AN ECONOMIC ANALYSIS OF IRRIGATED BARLEY PRODUCTION IN IRAN: A STUDY IN TEHRAN PROVINCE

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Affectionately Dedicated to

My Countrymen
For the opportunity provided me for higher education

My Respected Father
Who was Source of my strength

My Beloved Mother
Who inspired me

My Dear Wife
For the support and encouragement

My Pretty Daughter
Who brought joy in our life

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CERTIFICATE

This is to certify that the thesis entitled "**AN ECONOMIC ANALYSIS OF IRRIGATED BARLEY PRODUCTION IN IRAN: A STUDY IN TEHRAN PROVINCE**" submitted by ***SYAMAK MASHAYEKHI*** for the award of degree of **DOCTOR OF PHILOSOPHY** in **AGRICULTURAL ECONOMICS** to the University of Agricultural Science, Bangalore is a record of ***bona fide*** research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore
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INTRODUCTION

CHAPTER - I

INTRODUCTION

Iran is located in south west of Asia and is one of the middle-east countries. It lies in the northern temperate zone, between latitudes 25° north and 39° 47' south and between longitude 44° 02' east and 63° 20' west.

Iran comprises a land area of over 1.6 million square kilometers with about 70 million population and ranks sixteenth in geographical size in the world. Iran is bounded by Turkmenistan, Caspian Sea, Azerbaijan, and Armenia on the North, Afghanistan and Pakistan on the East, Oman Sea and Persian Gulf on the South, and Iraq and Turkey on the West. About 42 percent of working people in Iran are engaged in service sector followed by agriculture (33 percent) and industry 25 percent (Anon. 1998).

Iran is one of the world's largest oil rich countries and has the second largest gas reserves. The other major export products consist of mineral products, food products, carpet, pistachio, caviar, skin and leather, handicrafts, clothes, etc.

The agricultural sector plays a major role in Iran economy. Agriculture sector contributes to more than 17 percent to the gross domestic product (Anon. 2003). It absorbs a great number of manpower. Iran enjoys various types of climate enabling the country to produce a wide range of temperate, sub-tropical and tropical crops. Equally important there is a temperature difference of between 40 and 50 degrees Celsius at any one time between some areas, enabling the production of a variety of crops throughout the year.

About 12.34 million hectares of the country's total land area is cultivated, which contributes 7.49 percent of Iran's land area (Anon. 1991-2001a) of which, the total area under annual crops is 10.27 million hectares (83.23 percent) and the remaining 2.07 million hectares are under perennial crops. About 5.54 million hectares (54 percent) of agricultural lands are in irrigated agriculture and the rest (4.73 million hectares) under dry farming. It can be seen from table 1.1 that Wheat and Barley are two major annual crops of Iran. Other principal crops include pea, alfalfa, rice, cotton, oil seeds, lentil, potatoes, vegetables, fruits, nuts (pistachios, almonds, and walnuts), sugarcane, sugar beets, herbs, spices (cumin, sumac, and saffron), tea, and tobacco. Major agricultural exports include fresh and dried fruits, nuts, animal hides, processed foods, and spices.

Iran has a number of agricultural development programmes in recent years like the Pivotal Wheat Programme, Olive Plantation and Development Programme, The sugar and its by-products development programme and so on. These programmes aim to increase productive job opportunities through diversification of agriculture, reduction of imports, development of agricultural exports and as a whole food sufficiency and increase in the incomes of farmers.

The rural co-operative development programme is perhaps one of the most ambitious and also highly successful. This programme includes the consolidation of small farm lands and farm equipment to enable greater efficiency in the use of technology and the reduction of production costs.

