the farmers in the study area were poor and were not in a position to use modern implement in its cultivation. This is the income with which they can use advanced tools in the cultivation process of food grains. So, the higher productivity has a positive impact on farm mechanization.

7.3.17 Bridge the Gap for Food Grain Shortages

Agriculture productivity is mostly dependent of nature. If nature favours higher will be the productivity and vice versa. The climatic conditions in the province and even in the district are not similar. There may be the chance of shortage in food grain production, which possess adverse impact on food grain marketing, milling, their prices and even it may not be available in one or some the areas. The gap may be bridged up by the production of the other areas.

7.3.18 Source for other Sources of Income

In the District it has also been observed that most of the farmers intended to investigate for foreign labour visas for one or more of the family members aiming to work there and to support their family through foreign remittances. The foreign remittances are further used for generating farm and non-farm incomes.

7.3.19 Impact on Children Education

Most of the farmers wanted to admit their children in private schools rather government schools for getting better education. It is possible only when they have sufficient income and the income depended upon the health food grain productivity. The education then can be a contributive factor for the development of the district.

7.3.20 Reduction in the Social problems

Most of the farmers stated that the involvement of the family members in food grain cultivation not only contribute to the family but also a mean to avoid them from social evils in the district. There for it is better to engage them in such like activities.

7.3.21 Food Grain Production and Cultural & Religious Activities

Marriages of the daughters and sons were also bind up with revenue generated from food crops. The farmers used rice in traditional occasions like

marriages, deaths and births. The farmers use a mixture of food grain in some occasions like "Hasanain". The farmers also used rice food in other cultural like "Sunat of Children". They also used to give alms to the beggars in kind of rice, wheat and maize. Similarly, the farmers cook rice at the end of Holy Quran in their homes or in mosques. The farmers also used to compensate their "Mullas" either in cash or in kind of wheat or maize. The farmers also used to compensate the village "Kasabgar" by food grains in the villages.

7.3.22 Extension in the Market for Tractors and Threshers

Now a days, for the land preparation in rice, wheat and maize cultivation, tractors are used. Threshers are also used for these three crops. Higher productivity will further extent the market for tractors and threshers. In thresher at least one driver and for tractor one person was employed. They used to take their charges either in cash in land preparation and in kind for threshing.

7.3.23 Food Grain and Sense of Brotherhood

In food grain cultivation, in the study area, both hired and volunteer labours were used. The volunteers were mainly friends and relatives. The volunteers used to work free of cost but they expect also the same for whom the work was done. Locally it called "Ashar" which is a kind of working as a labour in exchange.

7.3.24 Increase in Livestock Production

In the study area, each of the farmers possesses at least one cow, from which he used to derive milk for their own consumption. But it was possible when they possess food for their livestock. Food for livestock was available from rice starw, wheat boosa and maize stalk. The increase in the livestock was observed when they have more and more of food crops' straw. In more food crops cultivation in general and particularly, rice, wheat and maize, will thus increase the livestock production in the study area.

7.4 Causes of Low Yield Per Acre in District Swat

In the field survey, the perceptions of the farmers about the problems relevant to food grain cultivation were noted. Following were the important causes of low yield per acre in district Swat.

7.4.1 Fragmentation of Holdings

In the research area land has been divided into small plots. Land owned by a person is scattered over different parts. On this account, improved agricultural implements cannot be applied. Crops cannot be safeguarded. Due to this, food grain yield per acre remained low.

7.4.2 Scarcity of Capital

Swati farmers were mostly poor. Due to low income, capital usage was inadequate. The farmers could utilize land properly. Hence it caused low food grain yield per acre.

7.4.3 Usage of Primitive Methods of Farming

The farmers in the study area were using out-dated and primitive implements. Mostly cultivation was carried on with animals and plough. Because of improper cultivation, the output per acre was low.

7.4.4 Illiteracy

Majority of Swati farmers were illiterate and ignorant. Primitive practices were used instead of improved practices. Extravagant and unnecessary expenses were carried on. Hence food grain production per acre was too low.

7.4.5 Inferior Quality Seed

Most of the farmers used traditional varieties instead of improved varieties, which caused low yield per acre. JP-5 was very common in the area although profitable varieties of rice existed. However, it was not sufficient for the market

demand. The farmers used to store a little portion of grains for seeds, which was damaged by insects. The farmers could not procure better quality seeds for lack of money.

7.4.6 Inadequate Fertilizer

The farmers in the relevant area did not use the recommended fertilizers of Agriculture Research Stations and did not use sufficient doses of fertilizers. This caused low paddy yield per acre.

7.4.7 Lack of Credit

As most of the farmers in district Swat were poor and having low income, the required capital was inadequate. The farmers were not given credit on easy rate of interest so that they may improve their land production of food grain by applying modern agricultural implements. So, due to non-availability of credit the rice yield per acre was too low.

7.4.8 High Prices of Inputs

The per-acre yield of food grain was too low due to highest prices of form inputs in the district. If the inputs had given to the farmers at appropriate prices, the farmers would have utilized the inputs adequately.

7.4.9 Marketing Facilities

The farmers in the research area were not getting fair prices for their production. Weights and measures were not uniformed. There were large number of middlemen between the consumers and the farmers and they got their share and as a result, farmers' income was reduced. Farmers could not take their produce to cities and they preferred to sell them in village because they could not bear high expenses in market cities. Therefore they were forced to sell at low prices.

7.4.10 Lack of Transport and Communication Facility

Means of transport and communication were inadequate, insufficient, expensive and backward in the research area. Bad roads not only add to cost, but also lead to increase in number of dealers and middlemen. So under these conditions farmers could not take their food grain production to market and sold them at a low price. So they more often sold them to the village money shopkeepers or traveling merchant for a very low price.

7.4.11 Lack of Storage Facilities

In the research area, storage facilities were very limited and as such cultivators were forced to sell their food grain production soon after the cutting of the harvest. In harvesting time there was greater supply of food grain production as a result prices fall and merchants took advantages of this weakness of the cultivators. They used to exploit them buying at low prices.

7.4.12 Land Ownership

As most of the farmers in district Swat did not possess their own land, they were deprived of a greater portion of their produce. Landowners were mainly interested in extracting as much money/produce from the farmers as they could and they paid no attention for the improvement of land.

7.4.13 Selection of Appropriate Varieties

High yield depends upon to grow appropriate food grain varieties in general and particularly of rice, wheat and maize. The farmers still grow the traditional varieties of rice maize and wheat rather improved and profitable varieties. The farmers don not grow those varieties according to the climatic conditions of the district, which caused low yield per acre in district Swat.

7.4.14 Selection of Recommended and Certified Seed

Most of the farmers practiced conservation of traditional varieties. The farmers do not take care for using those certified seeds of food grain, which are recommended for cultivation in particular areas of the study area. If the farmers grow only those seeds, which are recommended by the agriculture research station of district Swat, food grain productivity can be increased.

7.4.15 Marketing of Food Grains

Most of the farmers do not get fair prices for their products due to the exploitation of middlemen in the study area. Some of the farmers were compelled to sell their produce at low prices to these middlemen because they have no access to terminal markets. Due to advancing some loans from these middlemen, the farmers were exploited for their products. Further, the farmers did not present food grains in competitive form. The product were not properly graded and weighted.

7.5 Summary

The pre harvest economic practices in food grain crops cultivation were land use, conservation of traditional varieties, raising nursery and maintenance, land preparation and water management, transplanting, weed control, insect and disease control and fertility management. The post harvest economic practices were drying, threshing and cleaning, transportation, milling, storage, record keeping/stock control and straw management.

Food grain crops cultivation was strongly associated with sources of income, labour force and capital employment, woman participation in food grain cultivation, labour opportunities and decision making in the households, labour distribution, food grain marketing, credit and financing, consumption pattern, price fluctuations, poverty alleviation, self-sufficiency in food grain, extension of markets, strengthening fertilizer business, prices of food grain maden commodities, farm mechanization, food grain shortages, children education,

reduction in the social problems, cultural & religious activities, extension in tractors and threshers, sense of brotherhood and livestock production.

Food grain cultivation was the main source of livelihood of the farmers. Decisions about farm operations were generally made by men. The produce of food grain was generally sold in local markets. The farmers mostly used non-institutional credit. The major head of expenditures was food items. Causes of low yield per acre in District Swat were fragmentation of holdings, scarcity of capital, usage of primitive methods of farming, illiteracy, inferior quality seed, inadequate fertilizer, cemented water channels, lack of credit, high prices of inputs, marketing facilities, lack of transport and communication facilities, lack of storage facilities and land ownerships.

Chapter-8

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This chapter intends to present the concise findings derived from the study. Conclusions based on finding of the study followed by appropriate suggestions have also given in this chapter.

8.2 Summary Findings of the Study

In this section, findings relevant to each crop i.e. rice, wheat and maize have been given. Details are given in subsequent sections.

8.2.1 Findings Relevant to Rice Crop

Following are the major findings relevant to rice crop in the study:

1. In the study area the rice varieties grown were JP-5, Basmati-385, Sara Saila, Swat-1, Swat-2, Dil Rosh 97 and Fakhr-e-Malakand. Its growers were 40%, 7.5%, 12.5%, 7.5%, 7.5%, 12.5% and 12.5% of the total growers respectively.
2. The cost components for each variety of rice were land preparation, raising nursery, fertilizers, transplanting, irrigation, cleaning/handling, pesticides, harvesting, threshing, gunny bags charges and land rent.
3. The revenue components for each variety of rice were rice paddy and straw.
4. The per acre cost of variety JP-5, Basmati-385, Sara Saila, Swat-1, Swat-2, Dil Rosh 97, Basmati-385 and Fakhr-e-Malakand were Rs. Rs.16385, Rs. 16271, Rs. 16235, Rs. 16185, Rs. 16235, Rs. 16295 and 16295 respectively while the per acre total revenues were Rs. 44, 000, Rs. 54, 900, Rs. 42, 500, Rs. 33700, Rs. 35, 300, Rs. 35, 300 and Rs. 55, 500 respectively.
5. The Benefit Cost Ratios for these varieties were 2.69, 3.37, 2.62, 2.08, 2.17, 2.16 and 3.41 respectively, indicated that Fakhr-e-Malakand was the most profitable variety of rice as compared to all other rice varieties.

6. The average size of area of rice farmers was 1.5 acres, used 5 tractor hours, 75 labours, 3 bags of fertilizer, 40 Kgs seed and 3 bottles of sprays for pesticides/insecticides.

7. Area, tractor hours, labour and seed were found statistically significant at both 10% and 5% level of significance. Fertilizer was significant at 5% level of significance only. PSTR was not statistically significant variables.

8. The output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides were 0.24578, 0.6712, 0.0789123, 0.871245, 0.12487 and 0.004871 respectively. If rice area is increased by 1% and all other inputs remain unchanged, the rice production will increase by 0.24%.

9. Value of Durbin Watson statistic (1.91) shows that there does not exist any problem of autocorrelation. The high value of R^2=0.72, showed that the fit was good.

10. The stepwise regression indicated that all the included explanatory variables except pesticides have a substantial effect on the response variable.

11. In the log linear Cobb-Douglas production function, the sum of all output elasticities equal 1.9969 (i.e. > 1), indicated that rice production was characterized by increasing returns to scale (also supported by Wald-Test results).

12. The total estimated rice production for mean, maximum and minimum values of rice inputs were 2700 Kgs, 4330 Kgs and 600 Kgs respectively.

13. The average product of area, tractor hours, fertilizer, seed, labour and pesticides at their mean values were 1800, 540, 900, 67.5, 36 and 900 Kgs respectively.

14. The marginal product at the mean values of area was 443.56 Kgs indicated that if rice area increases by one acre (over 1.5 acre) and all other variables constant, the production will increase by 443.56 Kgs. The marginal product of tractor hours, fertilizer, seed, labour and pesticides were 299.10 Kgs,

71.20 Kgs, 50.55 Kgs, 3.86 Kgs and 3.56 Kgs respectively. The marginal product at the maximum values of area, tractor hours, fertilizer, seed, labour and pesticides were 281.84, 461.77, 81.42, 79.92, 6.44 and 5.03 respectively. The marginal product at the minimum values of area, tractor hours, fertilizer, seed, labour and pesticides were 281.84, 461.77, 81.42, 79.92, 6.44 and 5.03 respectively.

5. The marginal rate of substitution of area for labour was 98.41, indicated that one unit of rice area (one acre area) can be substituted for 98 units of labour without changing the product scale. The marginal rate of substitution of area for fertilizer is 6.23, indicated that one unit of rice area (one acre area) can be substituted for 6 units of fertilizer bags without changing the product scale.

8.2.2 Findings Relevant to Wheat Crop

The major wheat varieties grown in the study area were Saleem-2000, Haider-2002, Khyber-87, Noshera-96, Tatara, Bakhtawar-92, Auqab-200, Suleman-96, Fakhri-Sarhad, Pir Sabak-2004 and Pir Sabak-2005 whose growers were 11%, 13%, 8%, 13%, 8%, 7%, 5%, 6%, 19%, 6% and 4% respectively.

The cost components for each variety of wheat were land preparation with tractor, seed, fertilizers, threshing (with tractors), labour charges, bags charges and land rent.

The revenue components for each variety of wheat were wheat grains and wheat Boosa.

The per acre cost of variety Salim-2000, Haider-2002, Khyber-87, Nowshera-96, Tatara, Bakhtawar-92, Auqab-2000, Suleman-96, Fakhre-Sarhad, Pir Sabak-2004 and Pir Sabak-2005 were Rs. 17, 960, Rs. 17, 710, Rs. 17, 460, Rs. 17, 860, Rs.17, 710, Rs. 17, 860, Rs. 17, 710, Rs. 17, 710, Rs. 17, 585, Rs. 17, 710 and Rs. 17, 710 respectively while the total per acre revenues were Rs. 39, 000, Rs. 29, 700, Rs. 36, 500, Rs. 34, 000, Rs.

31, 400, Rs. 39, 800, Rs. 37, 600, Rs. 34, 000, Rs. 41, 500, Rs. 30, 600 and Rs. 31, 500 respectively.

20. The benefit cost ratios for these varieties were 2.17, 1.68, 2.09, 1.90, 1.77, 2.23, 2.21, 1.92, 2.36, 1.71 and 1.78 respectively indicated that Fakhr-e-Sarhad was the most profitable variety as compare to all other varieties.

21. The average size of land holding of wheat farmers was 1.5 acre. The usage of tractor hours, fertilizer, seed, labour and pesticides were 4 hours, 3 bags, 50 Kgs, 30 labours and 3 bottles respectively.

22. The regression results indicated that area, tractor hours, labour, fertilizer and seed were statistically significant at both 10% and 5% level of significance as against pesticides, which was not statistically significant variable.

23. The wheat area (WA) elasticity of production indicated that if wheat area increases by 1% and all other inputs remain unchanged, the wheat production will increase by 0.61%. The output elasticities of tractor hours, fertilizer, seed, labour and pesticides were 0.1220, 0.0789123, 0.871245, 0.12487 and 0.004871 respectively.

24. Value of Durbin Watson statistic (2.14) shows that there does not exist any problem of autocorrelation. The high value of R^2=0.66, showed that the fit was good.

25. The stepwise regression indicated that all the included explanatory variables except pesticides have a substantial effect on the response variable.

26. In the log linear Cobb-Douglas production function, the sum of all output elasticities equal 1.50 (i.e. > 1), indicated that wheat production was characterized by increasing returns to scale (also supported by Wald-Test results).

27. The total estimated wheat production for mean, maximum and minimum values of wheat inputs were 1950.44 Kgs, 3996.06 Kgs and 341.19 Kgs respectively.

28. The average product of area, tractor hours, fertilizer, seed, labour and pesticides at their mean values were 1300, 488, 650, 39, 65 and 650 Kgs respectively.

29. The marginal product at the mean value of area was 794 Kgs indicated that if wheat area increases by one acre (over 1.5 acre) and all other variables constant, the production will increase by 794 Kgs. The marginal product for tractor hours, fertilizer, seed, labour and pesticides were 59, 96, 12, 14 and 68 Kgs respectively. The marginal product at the maximum values of area, tractor hours, fertilizer, seed, labour and pesticides were 678, 81, 148, 22, 24 and 104 Kgs respectively. The marginal product at the minimum values of area, tractor hours, fertilizer, seed, labour and pesticides were 1041, 21, 50, 3, 4 and 36 Kgs respectively.

30. The Marginal Rate of Substitution of wheat area for labour was 57.48, indicated that one unit of wheat area (one acre area) can be substituted for 57 units of labour without changing the product scale. The marginal rate of substitution of wheat area for fertilizer was 8.25 bags.

4.2.3 Findings Relevant to Maize Crop

31. The major maize varieties grown in district Swat were Azam, Pahari, Jalal, Babar and Ghori. The growers of variety Azam, Pahari, Jalal, Babar and Ghori were 24%, 16%, 12%, 39% and 9% of the total growers respectively.

32. The cost components were land preparation with tractor, seed, fertilizers, weedicides, threshing (with tractors), labour charges, bags charges and land rent.

33. The revenue components for each variety of maize were maize grains and stalk.

34. The per acre cost of variety Azam, Pahari, Jalal, Babar and Ghori were Rs. 18, 960, Rs. 18, 880, Rs. 18, 860, Rs. 18, 940 and Rs. 18, 840 respectively while the total revenues were Rs. 42, 500, Rs. 24200, Rs. 22500, Rs. 35800 and Rs. 26600 respectively.

35. The Benefit Cost Ratios for these varieties were 2.24, 1.28, 1.19, 1.89 and 1.4 respectively, indicated that variety Azam was the most profitable variety of maize as compared to all other varieties.

36. The average size of land holding was 1.5 acre. The usage of tractor hours, fertilizer, seed, labour and pesticides were 4 tractor hours, 3 fertilizer bags, 20 Kgs seed, 35 labours and 1 bottle of pesticides respectively.

37. The results indicate that area, tractor hours, labour, fertilizer and seed were statistically significant at both 10% and 5% level of significance against pesticides, which was not statistically significant variable.

38. The output elasticities of area, tractor hours, fertilizer, seed, labour and pesticides were 0.64123, 0.124587, 0.55461, 0.31244, 0.5874 and 0.08248 respectively. Maize Area (MA) elasticity of production (0.64) indicated that if maize area increases by 1% and all other inputs remain unchanged, the maize production will increase by 0.64%.

39. Value of Durbin Watson statistic (1.78) shows that there does not exist any problem of autocorrelation. The high value of R^2=0.73, showed that the fit was good.

40. The stepwise regression indicated that all the included explanatory variables except PSTR have a substantial effect on the response variable.

41. In the log linear Cobb-Douglas production function, the sum of all output elasticities equal 2.50 (i.e. > 1), indicated that maize production was characterized by increasing returns to scale (also supported by Wald-Test results).

42. The total estimated maize production for mean, maximum and minimum values of maize inputs were 1932 Kgs, 4698 Kgs and 232 Kgs respectively.

43 The average product of area, tractor hours, fertilizer, seed, labour and pesticides at their mean values were 1288.24, 483.09, 644.12, 96.6186, 55.21 and 1932.37Kgs respectively.

44 The marginal product at the mean values of area was 800 Kgs indicated that if maize area increases by one acre (over 1.5 acre) and all other variables constant, the production will increase by 800 Kgs. The marginal product tractor hours, fertilizer, seed, labour and pesticides were 60 Kgs, 357 Kgs, 30 Kgs, 32 Kgs and 158 Kgs respectively. The marginal product at the maximum values of area, tractor hours, fertilizer, seed, labour and pesticides were 744, 123, 650, 58, 69, and 385 Kgs respectively. The marginal product at the minimum values of area, tractor hours, fertilizer, seed, labour and pesticides were 875, 14, 69, 5, 4 and 19 Kgs respectively.

45 The Marginal Rate of Substitution of area for tractor hours is 13.72, indicated that one unit of maize area (one acre area) can be substituted for 14 units of labour without changing the product scale. The marginal rate of substitution of area for labour is 25.47, indicating that one unit of maize area (one acre area) can be substituted for 25 units of labour (man days) without changing the product scale.

8.2.4 Combined Findings about Food Grains

46 The average family size of food growers was found 6 per household.

47 Out of the two hundred farmers 21 % were found educated while the remaining 79 % were uneducated.

48 The economic practices undertaken in food-grains crops cultivation were land use, conservation of traditional varieties, raising nursery and maintenance, land preparation and water management, transplanting, weed control, insect and disease control, fertility management, harvesting and drying, threshing and cleaning, transportation, milling, storage, record keeping/stock control and straw management.