Table- 1.1: Principal Annual Crops in Iran (2000)

Crop	Area ('000 hectares)	Production ('000 Tonnes)	Yield (Kg / Ha)
Cereals			
Wheat	5101	8088	1586
Barley	1194	1686	1412
Rice	534	1971	3691
Pulses			
Pea	646	242	375
Bean	110	181	1645
Lentil	206	78	379
Vegetables			
Potato	169	3658	21645
Onion	44	1344	30545
Tomato	119	3191	26815
Indusrial crops			
Sugar beet	153	4332	28314
Sugar cane	26	2367	91038
Cotton	246	497	2020
Oil seeds	208	247	1188
Forage crops			
Alfalfa	556	3859	6941

Source: Anon. 1991-2001a

Since the country has a long history of agriculture, its habitants have already occupied almost all the fertile lands. In the more recent past, however, there had been a slight increase in the total area under cultivation, achieved through bringing under cultivation the barren lands and national resources lands. Estimates suggest the population growth in Iran will stabilize around the year 2025 at approximately 100 million people. Feeding 100 million individuals is the big challenge ahead. Under the most optimistic conditions additional food and fiber have to be produced each year for more than one million additional people from land already in use. It can be understood from trends of past and present food imports that the existing land resources have not been used optimally to fulfill the nutritional needs of the population.

The economic importance of the agricultural sector is obvious and consequently the support to agriculture and the achievement of self-sufficiency in this sector were placed at the top of the government's policies. It was declared that agriculture should be the main axis of economic activities and that the promotion of the other economic sectors should be conducted in relation and to support this sector.

1.1 The Case of Barley

Barley is a cereal grain of the genus *Hordeum* and family *Gramineae.* Barley has a very debatable origin. The place of origin of barley is Egypt. There is evidence of barley grains found in pits and pyramids of Egypt over 5000 years ago. It has two growing seasons, winter and spring. It is more suited to spring in temperate zone with a 90-day growing season; it is also grown in sub-arctic regions, like in Alaska and Norway, with very short growing seasons. The actual time from seeding to maturity will depend on temperature, light, nutrition, moisture and variety and generally range from 80-120 days (Hunter, 1982).

Among the various cereals, barley has been adapted to the widest variety of climates, from sub-Arctic to sub-tropical. In fact, Barley is the most adaptable of the cereals as it has a very good resistance to dry heat compared to other small grain crops. This feature allows it to grow in desert areas such as North Africa (Briggs, 1978). Barley, like many grains, contains desirable antioxidants, vitamins and minerals including niacin (vitamin B3), thiamine (vitamin B1), selenium, iron, magnesium, zinc, phosphorus and copper (Hunter, 1982). A number of current and ongoing research studies are concentrating on the potential health benefits of barley.

Yield is the product of the three components including number of heads per unit area; number of seeds per head; and seed weight. Environmental stress during the growing season can reduce yields by affecting any or all of these three components. Effects of stress during the flowering stage are most severe. Even moderate drought during this stage can result in appreciable yield loss.

Barley crop has varied uses like food for people (barley flakes, barley bran, pearl and pot barley, barley flour, beer, flavorings and sweeteners, malt extracts and malt flour), food for animal (dairy and beef cattle, hogs and chickens), Non-edible and industrial uses (bedding for livestock, building construction, paper and newsprint). Amongst this, the main use of barley is utilized for feeding livestock. Though animals do not as easily utilize barley's energy, it does have a higher protein content than corn, which reduces the need for a protein supplement in a feed compound. Consequently, barley, although grown in smaller quantities, competes with both corn and sorghum as a feed grain (Anderson, 1998).

Barley is the fourth largest grain crop after wheat, rice, and corn in the world. It is grown in many different countries throughout the world. The importance of barley and its products in brief can be understood in today's world, from the fact that there are 94 producing, 87 exporting and 162 barley-importing countries around the world (Anon. 1991- 2001c).

It can be seen from table 1.2 that the Russian Federation tops in barley production in the world but due to its high domestic consumption, it does not figure in the five major barley exporter countries. On the contrary, Germany is on third place in terms of production due to its low domestic consumption of barley in the world. Barley is used extensively as animal feed in the world. On an average, 71.4 percent of total barley production is fed to beef cattle, dairy cattle and poultry, followed by food and food manufacture (17.5 percent) and seed, other uses and waste (11.1 percent).