49. Food grain crops played positive significant role and have a strong relationship with sources of income, labour force and capital employment, woman participation in food grain cultivation, labour opportunities and decision making in the households, labour distribution within the villages, food grain marketing, credit and financing, consumption pattern, price fluctuations, poverty alleviation, self-sufficiency in food grain, extension of markets, strengthening fertilizer business, prices of food grain maden commodities, farm mechanization, food grain shortages, children education, reduction in the social problems, cultural & religious activities, extension in tractors and threshers, sense of brotherhood and livestock production.

50. Food grain cultivation was the main source of livelihood of the farmers. The villagers used to derive their food sustenance from farm products and livestock and animal husbandry were also the sources of their income.

51. Food grains cultivation was of great social significance because it provided the largest share of total labour employment to the local community. In rice crop cultivation on average 55 labours (man days) costing Rs. 6600 per acre were used for various activities. In wheat crop cultivation, on average 30 labours (man days) costing Rs. 3600 per acre for various operations (from sowing to threshing) were used. In maize crop cultivation, on average 35 labours (man days) costing Rs. 4200 per acre for various operations (from sowing to threshing) were used. Further, On average rice crop took into account approximately 1010487 labour man-days for its cultivation in district Swat during 2006-07. While wheat and maize crops took into account approximately 1864110 and 5469887 for labour man-days for its cultivation in 2006-07.

52. The farmers used the oxen for various operations like ploughing, short haulage, harrowing and threshing. Light hand-ploughs, cutlasses, forks and sickles were normal equipment used by food growers.

53. None of the women folk of the household worked for wages in district Swat rather they helped the family to sew the children's clothes, cook, wash and keep the home scrupulously clean. Women had less opportunity than men in availing labour opportunities. Decisions about expenditures were made by men but in various cases like saving money and dealing traditions, women generally used to take the decisions.

54. The distribution of labour depended upon the nature of occupation. Some people were working on daily wages basis while some were working together in groups' forms in food grain cultivation.

55. The majority of the food growers used to sell their produce in the village markets rather terminal markets.

56. The farmers mostly used non-institutional loans for farm activities mainly for purchasing seed, fertilizer and pesticides.

57. The average expenditures on food items were Rs.4000 per month, which is 47% of the total expenditures. The average consumption on clothing was Rs. 300 per month, which is 3% of the total expenditure. The average consumption on education was Rs. 2000 per month, which is 23% of the total expenditure. The average expenditures on health were Rs. 1000 per month, which was 11% of expenditures. The average per month electricity charges was Rs. 600. House rent expenditures were Rs. 300 per month, which is 3% of the total expenditures.

58. Causes of low yield per acre in District Swat were included fragmentation of holdings, scarcity of capital, usage of primitive methods of farming, illiteracy, inferior quality seed, inadequate fertilizer, cemented water channels, lack of credit, high prices of inputs, marketing facilities, lack of transport and communication facilities, lack of storage facilities and land ownerships.

8.3 Conclusions

From the facts and figures it is clear that food grain represents the way of life and its cultivation is most closely connected with the socioeconomic conditions of food growers in District Swat. Any improvements in food grain cultivation will ultimately improve the standard of living of the local community and further will have a positive impact on sources of income, labour force and capital employment, woman participation, labour distribution within the villages, food grain marketing, credit and financing, consumption pattern, price fluctuations, poverty alleviation, self-sufficiency, extension of markets, strengthening fertilizer business, reduction in prices of food grain maden commodities, farm mechanization, reduction in food grain shortages, children education, reduction in the social problems, extension in tractors and threshers market, prevailing brotherhood and increasing livestock production.

The yield (Kg/ha) is too low as compared to the provincial and national level. The area under cultivation played significant role in total productivity. The cultivated area under different food grain crops in the district is still low and needs to be extended so as to overcome the shortage of food grains in general and particularly of wheat in the study area.

The results showed that all the three food crops are characterized by increasing returns to scale i.e. food grains' output increases more than their inputs. This provides a place for managing the food grain inputs efficiently so as to ensure their productivity as required.

8.4 Recommendations

Based on the findings of this study, the following suggestions are made:

1) The government should make efforts to bring more area under food crops cultivation for increasing food crop production.
2) Information (awareness) should be given to the farmers to grow improved varieties rather traditional varieties. The farmers should grow the most

profitable varieties of food grain according to the climatic conditions of the district.

3) The farmers should use only recommended seed, which is healthy, desired resistant and standard.

4) Timely and balanced fertilizer application schedule should be followed.

5) Pest damage should be reduced to tolerable levels through logical and justified integration of a variety of techniques, such as use of natural enemies, development of resistant crop varieties, modifications of the pest environment and when necessary an appropriate and timely use of chemicals.

6) Proper storage facilities should be provided to the food grain growers. Further, storage premises and their surroundings should be kept scrupulously clear so as to provide healthy production to the markets.

7) Institutional credit facilities should be provided to the farmers at a low rate of interest. The banks should provide loans to the farmers for both long term and short term. The credit from the debtors should be taken on proper time so that the farmers may be able to pay.

8) Education should be popularized in the district to protect them from extravagance and irresponsibility and in this way the resources will be effectively diverted to agriculture sector. The farming skill will also be flourished from it.

9) The Government should overcome the problem of water logging and salinity in the research area. Proper funds should be allocated for this purpose. The Government should try to discourage fragmentation of holdings in the district. Appropriate packages should also be allocated for natural calamities such as locustorm, cyclones floods and droughts. These packages should be distributed carefully.

10) Efforts should be made to increase farmers' income through improvements in food grain quality, plus better utilization of its by-products. The

Government should determine support prices to increase rural incomes and contribute to food security.

11) The agriculture research stations should play active role in solving farmers' problems. It should set up a good relationship with the farmers. It should point out the causes of low yield and suggest measures for improvement. Furthermore, it should arrange seminars and programmes to aware the farmers about the agriculture updates. It should work free of political interference.

12) Multi-cropping system should be adopted in the research area to utilize the holdings and increasing food grain productivity so as to sell them in terminal markets.

13) As the food grain productivity is mostly dependent on nature, therefore, the government should start such initiatives, which reduce the dependence of the farmers on agriculture sector.

8.5 Limitations of the Study

The present research work suffers from the following limitations:

1) Almost all the cost components have been included but these are not fixed for all the areas and farmers because the farmers do some of the activities by themselves rather to hire labour for them.

2) Costs and revenues are sensitive to climatic zones and natural calamities, while in present study, only routine/normal figures have been taken into account.

3) Food crops have diverse nature of the cost and revenue in irrigated and unirrigated areas, while in this study, only irrigated areas have been considered.

4) The study has been carried out for the sampled observations while the sampling errors always exist even though the sample has been drawn fairly.

5) Time and financial constraints also involved in covering each and every angle of the study.

6) Some sample farmers hesitated while giving the information.

6.6 Policy Implications and Future Research

In the present study an in-depth analysis of the cost and revenues of different varieties of rice, wheat and maize has been made which is a guideline for agriculture economist and farmers for growing the most profitable varieties. The relationship of crop inputs with their output has been assessed. This will help the government to formulate policies for increasing cultivated area under food crops in the study area. The economic practices, which have been identified, if undertaken properly and efficiently, can be helpful for increasing food grain productivity in District Swat, NWFP and Pakistan. If the practices undertaken in food grain cultivation are efficiently managed following the instructions of agriculture research stations, the food grain productivity will become competitive in both domestic and national markets.

The average product of labour is still low and needs to be increased through farm mechanization in the study area. Because, there was abondance of labour and most of labours are disguised unemployed in the study area.

The policy makers should make attempts to motivate the farmers to grow food grain crops for commercial purposes rather for subsistence farming.

Further, there is a need to increase the sources of income of farmers, to make sound the food grain markets, to make credit and financing fruitful, to make the consumption pattern standard, to ensure women participation, reducing price fluctuations in food grains, to reduce the poverty level, to be self-sufficient in food grain, to strengthen fertilizer business, to reduce the prices of food grain maden commodities, to develop farm mechanization and to reduce food grain shortages, to spread farmers' children education, to reduce the social problems, to extend tractors and threshers market, to prevail brotherhood and to increase livestock production through food grain cultivation.

This research also provides a guideline for carrying such type of research for the rest of the districts. The study can also be extended, not only to the other food grain crops, but also to fruits and vegetables in the NWFP in particular and Pakistan in general.

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APPENDIX-A

AREA MEASUREMENTS / CONVERSION UNITS

1 foot	=	12 inches
1 square foot	=	12 square inches
16 × 17 square feet	=	1 Marla
20 Marla	=	1 Kanal
4 Kanal	=	1 Jarib
2 Jaribs	=	1 Acre
2.47 Acres	=	1 Hectare
1quintal	=	100 kilograms
1 Maund	=	50 kilograms
1 metric ton	=	1000 kilograms

APPENDIX-B

QUESTIONNAIRE ON

ECONOMIC ANALYSIS OF STAPLE FOOD GRAINS CROPS: VARIETIES' INPUT OUTPUT COMPARISON, ECONOMIC PRACTICES AND SIGNIFICANCE IN THE ECONOMY OF DISTRICT SWAT

Date of interview:
Questionnaire No:

1. **Identity**

   a) Name of respondent: _____

   b) Village's name: _____

   c) Tehsil: _____

   d) Family size _____

   e) Educational level

   i) Educated ☐ ii) Uneducated ☐

2. **Tenurial Status**

   i) Owner cultivator ☐ ii) Owner cum tenant ☐ iii) Tenant ☐

3. **Size of Area (Acre) under Food Grain**

Size	Irrigated	Un-irrigated	Total
1 to 2			
2 to 4			
4 & above			

4. **Cropping Pattern**

Kharif crop			Rabi crop		
Name	Area	Yield (mds)	Name	Area	Yield (mds)

5. **What kind of variety do you use?**

   a. Traditional variety ☐ b. Recommended variety ☐

6. **Which variety of food grains do you grow?**

   a. of rice ----------

   b. of wheat ----------

   c. of maize ----------

7. **Cost of Rice Variety _____ for your cultivated area**

Particulars	Unit	Quantity	Rates (Rs.)	Amount/ acre (Rs.)
Land preparation i) Ploughing with tractor ii) Puddling with bullocks				
Raising nursery i) Seed ii) Nursery bed preparation iii)Nursery maintenance iv)Nursery pulling, transport				
Fertilizers i) DAP ii) Urea				
Transplanting				
Irrigation				
Pesticides				
Harvesting				
Threshing (with tractor)				
Cleaning/handling				
Land rent				
Total Cost				