It can be visualized from table 1.3 that barley is grown in significant quantities in all the provinces of Iran. Khorasan, Lorestan and Ardebil provinces topped list in terms of area among 29 Iran's provinces. On the other hand, Khorasan, Lorestan and Esfahan provinces have occupied the first three places in barley production, respectively. Barley in Iran is mostly utilized as feed (91 percent). Only one percent of domestic supply of barley is used for human consumption and the rest is utilized as seed, for other uses and as waste. After wheat, barley is the second major crop produced in Iran. It constitutes 11.66 per cent of total cultivated area in Iran i.e., 1.194 million hectares out of 10.27 million hectares (table 1.1).

Table- 1.2: Production and trade of Barley in the World (2000)

Particular	Total Quantity ('000 Tonnes)	Percent to total World
Production		
Russian Federation	14,100	10.4
Canada	13,468	10.1
Germany	12,201	9.0
Spain	11,283	8.3
France	9,717	7.2
World Total	135,156	100
Imports		
Saudi Arabia	5,344	18.7
USA	2,929	10.3
China	2,274	7.9
Japan	1,684	5.9
Belgium	1,395	4.9
World Total	28,646	100
Exports		
Germany	6,939	23.0
France	5,005	16.5
Australia	3,005	9.9
Canada	2,232	7.4
United Kingdom	1,934	6.4
World Total	30,205	100

Source: Anon. 1991-2001b
Anon. 1991-2001c

Table – 1.3: Province-wise area and production of Barley in Iran (2000)

Provinces	Area (Ha)	Production (Tonnes)	Percentage	
			% to total barley area	% to total barley production
East Azarbayejan	81,085	81,688	6.8	4.85
West Azarbayejan	35,166	56,763	2.9	3.37
Ardebil	88,614	112,220	7.4	6.66
Esfahan	43,045	134,957	3.6	8.00
Ilam	33,483	16,898	2.8	1.00
Booshehr	1,284	400	0.1	0.02
Tehran	32,081	92,715	2.7	5.50
Chahar Mahal Bakh.	24,941	25,328	2.1	1.50
Khorasan	170,270	324,691	14.3	19.26
Khoozestan	33,389	36,094	2.8	2.14
Zanjan	31,658	26,957	2.7	1.60
Semnan	14,780	35,187	1.2	2.09
Sistan & Balooch.	3,789	5,583	0.3	0.33
Fars	54,227	101,773	4.5	6.04
Ghazvin	24,769	42,110	2.1	2.50
Ghom	20,019	51,128	1.7	3.03
Kordestan	29,103	26,521	2.4	1.58
Kerman	10,906	17,418	0.9	1.03
Kermanshah	78,290	56,525	6.6	3.35
Kohkiloyeh Boyer.	35,409	25,142	3.0	1.49
Gholestan	74,063	72,288	6.2	4.29
Gilan	7,833	5,501	0.7	0.33
Lorestan	145,231	135,187	12.1	8.02
Mazandaran	24,737	17,259	2.1	1.02
Markazi	33,207	78,810	2.8	4.67
Hormozgan	1,755	2,061	0.1	0.12
Hamedan	51,834	85,173	4.3	5.05
Yazd	3,919	10,352	0.3	0.61
Jiroft & Kohnooj	5,601	9,312	0.5	0.55
Total	1,194,477	1,686,039	100	100

Source: Anon. 1991-2001a

The economics of barley in Iran in relation with the world on an average during the period 1991 – 2001 is presented in table 1.4. Iran stands fifteenth out of 94 barley - producing countries in the world, occupying 2.66 percent of area under barley, produces only 1.74 percent of world barley production. This is mainly because of low yield of barley in Iran (35.1 percent less than the world average).

Iran is one of the largest barley importers in the world and stands seventh out of 162 barley-importing countries in the world in the year 2000. The average barley imports by Iran has been 487 thousand tonnes during years 1991-2001, which is about 1.9 percent of total barley imports in the world during this period. On the contrary, Iran has a negligible share in barley world exports market.

The average barley yield in Iran has been always less than world average and there is fluctuation in yield of barley from 1991 to 2001 (figure.1). As in the case of Iran barley is the second most important crop in Tehran province also. According to statistics of Ministry of Agriculture - Jihad of Iran, in the year 2000, barley constituted 21 percent of total cultivated area in Tehran province.

In Tehran province the annual crops under dry farming are very negligible (less than 0.3 percent) arable crop area. In the case of barley, out of 28,581 hectares under barley in the year 1999, only 66 hectares (0.2 percent) was under dry farming. It is mainly because of the scanty rainfall in this province. The average yield of barley in dry farming on an average is almost one seventh of irrigated barley (435 Kg/Ha Vs. 2895 Kg/Ha). Since the area under rainfed barley was very negligible and not important, this study is focused on only irrigated barley.

Table- 1.4: Economics of Barley in Iran during 1991 – 2001

Item	Iran	World	Percentage to World
Production (tonnes)	2,622,017	150,847,415	1.74
Area harvested (Ha)	1,719,350	64,646,495	2.66
Yield (Kg / Ha)	1,525	2,348	64.9
Imports (tonnes)	486,833	26,045,535	1.87
Exports (tonnes)	89	27,316,428	0.0003

Source: Anon. 1991-2001a
Anon. 1991-2001b
Anon. 1991-2001c

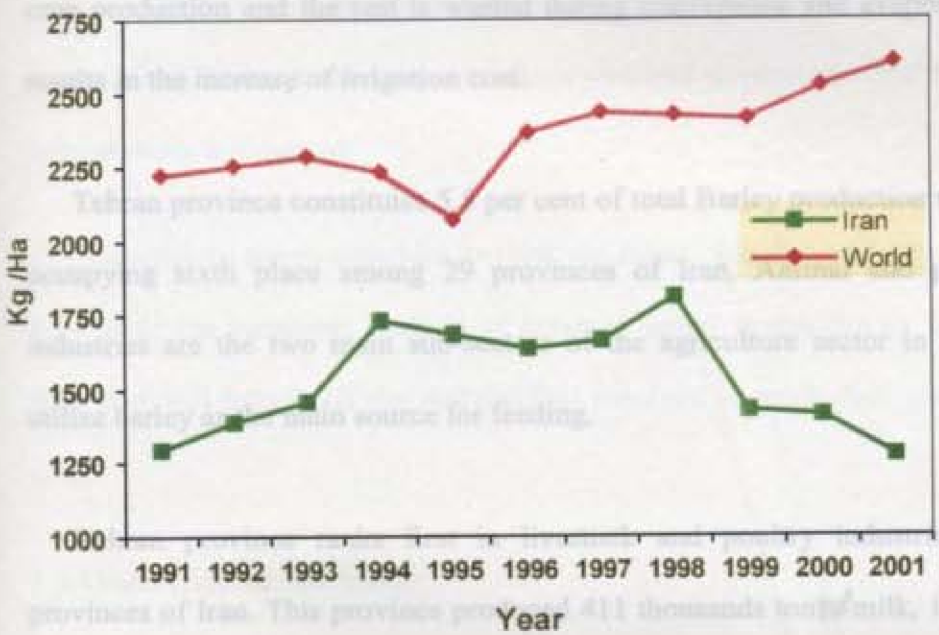

Fig.1: Barley Yield in Iran and World (1991-2001)

It is interesting to note that in the most parts of the province, irrigated barley production is taken up under traditional irrigation system. Water loss under this system of irrigation is very high, resulting in low efficiency in water utilization. It is estimated nearly one third of the water delivered from the source of irrigation is actually used for crop production and the rest is wasted during conveyance and evaporation loss, which results in the increase of irrigation cost.

Tehran province constitutes 5.5 per cent of total Barley production of Iran (Table1.3), occupying sixth place among 29 provinces of Iran. Animal and poultry husbandry industries are the two main sub-sectors of the agriculture sector in this province that utilize barley as the main source for feeding.