8. Cost of Wheat Variety _____ for your cultivated area

Particulars	Unit	Quantity	Rates	Amount (Rs.)
Land preparation with tractor				
Seed				
Fertilizers i) DAP ii) Urea				
Threshing (with tractors)				
Labour charges From sowing to threshing				
Bags charges				
Land rent				
Total Cost				

9. Cost of Maize Variety _____ for your cultivated area

Particulars	Unit	Quantity	Rates	Amount (Rs.)
Land preparation with tractor				
Seed				
Fertilizers i) DAP ii) Urea				
Weedicides				
Threshing (with tractors)				
Labour charges from sowing to threshing				
Bags charges				
Land rent				
Total Cost				

10. Revenue of Rice Variety ---------- for your Cultivated Area

Type of yield	Quantity(mds)	Rate/mds	Total amount (Rs.)
i) Paddy ii) Straw			
Total Production			
Net Production			

11. Revenue of Wheat Variety ---------- for your Cultivated Area

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain Boosa			
Total Revenue			
Net Revenue			

12 Revenue of Maize variety ---------- for your Cultivated Area

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Maize grain Stalk			
Total Revenue			
Net Revenue			

13. Where do you sell the rice production? _____

14. Who provide you seeds? _____

15. Which specific variety do you think more profitable? _____

16. Do you take loan for financing food grain cultivation?

if yes, please specify, from which source

a. Institutional credit b. Non- institutional credit

also state for what purpose you got loan _____

17. What practices do you perform by yourself while cultivating rice crop?

_____

18. For which practices do you hire labors while cultivating rice crop?

_____

19. What practices do you perform by yourself while cultivating wheat crop?

_____

20. For which practices do you hire labors while cultivating wheat crop?

_____

21. What practices do you perform by yourself while cultivating maize crop?

_____

22. For which practices do you hire labors while cultivating maize crop?

_____

23. Who is the main decision maker in food grain cultivation?

24. What type of labours do you use for agriculture practices?

a. Local b. Non local

also state whether you use hired labour or use volunteers _____

25. From where you get revenue for financing cultural and social activities?

_____

26. What type of capital do you use in food grain cultivation?

a. In rice cultivation

b. In wheat cultivation

c. In maize cultivation

27. From where you get revenue for financing day-to-day expenses

_____

28. Where you plan to utilize your income if you get more productivity from food grain crops _____

29. What are your different sources of income?

a. _____

b. _____

c. _____

d. (others) _____

30. Consumption Pattern for various heads

Main Items of Expenditures	Amount Spent p.m (Rs.)
a. Food	_____
b. Clothing	_____
c. Education	_____
d. Health	_____
e. Electricity	_____
f. House rent	_____
g. Natural gas	_____

31. Present Assets of your Family

a. _____
b. _____
c. _____
d. _____
e. (others)

32. What problems do you face in food grain cultivation?

a. _____
b. _____
c. _____
d. _____
e. _____

20. What do you suggest for increasing low productivity of food grains?

a. _____
b. _____
c. _____
d. _____

APPENDIX-C

MARGINAL RATE OF SUBSTITUTION AMONG INPUTS

Appendix-C (1): Marginal Rate of Substitution among Rice Inputs

Substitution Between Variables	Marginal Rate of Substitution Equation
Substitution of RA for TRHR	$MRS_{RA/TRHR} = a_1/a_2 (TRHR \times RA^{-1})$
Substitution of RA for FERTR	$MRS_{RA/FERTR} = a_1/a_3 (FERTR \times RA^{-1})$
Substitution of RA for SDR	$MRS_{RA/SDR} = a_1/a_4 (SDR \times RA^{-1})$
Substitution of RA for LABR	$MRS_{RA/LABR} = a_1/a_5 (LABR \times RA^{-1})$
Substitution of RA for PSTR	$MRS_{RA/PSTR} = a_1/a_6 (PSTR \times RA^{-1})$
Substitution of TRHR for RA	$MRS_{TRHR/RA} = a_2/a_1 (RA \times TRHR^{-1})$
Substitution of TRHR for FERTR	$MRS_{TRHR/FERTR} = a_2/a_3 (FERTR \times TRHR^{-1})$
Substitution of TRHR for SDR	$MRS_{TRHR/SDR} = a_2/a_4 (SDR \times TRHR^{-1})$
Substitution of TRHR for LAB	$MRS_{TRHR/LAB} = a_2/a_5 (LAB \times TRHR^{-1})$
Substitution of TRHR for PST	$MRS_{TRHR/PSTR} = a_2/a_6 (PSTR \times TRHR^{-1})$
Substitution of FERTR for RA	$MRS_{FERTR/RA} = a_3/a_1 (RA \times FERTR^{-1})$
Substitution of FERTR for TRHR	$MRS_{FERTR/THR} = a_3/a_2 (THR \times FERTR^{-1})$
Substitution of FERTR for SDR	$MRS_{FERTR/SDR} = a_3/a_4 (SDR \times FERTR^{-1})$
Substitution of FERTR for LABR	$MRS_{FERTR/LABR} = a_3/a_5 (LABR \times FERTR^{-1})$
Substitution of FERTR for PSTR	$MRS_{FERTR/PSTR} = a_3/a_6 (PSTR \times FERTR^{-1})$
Substitution of SDR for RA	$MRS_{SDR/RA} = a_4/a_1 (RA \times SDR^{-1})$
Substitution of SDR for TRHR	$MRS_{SDR/THR} = a_4/a_2 (THR \times SDR^{-1})$
Substitution of SDR for FERTR	$MRS_{SDR/FERTR} = a_4/a_3 (FERTR \times SDR^{-1})$
Substitution of SDR for LABR	$MRS_{SDR/LABR} = a_4/a_5 (LABR \times SDR^{-1})$
Substitution of SDR for PSTR	$MRS_{SDR/PSTR} = a_4/a_6 (PSTR \times SDR^{-1})$
Substitution of LABR for RA	$MRS_{LABR/RA} = a_5/a_1 (RA \times LABR^{-1})$
Substitution of LABR for TRHR	$MRS_{LABR/TRHR} = a_5/a_2 (TRHR \times LABR^{-1})$
Substitution of LABR for FERTR	$MRS_{LABR/FERTR} = a_5/a_3 (FERTR \times LABR^{-1})$
Substitution of LABR for SDR	$MRS_{LABR/SDR} = a_5/a_4 (SDR \times LABR^{-1})$
Substitution of LABR for PSTR	$MRS_{LABR/PSTR} = a_5/a_6 (PSTR \times LABR^{-1})$
Substitution of PSTR for RA	$MRS_{PSTR/RA} = a_6/a_1 (RA \times PSTR^{-1})$
Substitution of PSTR for TRHR	$MRS_{PSTR/TRHR} = a_6/a_2 (TRHR \times PSTR^{-1})$
Substitution of PSTR for FERTR	$MRS_{PSTR/FERTR} = a_6/a_3 (FERT \times PSTR^{-1})$
Substitution of PSTR for SDR	$MRS_{PSTR/SDR} = a_6/a_4 (SDR \times PSTR^{-1})$
Substitution of PSTR for LABR	$MRS_{PSTR/LABR} = a_6/a_5 (LABR \times PSTR^{-1})$

Source: Personal derivation

Appendix-C (2): Marginal Rate of Substitution among Wheat Inputs

Substitution Between Variables	Marginal Rate of Substitution Equation
Substitution of WA for TRHW	$MRS_{WA/TRHW} = b_1/b_2\ (TRHW \times WA^{-1})$
Substitution of WA for FERTW	$MRS_{WA/FERTW} = b_1/b_3\ (FERTW \times WA^{-1})$
Substitution of WA for SDW	$MRS_{WA/SDW} = b_1/b_4\ (SDW \times WA^{-1})$
Substitution of WA for LABW	$MRS_{WA/LABW} = b_1/b_5\ (LABW \times WA^{-1})$
Substitution of WA for PSTW	$MRS_{WA/PSTW} = b_1/b_6\ (PSTW \times WA^{-1})$
Substitution of TRHW for WA	$MRS_{THW/WA} = b_2/b_1\ (WA \times THW^{-1})$
Substitution of TRHW for FERTW	$MRS_{TRHW/FERTW} = b_2/b_3\ (FERTW \times TRHW^{-1})$
Substitution of TRHW for SDW	$MRS_{TRHW/SDW} = b_2/b_4\ (SDW \times TRHW^{-1})$
Substitution of TRHW for LABW	$MRS_{TRHW/LABW} = b_2/b_5\ (LABW \times TRHW^{-1})$
Substitution of TRHW for PSTW	$MRS_{THW/PSTW} = b_2/b_6\ (PSTW \times THW^{-1})$
Substitution of FERTW for WA	$MRS_{FERTW/WA} = b_3/b_1\ (WA \times FERTW^{-1})$
Substitution of FERTW for TRHW	$MRS_{FERTW/RTHW} = b_3/b_2\ (TRHW \times FERTW^{-1})$
Substitution of FERTW for SDW	$MRS_{FERTW/SDW} = b_3/b_4\ (SDW \times FERTW^{-1})$
Substitution of FERTW for LABW	$MRS_{FERTW/LABW} = b_3/b_5\ (LABW \times FERTW^{-1})$
Substitution of FERTW for PSTW	$MRS_{FERTW/PSTW} = b_3/b_6\ (PSTW \times FERTW^{-1})$
Substitution of SDW for WA	$MRS_{SDW/WA} = b_4/b_1\ (WA \times SDW^{-1})$
Substitution of SDW for TRHW	$MRS_{SDW/TRHW} = b_4/b_2\ (TRHW \times SDW^{-1})$
Substitution of SDW for FERTW	$MRS_{SDW/FERTW} = b_4/b_3\ (FERTW \times SDW^{-1})$
Substitution of SDW for LABW	$MRS_{SDW/LABW} = b_4/b_5\ (LABW \times SDW^{-1})$
Substitution of SDW for PSTW	$MRS_{SDW/PSTW} = b_4/b_6\ (PSTW \times SDW^{-1})$
Substitution of LABW for WA	$MRS_{LABW/WA} = b_5/b_1\ (WA \times LABW^{-1})$
Substitution of LABW for TRHW	$MRS_{LABW/TRHW} = b_5/b_2\ (TRHW \times LABW^{-1})$
Substitution of LABW for FERTW	$MRS_{LABW/FERTW} = b_5/b_3\ (FERTW \times LABW^{-1})$
Substitution of LABW for SDW	$MRS_{LABW/SDW} = b_5/b_4\ (SDW \times LABW^{-1})$
Substitution of LABW for PSTW	$MRS_{LABW/PSTW} = b_5/b_6\ (PSTW \times LABW^{-1})$
Substitution of PSTW for WA	$MRS_{PSTW/WA} = b_6/b_1\ (WA \times PSTW^{-1})$
Substitution of PSTW for TRHW	$MRS_{PSTW/THW} = b_6/b_2\ (THW \times PSTW^{-1})$
Substitution of PSTW for FERTW	$MRS_{PSTW/FERTW} = b_6/b_3\ (FERTW \times PSTW^{-1})$
Substitution of PSTW for SDW	$MRS_{PSTW/SDW} = b_6/b_4\ (SDW \times PSTW^{-1})$
Substitution of PSTW for LABW	$MRS_{PSTW/LABW} = b_6/b_5\ (LABW \times PSTW^{-1})$

Source: Personal derivation

Appendix-C (3): Marginal Rate of Substitution among Maize Inputs

Substitution Between Variables	Marginal Rate of Substitution Equation
Substitution of MA for TRHM	$MRS_{MA/TRHM} = c_1/c_2 (TRHM \times MA^{-1})$
Substitution of MA for FERTM	$MRS_{MA/FERTM} = c_1/c_3 (FERTM \times MA^{-1})$
Substitution of MA for SDM	$MRS_{MA/SDM} = c_1/c_4 (SDM \times MA^{-1})$
Substitution of MA for LABM	$MRS_{MA/LABM} = c_1/c_5 (LABM \times MA^{-1})$.
Substitution of MA for PSTM	$MRS_{MA/PSTM} = c_1/c_6 (PSTM \times MA^{-1})$
Substitution of TRHM for MA	$MRS_{TRHM/MA} = c_2/c_1 (MA \times TRHM^{-1})$
Substitution of TRHM for FERTM	$MRS_{TRHM/FERTM} = c_2/c_3 (FERTM \times TRHM^{-1})$
Substitution of TRHM for SDM	$MRS_{TRHM/SDM} = c_2/c_4 (SDM \times TRHM^{-1})$
Substitution of TRHM for LABM	$MRS_{TRHM/LABM} = c_2/c_5 (LABM \times TRHM^{-1})$
Substitution of TRHM for PSTM	$MRS_{TRHM/PSTM} = c_2/c_6 (PSTM \times TRHM^{-1})$
Substitution of FERTM for MA	$MRS_{FERTM/MA} = c_3/c_1 (MA \times FERTM^{-1})$
Substitution of FERTM for TRHM	$MRS_{FERTM/TRHM} = c_3/c_2 (TRHM \times FERTM^{-1})$
Substitution of FERTM for SDM	$MRS_{FERTM/SDM} = c_3/c_4 (SDM \times FERTM^{-1})$
Substitution of FERTM for LABM	$MRS_{FERTM/LABW} = c_3/c_5 (LABM \times FERTM^{-1})$
Substitution of FERTM for PSTM	$MRS_{FERTM/PSTM} = c_3/c_6 (PSTM \times FERTM^{-1})$
Substitution of SDM for MA	$MRS_{SDM/MA} = c_4/c_1 (MA \times SDM^{-1})$
Substitution of SDM for TRHM	$MRS_{SDM/THM} = c_4/c_2 (THM \times SDM^{-1})$
Substitution of SDM for FERTM	$MRS_{SDM/FERTM} = c_4/c_3 (FERTM \times SDM^{-1})$
Substitution of SDM for LABM	$MRS_{SDM/LABM} = c_4/c_5 (LABM \times SDM^{-1})$
Substitution of SDM for PSTM	$MRS_{SDM/PSTM} = c_4/c_6 (PSTM \times SDM^{-1})$
Substitution of LABM for MA	$MRS_{LABM/MA} = c_5/c_1 (MA \times LABM^{-1})$
Substitution of LABM for TRHM	$MRS_{LABM/TRHM} = c_5/c_2 (TRHM \times LABM^{-1})$
Substitution of LABM for FERTM	$MRS_{LABM/FERTM} = c_5/c_3 (FERTM \times LABM^{-1})$
Substitution of LABM for SDM	$MRS_{LABM/SDM} = c_5/c_4 (SDM \times LABM^{-1})$
Substitution of LABM for PSTM	$MRS_{LABM/PSTM} = c_5/c_6 (PSTM \times LABM^{-1})$
Substitution of PSTM for MA	$MRS_{PSTM/MA} = c_6/c_1 (MA \times PSTM^{-1})$
Substitution of PSTM for TRHM	$MRS_{PSTM/TRHM} = c_6/c_2 (TRHM \times PSTM^{-1})$
Substitution of PSTM for FERTM	$MRS_{PSTM/FERTM} = c_6/c_3 (FERTM \times PSTM^{-1})$
Substitution of PSTM for SDM	$MRS_{PSTM/SDM} = c_6/c_4 (SDM \times PSTM^{-1})$
Substitution of PSTM for LABM	$MRS_{PSTM/LABM} = c_6/c_5 (LABM \times PSTM^{-1})$

Source: Personal derivation

APPENDIX-D

PER ACRE COST AND REVENUE OF DIFFERENT RICE VARIETIES

Appendix-D (1): Per Acre Cost of Variety JP-5

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation				
i) Ploughing with tractor	Hr	3	200	600
ii) Puddling with bullocks	Day	1	500	500
Raising nursery				
i) Seed	Kg	30	15	450
ii) Nursery bed preparation	Day	2	120	240
iii) Nursery maintenance	Day	1	120	120
iv) Nursery pulling, transport	Day	4	120	480
Fertilizers				
i) DAP	Kg	25	9	225
ii) Urea	Kg	50	8.6	430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides				
i) Furadan (Insecticides)	Kg	16	50	800
ii) Machety (weedicides)	ml	800	300	300
iii) labour charges	Day	3	120	360
Harvesting	Day	10	120	1200
Threshing				
i) Tractor charges	Hr	1	300	300
ii) Labour charges	Day	8	120	960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16385

Appendix-D (2): Total and Net Revenue of Variety JP-5

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy	40	1000	40000
ii) Straw	--	4000	4000
Total Revenue	--	--	44,000
Net Revenue	--	--	27, 615

Source: Field survey

Appendix-D (3): Per Acre Cost of Variety Basmati-385

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation				
i) Ploughing with tractor	Hr	3	200	600
ii) Puddling with bullocks	Day	1	500	500
Raising nursery				
i) Seed	Kg	28	12	336
ii) Nursery bed preparation	Day	2	120	240
iii) Nursery maintenance	Day	1	120	120
iv) Nursery pulling, transport	Day	4	120	480
Fertilizers				
i) DAP	Kg	25	9	225
ii) Urea	Kg	50	8.6	430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides				
i) Furadan (Insecticides)	Kg	16	50	800
ii) Machety (weedicides)	ml	800	300	300
iii) labour charges	Day	3	120	360
Harvesting	Day	10	120	1200
Threshing				
i) Tractor charges	Hr	1	300	300
ii) Labour charges	Day	8	120	960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16, 271

Appendix-D (4): Total and Net Revenue of Variety Basmati-385

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy	42	1200	50, 400
ii) Straw		4500	4, 500
Total Revenue			54, 900
Net Revenue			38, 629

Source: Field survey

Appendix-D (5): Per Acre Cost of Variety Sara Saila

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation				
i) Ploughing with tractor	Hr	3	200	600
ii) Puddling with bullocks	Day	1	500	500
Raising nursery				
i) Seed	Kg	30	10	300
ii) Nursery bed preparation	Day	2	120	240
iii) Nursery maintenance	Day	1	120	120
iv) Nursery pulling, transport	Day	4	120	480
Fertilizers				
i) DAP	Kg	25	9	225
ii) Urea	Kg	50	8.6	430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides				
i) Furadan (Insecticides)	Kg	16	50	800
ii) Machety (weedicides)	ml	800	300	300
iii) labour charges	Day	3	120	360
Harvesting	Day	10	120	1200
Threshing				
i) Tractor charges	Hr	1	300	300
ii) Labour charges	Day	8	120	960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16, 235

Appendix-D (6): Total and Net Revenue of Variety Sara Saila

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy	38	1000	38, 000
ii) Straw	-	4500	4500
Total Revenue			42, 500
Net Revenue			26, 265

Source: Field survey

Appendix-D (7): Per Acre Cost of Variety Dil Rosh-97

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation				
i) Ploughing with tractor	Hr	3	200	600
ii) Puddling with bullocks	Day	1	500	500
Raising nursery				
i) Seed	Kg	25	10	250
ii) Nursery bed preparation	Day	2	120	240
iii) Nursery maintenance	Day	1	120	120
iv) Nursery pulling, transport	Day	4	120	480
Fertilizers				
i) DAP	Kg	25	9	225
ii) Urea	Kg	50	8.6	430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides				
i) Furadan (Insecticides)	Kg	16	50	800
ii) Machety (weedicides)	ml	800	300	300
iii) labour charges	Day	3	120	360
Harvesting	Day	10	120	1200
Threshing				
i) Tractor charges	Hr	1	300	300
ii) Labour charges	Day	8	120	960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16, 185

Appendix-D (8): Total and Net Revenue of Variety Dil Rosh-97

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy	27	1100	29, 700
ii) Straw		4000	4000
Total Revenue			33700
Net Revenue			17, 515

Source: Field survey

Appendix-D (9): Per Acre Cost of Variety Swat-1

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation i) Ploughing with tractor ii) Puddling with bullocks	 Hr Day	 3 1	 200 500	 600 500
Raising nursery i) Seed ii) Nursery bed preparation iii) Nursery maintenance iv) Nursery pulling, transport	 Kg Day Day Day	 30 2 1 4	 10 120 120 120	 300 240 120 480
Fertilizers i) DAP ii) Urea	 Kg Kg	 25 50	 9 8.6	 225 430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides i) Furadan (Insecticides) ii) Machety (weedicides) iii) labour charges	 Kg ml Day	 16 800 3	 50 300 120	 800 300 360
Harvesting	Day	10	120	1200
Threshing i) Tractor charges ii) Labour charges	 Hr Day	 1 8	 300 120	 300 960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16, 235

Appendix-D (10): Total and Net Revenue of Variety Swat-1

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy ii) Straw	28	1100 4500	30, 800 4500
Total Revenue			35, 300
Net Revenue			19, 065