Tehran province ranks first in livestock and poultry industries among the 29 provinces of Iran. This province produced 411 thousands tonnes milk, 177 thousand tonnes eggs and 91 thousand tonnes chicken meat, which contributed 33.8, 29.7 and 11.3 percent of total milk, egg and poultry products in Iran, respectively. On the other hand, Tehran province has highest number of dairy cattle in Iran. The total number of the dairy cattle in this province was 145,517 heads, which contributed 28.5 percent of total dairy cattle in the country in the year 2000 (Anon. 2001_b).

Though Tehran province occupies first place in poultry and livestock production, it is unable to meet internally the barley requirement, which is a major component of livestock feed. Hence farmers make arrangement of their requirements of barley from the other provinces and imported barley, which increases the cost of livestock and poultry products. The identification of the factors, which may improve the productivity of barley production in Tehran province may bring down the quantity of barley imports as well as the cost of production of livestock and poultry products. This leads to improvement of the economy of this province and whole country. A very few studies have been attempted on the economics of barley crop in the world and this is the first study about economic aspects of barley production in Tehran province. In this background on the importance of barley for agricultural economy of Tehran province in particular and Iran in general the present study is proposed.

Keeping the above situations in view, the major objective of the present investigation is to study the economic analysis of irrigated barley production in Tehran province of Iran, that will benefit all the stakeholders involved in production and usage of Barley crop.

1.2 Objectives of the Study

The specific objectives of the study are as under:

1. To estimate the cost of production of Barley on different size groups of farms.
2. To study the resource productivity and resource use efficiency in Barley production.
3. To determine the optimum farm size of Barley cultivation.
4. To study the status and problems of Barley producers.

1.3 Hypotheses of the study

1. The average cost of barley production is inversely related to the size of farm.
2. The Barley producers are allocating inputs efficiently.

3. The Barley farmers are technically inefficient.
4. The average size of Barley farms is less than optimum size.
5. Barley cultivation in Tehran province is subjected to production constraints.

1.4 Organization of Thesis

1. Chapter I: deals with the importance and scope of the research problem, hypothesis and objectives of the study.
2. Chapter II: provides precise review of the concepts used in earlier studies and specifies appropriate concepts as relevant in the present study.
3. Chapter III: presents the socio-economic characteristics of the area under study, the data base and the various analytical tools and techniques used.
4. Chapter IV: presents the salient results obtained from the analysis of the data collected for the study.
5. Chapter V: brings out the logical reasoning for the results of the study.
6. Chapter VI: summaries the findings and indicates policy implications.
7. Chapter VII: presents the references made from the reports, journals, books and other sources.

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

A review of studies is essential to look into the relevant studies conducted on the problems so far. It helps in identifying the conceptual and methodological approaches and interpreting the empirical results of the present study. This helps the researcher to know the present status of research in the area and identify the gaps if any in these studies and incorporates in the present research study. In this chapter, keeping in view the objectives of the study, the relevant literature is reviewed in the areas related to present study. The chapter has been organized under following heads:

2.1 Cost and returns analysis

2.2 Production function analysis and allocative efficiency

2.3 Frontier production approach and technical efficiency

2.4 Cost function analysis and optimum size of farm

2.5 Constraints analysis

2.1 Cost and returns analysis

Venkataram (1964) estimated costs and returns of grape production in Bangalore south taluk of Karnataka state, India. The costs were categorized into establishment and maintenance costs. All costs incurred during first year was considered as establishment costs and costs required to operate the grape orchard as maintenance costs. The apportioned establishment cost along with 10 percent interest on the value of land was taken as fixed cost and included in the total cost.

Narasimhan and Selvaraj (1976) studied the cost of cultivation and marketing and returns of flower in Madurai city, India. The results showed that Jasmine was a profitable crop fetching as much as Rs. 6000 net income per acre per year, even though the cultivator had to invest a certain amount in the first year without profit.