Source: Field survey

Appendix-D (11): Per Acre Cost of Variety Swat-2

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation				
i) Ploughing with tractor	Hr	3	200	600
ii) Puddling with bullocks	Day	1	500	500
Raising nursery				
i) Seed	Kg	30	12	360
ii) Nursery bed preparation	Day	2	120	240
iii) Nursery maintenance	Day	1	120	120
iv) Nursery pulling, transport	Day	4	120	480
Fertilizers				
i) DAP	Kg	25	9	225
ii) Urea	Kg	50	8.6	430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides				
i) Furadan (Insecticides)	Kg	16	50	800
ii) Machety (weedicides)	ml	800	300	300
iii) labour charges	Day	3	120	360
Harvesting	Day	10	120	1200
Threshing				
i) Tractor charges	Hr	1	300	300
ii) Labour charges	Day	8	120	960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16, 295

Appendix-D (12): Total and Net Revenue of Variety Swat-2

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy	28	1100	30, 800
ii) Straw		4500	4500
Total Revenue			35, 300
Net Revenue			19, 005

Source: Field survey

Appendix-D (13): Per Acre Cost of Variety Fakhr-e-Malakand

Particulars	Unit	Quantity	Rates (Rs.)	Amount/acre (Rs.)
Land preparation				
i) Ploughing with tractor	Hr	3	200	600
ii) Puddling with bullocks	Day	1	500	500
Raising nursery				
i) Seed	Kg	30	12	360
ii) Nursery bed preparation	Day	2	120	240
iii) Nursery maintenance	Day	1	120	120
iv) Nursery pulling, transport	Day	4	120	480
Fertilizers				
i) DAP	Kg	25	9	225
ii) Urea	Kg	50	8.6	430
Transplanting	Day	15	120	1800
Irrigation	Day	4	120	480
Cleaning/handling	Day	7	120	840
Pesticides				
i) Furadan (Insecticides)	Kg	16	50	800
ii) Machety (weedicides)	ml	800	300	300
iii) labour charges	Day	3	120	360
Harvesting	Day	10	120	1200
Threshing				
i) Tractor charges	Hr	1	300	300
ii) Labour charges	Day	8	120	960
Gunny bags charges	Bag	20	40	800
Land rent	--	--	--	5500
Total Cost	-	-	-	16, 295

Appendix-D (14): Total and Net Revenue of Variety Fakhr-e-Malakand

Type of yield	Quantity (mds)	Rate / md (Rs.)	Total amount (Rs.)
i) Paddy	48	1000	48, 000
ii) Straw		7500	7500
Total Revenue			55, 500
Net Revenue			39, 205

Source: Field survey

APPENDIX-E

PER ACRE COST AND REVENUE OF DIFFERENT WHEAT VARIETIES

Appendix-E (1): Per Acre Cost of Variety Saleem-2000

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	30	1500
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 960

Appendix-E (2): Total and Net Revenue of Variety Saleem-2000

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	25	1200	30, 000
Boosa	-	9000	9, 000
Total Revenue			39, 000
Net Revenue			21040

Source: Field survey

Appendix-E (3): Per Acre Cost of Variety Haider-2002

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	25	1250
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 710

Appendix-E (4): Total and Net Revenue of Variety Haider-2002

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	23	900	20700
Boosa		9000	9000
Total Revenue			29700
Net Revenue			11, 990

Source: Field survey

Appendix-E (5): Per Acre Cost of Variety Khyber-87

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	20	1000
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 460

Appendix-E (6): Total and Net Revenue of Variety Khyber-87

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	25	1100	27500
Boosa		9000	9000
Total Revenue			36500
Net Revenue			19040

Source: Field survey

Appendix-E (7): Per Acre Cost of Variety Nowshera-96

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	28	1400
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 860

Appendix-E (8): Total and Net Revenue of Variety Nowshera-96

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	25	1000	25000
Boosa		9000	9000
Total Revenue			34000
Net Revenue			16, 140

Source: Field survey

Appendix-E (9): Per Acre Cost of Variety Tatara

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	25	1250
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 710

Appendix-E (10): Total and Net Revenue of Variety Tatara

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	28	800	22400
Boosa		9000	9000
Total Revenue			31, 400
Net Revenue			13, 690

Source: Field survey

Appendix-E (11): Per Acre Cost of Variety Bakhtawar-92

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	28	1400
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 860

Appendix-E (12): Total and Net Revenue of Variety Bakhtawar-92

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	28	1100	30800
Boosa		9000	9000
Total Revenue			39800
Net Revenue			21, 940

Source: Field survey

Appendix-E (13): Per Acre Cost of Variety Auqab-2000

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	25	1250
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 710

Appendix-E (14): Total and Net Revenue of Variety Auqab-2000

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	26	1100	28600
Boosa		9000	9000
Total Revenue			37600
Net Revenue			19, 890

Source: Field survey

Appendix-E (15): Per Acre Cost of Variety Suleman-96

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	25	1250
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 710

Appendix-E (16): Total and Net Revenue of Variety Suleman-96

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	25	1000	25000
Boosa		9000	9000
Total Revenue			34000
Net Revenue			16, 290

Source: Field survey

Appendix-E (17): Per Acre Cost of Variety Fakhri-Sarhad

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	45	25	1125
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 585

Appendix-E (18): Total and Net Revenue of Variety Fakhri-Sarhad

Type of Yield	Quantity (mds)	Rate/md	Total amount (Rs.)
Wheat grain	32	1000	32000
Boosa		9500	9500
Total Revenue			41500
Net Revenue			23, 915

Source: Field survey

Appendix-E (19): Per Acre Cost of Variety Pir Sabak-2004

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	25	1250
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 710

Appendix-E (20): Total and Net Revenue of Variety Pir Sabak-2004

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	24	900	21600
Boosa		9000	9000
Total Revenue			30600
Net Revenue			12, 890

Source: Field survey

Appendix-E (21): Per Acre Cost of Variety Pir Sabak-2005

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	50	25	1250
Fertilizers				
i) DAP	bag	1	3000	3000
ii) Urea	bag	2	680	1360
Threshing (with tractors)	Hour	1	1000	1000
Labour charges				
From sowing to threshing	Day	30	120	3600
Bags charges	Bag	20	40	800
Land rent	--		5500	5500
Total Cost				17, 710

Appendix-E (22): Total and Net Revenue of Variety Pir Sabak-2005

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Wheat grain	25	900	22500
Boosa		9000	9000
Total Revenue			31500
Net Revenue			13, 790

Source: Field survey

APPENDIX-F

PER ACRE COST AND REVENUE OF MAIZE VARIETIES

Appendix-F (1): Per-acre Cost of variety Azam

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	20	40	800
Fertilizers				
i) DAP	Bag	1	3000	3000
ii) Urea	Bag	2	680	1360
Weedicides	-	-	600	600
Threshing (with tractors)	Hour	1	1500	1500
Labour charges from sowing to threshing	Day	35	120	4200
Bags charges	Bag	20	40	800
Land rent	--	-	5500	5500
Total Cost				18, 960

Appendix-F (2): Total and Net Revenue of Variety Azam

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Maize grain	30	1250	37, 500
Stalk		5000	5, 000
Total Revenue			42, 500
Net Revenue			23, 540

Source: Field survey

Appendix-F (3): Per-acre Costs of variety Pahari

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	20	36	720
Fertilizers				
i) DAP	Bag	1	3000	3000
ii) Urea	Bag	2	680	1360
Weedicides	-	-	600	600
Threshing (with tractors)	Hour	1	1500	1500
Labour charges from sowing to threshing	Day	35	120	4200
Bags charges	Bag	20	40	800
Land rent	--	-	5500	5500
Total Cost				18, 880

Appendix-F (4): Total and Net Revenue of Variety Pahari

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Maize grain	24	800	19200
Stalk		5000	5000
Total Revenue			24200
Net Revenue			5320

Source: Field survey

Appendix-F (5): Per-acre Costs of variety Jalal

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	20	35	700
Fertilizers i) DAP ii) Urea	 Bag Bag	 1 2	 3000 680	 3000 1360
Weedicides	-	-	600	600
Threshing (with tractors)	Hour	1	1500	1500
Labour charges from sowing to threshing	Day	35	120	4200
Bags charges	Bag	20	40	800
Land rent	--	-	5500	5500
Total Cost				18, 860

Appendix-F (6): Total and Net Revenue of Variety Jalal

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Maize grain Stalk	25	700 5000	17500 5000
Total Revenue			22500
Net Revenue			3640

Source: Field survey

Appendix-F (7): Per-acre Costs of variety Babar

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	20	39	780
Fertilizers				
i) DAP	Bag	1	3000	3000
ii) Urea	Bag	2	680	1360
Weedicides	-	-	600	600
Threshing (with tractors)	Hour	1	1500	1500
Labour charges from sowing to threshing	Day	35	120	4200
Bags charges	Bag	20	40	800
Land rent	--	-	5500	5500
Total Cost				18, 940

Appendix-F (8): Total and Net Revenue of Variety Babar

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Maize grain	28	1100	30800
Stalk		5000	5000
Total Revenue			35800
Net Revenue			16, 860

Source: Field survey

Appendix-F (9): Per-acre Costs of variety Ghori

Particulars	Unit	Quantity	Rates	Amount/Acre (Rs.)
Land preparation with tractor	Hour	3	400	1200
Seed	Kg	20	34	680
Fertilizers				
i) DAP	Bag	1	3000	3000
ii) Urea	Bag	2	680	1360
Weedicides	-	-	600	600
Threshing (with tractors)	Hour	1	1500	1500
Labour charges from sowing to threshing	Day	35	120	4200
Bags charges	Bag	20	40	800
Land rent	--	-	5500	5500
Total Cost				18, 840

Appendix-F (10): Total and Net Revenue of Variety Ghori

Type of Yield	Quantity(mds)	Rate/md	Total amount (Rs.)
Maize grain	24	900	21600
Stalk		5000	5000
Total Revenue			26600
Net Revenue			7760

Source: Field survey

Appendix-G

Stepwise Regression Results for Rice Input Output Relationship

Appendix-G (1): Variable (ln RA) entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.00123	0.1324	15.11503	0.0000
ln RA	0.124578	0.013451	9.261616	0.0000
R-Squared	0.610936			

Appendix-G (2): Variable (ln RA) and (ln TRHR) entered

Variable	**Coefficient**	Std. Error	**t-Statistic**	**Prob.**
C	2.31245	0.41257	5.604988	0.0000
ln RA	0.54123	0.09134	5.925443	0.0000
ln TRHR	0.215487	0.04123	5.226461	0.0000
R-Squared	0.638123			

Appendix-G (3): Variable (ln RA), (ln TRHR) and (ln FERTR) entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.97845	0.1245	15.89116	0.0000
ln RA	0.554412	0.084512	6.560157	0.0000
ln TRHR	0.336451	0.051874	6.485927	0.0000
ln FERTR	0.01488	0.011334	1.312864	0.0000
R-Squared	0.715261			

Appendix-G (4): Variable (ln RA), (ln TRHR), (ln FERTR) and (ln SDR) entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.364581	0.12547	18.84579	0.0000
ln RA	0.61248	0.08451	7.247426	0.0000
ln TRHR	0.31222	0.011123	28.06977	0.0000
ln FERTR	0.55411	0.0487152	11.37448	0.0000
ln SDR	0.54152	0.013412	40.37578	0.0011
R-Squared	0.77006			

Appendix-G (5): Variable (ln RA), (ln TRHR), (ln FERTR), (ln SDR) and (ln LABR) entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.994167	0.113451	17.57734	0.0000
ln RA	0.54126	0.012451	43.47121	0.0000
ln TRHR	0.31254	0.012341	25.32534	0.0002
ln FERTR	0.7145662	0.087161	8.198233	0.0000
ln SDR	0.287771	0.021546	13.35612	0.0011
ln LABR	0.2234661	0.012451	17.94764	0.0052
R-Squared	0.891906			

Appendix-H

Stepwise Regression Results for Wheat Input Output Relationship

Appendix-H(1): Variable ln WA entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.001245	0.14551	34.37046	0.00032
ln WA	0.1245	0.01123	11.08638	0.00813
R-Squared	0.658936			

Appendix-H(2): Variable ln WA and ln TRHW entered

Variable	*Coefficient*	Std. Error	t-Statistic	Prob.
C	4.781245	0.187413	25.51181	0.0000
ln WA	0.33451	0.01781	18.78214	0.0012
ln TRHW	0.1348	0.0125487	10.74215	0.0001
R-Squared	0.70124			

Appendix-H(3): Variable ln WA, ln TRHW and ln FERTW entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.124	0.14612	35.06707	0.0000
ln WA	0.3148	0.01384	22.74566	0.0000
ln TRHW	0.84123	0.064871	12.96774	0.0000
ln FERTW	0.6412	0.03461	18.52644	0.0000
R-Squared	0.752354			

Appendix-H(4): Variable ln WA, ln TRHW, ln FERTW and ln SDW entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.0171	0.5241	9.572791	0.0000
ln WA	0.28145	0.012354	22.78209	0.0000
ln TRHW	0.84623	0.0413871	20.44671	0.0002
ln FERTW	0.81347	0.064125	12.68569	0.0000
ln SDW	0.1264	0.02813	4.493423	0.0000
R-Squared	0.7912458			

Appendix-H(5): Variable ln WA, ln TRHW, ln FERTW, ln SDW and ln LABW entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.12548	0.13254	31.1263	0.0000
ln WA	0.16812	0.012	14.01	0.0000
ln TRHW	0.114782	0.015811	7.259629	0.0036
ln FERTW	0.3518	0.01233	28.53204	0.0048
ln SDW	0.615791	0.104521	5.891553	0.0001
ln LABW	0.125468	0.01547	8.110407	0.000748
R-Squared	0.8101245			

Appendix-I

Stepwise Regression Results for Maize Input Output Relationship

Appendix-I (1): Variable ln MA entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.0124	0.12487	16.11596	0.00000
ln MA	0.8124	0.082457	9.852408	0.00000
R-Squared	0.6114578			

Appendix-I (2): Variable ln MA and ln TRHM entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.87123	0.0843	45.92206	0.00457
ln MA	0.63124	0.1022	6.176517	0.00087
ln TRHM	0.84123	0.044456	18.92276	0.02458
R-Squared	0.668798			

Appendix-I (3): Variable ln MA, ln TRHM and ln FERTM entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.3587	0.04318	54.62483	0.002154
ln MA	0.24561	0.04466	5.499552	0.007845
ln TRHM	0.6412	0.06666	9.618962	0.000897
ln FERTM	0.84512	0.14135	5.978918	0.000548
R-Squared	0.7087974			

Appendix-I (4): Variable ln MA, ln TRHM, ln FERTM and ln SDM entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.02114	0.244561	12.35332	0.0124574
ln MA	0.31254	0.02487	12.56695	0.000078
ln TRHM	0.513874	0.03311	15.52021	0.004577
ln FERTM	0.4422	0.07713	5.733178	0.000478
ln SDM	0.9874	0.06644	14.86153	0.04545
R-Squared	0.771248			

Appendix-I (5): Variable ln MA, ln TRHM, ln FERTM, ln SDW and ln LABM entered

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.038742	0.21547	9.461837	0.000411
ln MA	0.94213	0.08452	11.14683	0.001247
ln TRHM	0.123487	0.001882	65.61477	0.02141
ln FERTM	0.21888	0.013415	16.31606	0.012421
ln SDM	0.99113	0.03546781	27.94449	0.00210
ln LABM	0.228412	0.01987461	11.49265	0.001248
R-Squared	0.8000078			

APPENDIX-J

Marginal Product Estimation for Rice Inputs

APPENDIX-J (1): Marginal Product Estimation for Mean Values of Rice Inputs

Inputs	Marginal Product equation of Inputs	Marginal Product (Kgs)
MP_{RA}	$17.74316 \times 0.245781 \times 1.5^{0.245781-1} \times 5^{0.6712} \times 3^{0.07891} \times 40^{0.871245} \times 75^{0.12487} \times 3^{0.004871}$	443.56
MP_{TRHR}	$17.74316 \times 0.6712 \times 1.5^{0.245781} \times 5^{0.6712-1} \times 3^{0.07891} \times 40^{0.871245} \times 75^{0.12487} \times 3^{0.004871}$	299.10
MP_{FERTR}	$17.74316 \times 0.07891 \times 1.5^{0.245781} \times 5^{0.6712} \times 3^{0.07891-1} \times 40^{0.871245} \times 75^{0.12487} \times 3^{0.004871}$	71.20
MP_{SDR}	$17.74316 \times 0.871245 \times 1.5^{0.245781} \times 5^{0.6712} \times 3^{0.07891} \times 40^{0.871245-1} \times 75^{0.12487} \times 3^{0.004871}$	50.55
MP_{LABR}	$17.74316 \times 0.12487 \times 1.5^{0.245781} \times 5^{0.6712} \times 3^{0.07891} \times 40^{0.871245} \times 75^{0.12487-1} \times 3^{0.004871}$	3.86
MP_{PSTR}	$17.74316 \times 0.004871 \times 1.5^{0.245781} \times 5^{0.6712} \times 3^{0.07891} \times 40^{0.871245} \times 75^{0.12487} \times 3^{0.004871-1}$	3.56

Source: Personal calculations

APPENDIX-J (2): Marginal Product Estimation for Maximum Values of Rice Inputs

Inputs	Marginal Product equation of Inputs	Marginal product (Kgs)
MP_{RA}	$17.74316 \times 0.245781 \times 3.6^{0.245781-1} \times 6^{0.6712} \times 4^{0.07891} \times 45^{0.871245} \times 80^{0.12487} \times 4^{0.004871}$	281.84
MP_{TRHR}	$17.74316 \times 0.6712 \times 3.6^{0.245781} \times 6^{0.6712-1} \times 4^{0.07891} \times 45^{0.871245} \times 80^{0.12487} \times 4^{0.004871}$	461.77
MP_{FERTR}	$17.74316 \times 0.07891 \times 3.6^{0.245781} \times 6^{0.6712} \times 4^{0.07891-1} \times 45^{0.871245} \times 80^{0.12487} \times 4^{0.004871}$	81.42
MP_{SDR}	$17.74316 \times 0.871245 \times 3.6^{0.245781} \times 6^{0.6712} \times 4^{0.07891} \times 45^{0.871245-1} \times 80^{0.12487} \times 4^{0.004871}$	79.92
MP_{LABR}	$17.74316 \times 0.12487 \times 3.6^{0.245781} \times 6^{0.6712} \times 4^{0.07891} \times 45^{0.871245} \times 80^{0.12487-1} \times 4^{0.004871}$	6.44
MP_{PSTR}	$17.74316 \times 0.004871 \times 3.6^{0.245781} \times 6^{0.6712} \times 4^{0.07891} \times 45^{0.871245} \times 80^{0.12487} \times 4^{0.004871-1}$	5.03

Source: Personal calculations

APPENDIX-J (2): Marginal Product Estimation for Minimum Values of Rice Inputs

Inputs	Marginal Product equation of Inputs	Marginal product (Kgs)
MP_{RA}	$17.74316 \times 0.245781 \times 0.2^{0.245781-1} \times 2^{0.6712} \times 1^{0.07891} \times 30^{0.871245} \times 50^{0.12487} \times 1^{0.004871}$	726.87
MP_{TRHR}	$17.74316 \times 0.6712 \times 0.2^{0.245781} \times 2^{0.6712-1} \times 1^{0.07891} \times 30^{0.871245} \times 50^{0.12487} \times 1^{0.004871}$	198.50
MP_{FERTR}	$17.74316 \times 0.07891 \times 0.2^{0.245781} \times 2^{0.6712} \times 1^{0.07891-1} \times 30^{0.871245} \times 50^{0.12487} \times 1^{0.004871}$	46.67
MP_{SDR}	$17.74316 \times 0.871245 \times 0.2^{0.245781} \times 2^{0.6712} \times 1^{0.07891} \times 30^{0.871245-1} \times 50^{0.12487} \times 1^{0.004871}$	17.18
MP_{LABR}	$17.74316 \times 0.12487 \times 0.2^{0.245781} \times 2^{0.6712} \times 1^{0.07891} \times 30^{0.871245} \times 50^{0.12487-1} \times 1^{0.004871}$	1.48
MP_{PSTR}	$17.74316 \times 0.004871 \times 0.2^{0.245781} \times 2^{0.6712} \times 1^{0.07891} \times 30^{0.871245} \times 50^{0.12487} \times 1^{0.004871-1}$	2.88