Basavaraja (1980) estimated costs and returns of hybrid and local tomato varieties in Bangalore district of Karnataka state, India. The results showed that the total cost of cultivation per acre of hybrid tomato was more than twice of that in local tomato. The results also indicated that labour was a major item of cost accounting for 29 percent and 39 percent of the total cost for hybrid and local tomato respectively. The gross returns and net returns over cost for hybrid tomato were 2.5 times higher than local tomato.

Nambisan and Krishnan (1980) studied the economics of gundumallige in India. The results showed that the profitable yields were obtained up to 20 to 25 years. Total cost of cultivation per hectare was worked out to Rs. 25,000 for initial five years. The anticipated receipts was Rs. 62,000 leaving a net profits of Rs. 37,000 for five years or an average of Rs. 7,400 per year.

Subrahmanyam and Mohandas (1982) estimated the amortized establishment costs of Coorg Mandarin (orange) in Karnataka state, India. The results showed that the maintenance cost per year was Rs. 107.41 per acre and the total cost per year was Rs.477.87.

Dangat *et al* (1985) estimated the costs and returns of production of Chrysanthemum in Maharashtra state, India. The results showed that the per hectare cost of production in 1981-82 was Rs. 34,391 which was more than two fold over that in 1969-70. The results also indicated that the total value of production during these years was Rs. 21,497 and Rs.37,966 per hectare, respectively.

Jaswal *et al* (1987) studied the costs and returns of production and marketing of guava in Allahabad district of Uttar Pradesh state, India. The results revealed that the establishment cost during first year was Rs. 2955 per hectare while in second and third year, it was Rs. 3243 each per hectare. The average maintenance cost per annum from 4^{th} to 10^{th} year was Rs. 2500. The results also indicated that the net income per hectare per annum from 4^{th} to 10^{th} year was Rs. 6080.

Rao (1991) estimated the costs and returns of sunflower cultivation in Raichur district of Karnataka state, India. The results revealed that the cost of cultivation per acre of irrigated sunflower was Rs. 2317 and it was higher than that of rainfed sunflower (Rs.1237). The net returns were also higher in case of irrigated sunflower (Rs. 2656) when compared to rainfed sunflower (Rs.1493). It was found that the costs and returns were higher in Kharif season as compared to Rabi season.

Hiremath (1993) studied the pattern of investment in Lime orchard in Bijapur district of Karnataka state, India. The results showed that the per hectare total maintenance cost of Lime orchard was Rs. 39,852, Rs. 32,655 and Rs. 30,686 in small size, medium size and large size orchards, respectively. The results also indicated that the per hectare net returns over total cost for small size orchards was Rs. 33,193 whereas in the case of medium and large size orchards, it was Rs.25,431 and Rs. 22,101, respectively.

Patil (1995) estimated the costs and returns of mango orchards in Konkan region of Maharashtra state, India. The results showed that per hectare cost of establishment of mango orchards was highest on large size orchard followed by small and medium. The per hectare annual cost of maintenance for large size orchards was Rs. 4204 and it was highest as compared to medium (Rs. 3670) and small (Rs. 2652) size orchards. Per hectare annual cost of cultivation of mango was highest on large orchards (Rs. 6392) and the lowest on small orchards (Rs. 4700). The results also revealed that the gross net income per hectare were highest for large size mango orchards (Rs. 22,640) followed by medium and small size orchards.

Venkataraman and Srinivas Gowda (1996) studied the economics of tomato production in Kolar district of Karnataka state, India. The results showed that per acre total cost of production was Rs. 36,611 out of which the variable costs were 74 percent of total cost. The results also indicated that a gross return per acre of tomato was Rs. 97,477 and the net returns over the total cost were Rs. 60,866.

Kumar (2002) evaluated the cost of cultivation and returns of perennial crops in Chitradurga district of Karnataka state, India. The results showed that the establishment cost of pomegranat per acre was highest among the small farmers and the establishment cost of fig garden per acre was highest among medium farmers. The maintenance cost of pomegranate per acre was highest for small farmers in all the five years, whereas the maintenance cost of fig per acre was found highest among the medium category farmers. The results also indicated that fig was more economical compared to pomegranate in the study area.