Source: Personal calculations

APPENDIX-K

Marginal Product Estimation for Wheat Inputs

APPENDIX-K (1): Estimated Marginal Product at Mean Values of wheat Inputs

Inputs	Marginal Product equation of Inputs	Marginal product (Kgs)
MP_{WA}	$146.936424\times 0.6104 \times WA^{0.6104-1}\times TRHW^{0.1220}\times FERTW^{0.1479}\times SDW^{0.2991}\times LABW^{0.2124}\times PSTW^{0.1041}$	794
MP_{TRHW}	$146.936424\times 0.1220 \times WA^{0.6104}\times TRHW^{0.1220-1}\times FERTW^{0.1479}\times SDW^{0.2991}\times LABW^{0.2124}\times PSTW^{0.1041}$	59
MP_{FERTW}	$146.936424\times 0.1479 \times WA^{0.6104}\times TRHW^{0.1220}\times FERTW^{0.1479-1}\times SDW^{0.2991}\times LABW^{0.2124}\times PSTW^{0.1041}$	96
MP_{SDW}	$146.936424\times 0.2991 \times WA^{0.6104}\times TRHW^{0.1220}\times FERTW^{0.1479}\times SDW^{0.2991-1}\times LABW^{0.2124}\times PSTW^{0.1041}$	12
MP_{LABW}	$146.936424\times 0.2124 \times WA^{0.6104}\times TRHW^{0.1220}\times FERTW^{0.1479}\times SDW^{0.2991}\times LABW^{0.2124-1}\times PSTW^{0.1041}$	14
MP_{PSTW}	$146.936424\times 0.1041 \times WA^{0.6104}\times TRHW^{0.1220}\times FERTW^{0.1479}\times SDW^{0.2991}\times LABW^{0.2124}\times PSTW^{0.1041-1}$	68

Source: Personal calculations

APPENDIX-K (2): Estimated Marginal Product at Maximum Values of wheat Inputs

Inputs	Marginal Product equation of Inputs	Marginal product (Kgs)
MP_{WA}	$146.936424 \times 0.6104 \times WA^{0.6104-1} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041}$	678
MP_{TRHW}	$146.936424 \times 0.1220 \times WA^{0.6104} \times TRHW^{0.1220-1} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041}$	81
MP_{FERTW}	$146.936424 \times 0.1479 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479-1} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041}$	148
MP_{SDW}	$146.936424 \times 0.2991 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991-1} \times LABW^{0.2124} \times PSTW^{0.1041}$	22
MP_{LABW}	$146.936424 \times 0.2124 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124-1} \times PSTW^{0.1041}$	24
MP_{PSTW}	$146.936424 \times 0.1041 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041-1}$	104

Source: Personal calculations

APPENDIX-K (3): Estimated Marginal Product at Minimum Values of wheat Inputs

Inputs	Marginal Product equation of Inputs	Marginal product (Kgs)
MP_{WA}	$146.936424 \times 0.6104 \times WA^{0.6104-1} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041}$	1041
MP_{TRHW}	$146.936424 \times 0.1220 \times WA^{0.6104} \times TRHW^{0.1220-1} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041}$	21
MP_{FERTW}	$146.936424 \times 0.1479 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479-1} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041}$	50
MP_{SDW}	$146.936424 \times 0.2991 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991-1} \times LABW^{0.2124} \times PSTW^{0.1041}$	3
MP_{LABW}	$146.936424 \times 0.2124 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124-1} \times PSTW^{0.1041}$	4
MP_{PSTW}	$146.936424 \times 0.1041 \times WA^{0.6104} \times TRHW^{0.1220} \times FERTW^{0.1479} \times SDW^{0.2991} \times LABW^{0.2124} \times PSTW^{0.1041-1}$	36

Source: Personal calculations

APPENDIX-L

Estimation of Marginal Product for Maize Inputs

APPENDIX-L (1): Estimation of Marginal Product for Mean Values of Maize Inputs

Inputs	Marginal Product equation of Inputs	Marginal Product (Kgs)
MP_{MA}	$33.45094375 \times 0.64123 \times MA^{0.64123-1} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	800
MP_{TRHM}	$33.45094375 \times 0.124587 \times MA^{0.64123} \times TRHM^{0.124587-1} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	60
MP_{FERTM}	$33.45094375 \times 0.55461 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461-1} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	357
MP_{SDM}	$33.45094375 \times 0.31244 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244-1} \times LABM^{0.5874} \times PSTM^{0.08248}$	30
MP_{LABM}	$33.45094375 \times 0.5874 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874-1} \times PSTM^{0.08248}$	32
MP_{PSTM}	$33.45094375 \times 0.08248 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874-1} \times PSTM^{0.08248-1}$	158

Source: Personal calculations

APPENDIX-L (2): Estimation of Marginal Product for Maximum Values of Maize Inputs

Inputs	Marginal Product Equation of Inputs	Marginal Product (Kgs)
MP_{MA}	$33.45094375 \times 0.64123 \times MA^{0.64123-1} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	744
MP_{TRHM}	$33.45094375 \times 0.124587 \times MA^{0.64123} \times TRHM^{0.124587-1} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	123
MP_{FERTM}	$33.45094375 \times 0.55461 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461-1} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	650
MP_{SDM}	$33.45094375 \times 0.31244 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244-1} \times LABM^{0.5874} \times PSTM^{0.08248}$	58
MP_{LABM}	$33.45094375 \times 0.5874 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874-1} \times PSTM^{0.08248}$	69
MP_{PSTM}	$33.45094375 \times 0.08248 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874-1} \times PSTM^{0.08248-1}$	385

Source: Personal calculations

APPENDIX-L (3): Estimation of Marginal Product for Minimum values of Maize Inputs

Inputs	Marginal Product equation of Inputs	Marginal product (Kgs)
MP_{MA}	$33.45094375 \times 0.64123 \times MA^{0.64123-1} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	875
MP_{TRHM}	$33.45094375 \times 0.124587 \times MA^{0.64123} \times TRHM^{0.124587-1} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	14
MP_{FERTM}	$33.45094375 \times 0.55461 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461-1} \times SDM^{0.31244} \times LABM^{0.5874} \times PSTM^{0.08248}$	69
MP_{SDM}	$33.45094375 \times 0.31244 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244-1} \times LABM^{0.5874} \times PSTM^{0.08248}$	5
MP_{LABM}	$33.45094375 \times 0.5874 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874-1} \times PSTM^{0.08248}$	4
MP_{PSTM}	$33.45094375 \times 0.08248 \times MA^{0.64123} \times TRHM^{0.124587} \times FERTM^{0.55461} \times SDM^{0.31244} \times LABM^{0.5874-1} \times PSTM^{0.08248-1}$	19

Source: Personal calculations

Appendix-M

Marginal Rate of Substitution between Rice Inputs

Substitution between	Marginal Rate of Substitution
Substitution of RA for TRHR	1.22
Substitution of RA for FERTR	6.23
Substitution of RA for SDR	7.52
Substitution of RA for LABR	98.41
Substitution of RA for PSTR	100.92
Substitution of TRHR for RA	0.82
Substitution of TRHR for FERTR	5.10
Substitution of TRHR for SDR	6.16
Substitution of TRHR for LAB	80.61
Substitution of TRHR for PST	82.68
Substitution of FERTR for RA	0.16
Substitution of FERTR for TRHR	0.20
Substitution of FERTR for SDR	1.21
Substitution of FERTR for LABR	15.80
Substitution of FERTR for PSTR	16.20
Substitution of SDR for RA	0.13
Substitution of SDR for TRHR	0.16
Substitution of SDR for FERTR	0.83
Substitution of SDR for LABR	13.08
Substitution of SDR for PSTR	13.41
Substitution of LABR for RA	0.01
Substitution of LABR for TRHR	0.01
Substitution of LABR for FERTR	0.06
Substitution of LABR for SDR	0.08
Substitution of LABR for PSTR	1.03
Substitution of PSTR for RA	0.01
Substitution of PSTR for TRHR	0.01
Substitution of PSTR for FERTR	0.06
Substitution of PSTR for SDR	0.07
Substitution of PSTR for LABR	0.98

Source: Personal calculations

Appendix-N

Marginal Rate of Substitution between Wheat Inputs

Substitution between	Marginal Rate of Substitution
Substitution of WA for TRHW	13.34
Substitution of WA for FERTW	8.25
Substitution of WA for SDW	68.03
Substitution of WA for LABW	57.48
Substitution of WA for PSTW	11.73
Substitution of TRHW for WA	0.07
Substitution of TRHW for FERTW	0.62
Substitution of TRHW for SDW	5.10
Substitution of TRHW for LABW	4.31
Substitution of TRHW for PSTW	0.88
Substitution of FERTW for WA	0.12
Substitution of FERTW for TRHW	1.62
Substitution of FERTW for SDW	8.24
Substitution of FERTW for LABW	6.96
Substitution of FERTW for PSTW	1.42
Substitution of SDW for WA	0.01
Substitution of SDW for TRHW	0.20
Substitution of SDW for FERTW	0.12
Substitution of SDW for LABW	0.84
Substitution of SDW for PSTW	0.17
Substitution of LABW for WA	0.02
Substitution of LABW for TRHW	0.23
Substitution of LABW for FERTW	0.14
Substitution of LABW for SDW	1.18
Substitution of LABW for PSTW	0.20
Substitution of PSTW for WA	0.09
Substitution of PSTW for TRHW	1.14
Substitution of PSTW for FERTW	0.70
Substitution of PSTW for SDW	5.80
Substitution of PSTW for LABW	4.90

Source: Personal calculations

Appendix-O

Marginal Rate of Substitution between Maize Inputs

Substitution Between	Marginal Rate of Substitution
Substitution of MA for TRHM	13.72
Substitution of MA for FERTM	2.31
Substitution of MA for SDM	27.36
Substitution of MA for LABM	25.47
Substitution of MA for PSTM	5.18
Substitution of TRHM for MA	0.06
Substitution of TRHM for FERTM	0.17
Substitution of TRHM for SDM	2.00
Substitution of TRHM for LABM	1.86
Substitution of TRHM for PSTM	0.38
Substitution of FERTM for MA	0.43
Substitution of FERTM for TRHM	5.94
Substitution of FERTM for SDM	11.83
Substitution of FERTM for LABM	11.02
Substitution of FERTM for PSTM	2.24
Substitution of SDM for MA	0.04
Substitution of SDM for TRHM	0.50
Substitution of SDM for FERTM	0.08
Substitution of SDM for LABM	0.93
Substitution of SDM for PSTM	0.19
Substitution of LABM for MA	0.04
Substitution of LABM for TRHM	0.54
Substitution of LABM for FERTM	0.09
Substitution of LABM for SDM	1.07
Substitution of LABM for PSTM	0.20
Substitution of PSTM for MA	0.19
Substitution of PSTM for TRHM	2.65
Substitution of PSTM for FERTM	0.45
Substitution of PSTM for SDM	5.28
Substitution of PSTM for LABM	4.91

Source: Personal calculations