Rajendran and Mohanty (2003) estimated the costs and returns in deep litter and cage systems of poultry rearing in India. Results revealed that the fixed investment per bird is found to be more in cage system of rearing for all the size groups. In both systems, the feed cost decrease gradually when the stock size increases except in medium size group underdeep litter system and accounts for more than 84 percent of the total cost of production irrespective of stock size and system of rearing. The cost of production per bird reveal that the cost of permanent and family labour and electricity increase with increase in stock size in case of deep litter system whereas in cage system, it is found to decrease with increase in flock size.

In short, past reviews on the cost and returns analysis reveals that among the different costs of production of annual crop, variable costs have accounted for the major portion of total cost whereas in the case of perennial crop, fixed costs is a major portion of total cost.

2.2 Production function analysis and allocative efficiency

Halter *et al* (1957) provided a description and illustrative example of a transcendental production function. They presented a function, which is consistent with classical production functions. They explained that the transcendental production function could exhibit non-constant elasticity. This function shows the three traditional phases of the marginal product curve. They examined only two–variable input case. They mentioned that the calculations could be followed in extending it to more than two inputs.

Suryanarayana (1958) fitted a Cobb-Douglas production function to find out the relationship between the output and inputs to the data collected from 196 sample farms of three districts of Telengana, Andhra Pradesh State, India. The results showed the coefficients of labour and capital were positive. The results also indicated diminishing returns to inputs of different orders of magnitude.

Chennareddy (1967) tested the hypothesis of production efficiency in the traditional south Indian agriculture by using the ratio of marginal value of products to marginal factor costs. The Cobb-Douglas type of production function was used. A total sample of 104 farmers in the rice and tobacco zones was selected. The results indicated that production efficiency exists in traditional farming in south Indian agriculture.

Sahota (1968) evaluated the efficiency of Indian farmers in allocating resources available to them among different production alternatives. He estimated the Cobb-Douglas production functions and derived marginal productivities for various agricultural inputs for different crops and farm sizes across different states in India for three agricultural years 1954-55, 1955-56 and 1956-57 for six typical regions. The results indicated comparatively few significant inefficiencies of resources allocation in Indian agriculture. The results also showed that the MVP's of fertilizer and irrigation water were considerably above their costs.

Singh and Pandey (1971) estimated the input-output relationship and examined the resource use efficiency in Uttar Pradesh, India. They used Cobb-Douglas type of production function at aggregate farm level. Data was collected based on a survey of 120 farmers classified into four size-groups of holdings from two villages of Mahava

Extension Block of Band district. The results showed that the farmers were handicapped with inadequacy of growth-promoting inputs such as manure, fertilizer and irrigation facilities and were using labor in excessive quantity.

Christensen *et al* (1973) tested the theory of production without imposing the assumptions of additivity and homogeneity. They examined the implications of these frontiers, by using the transcendental logarithmic production frontier. They presented empirical tests of the theory of production, based on time series data for the United States private domestic economy for 1929–1969. The results showed that the direct and indirect tests of the theory of production on the transcendental logarithmic production and price frontiers are consistent with the validity of the extensive set of equality, symmetry, and normalization restrictions implied by the theory. The results also were inconsistent with the hypothesis of group–wise additivity of the production possibility frontier in inputs and outputs.

Azad and Garg (1974) estimated a Cobb-Douglas production function to determine the productivity of various resources used in the production of sugarcane in Uttar Pradesh. The results showed that the marginal value product of fertilizers were Rs. 5.28 in planted sugarcane and Rs. 5.60 in ratooned sugarcane. The marginal value product of human labor was Rs. 0.60 whereas it was Rs. 1.00 for bullock labour. The results also indicated that the possibility of increasing fertilizer and reducing human and bullock labour.

Peter (1974) analyzed the input and output relations in banana in Kanyakumari district of Tamil Nadu State, India. The Cobb-Douglas model of production function was used to estimate the productivities of various inputs used in the plantation of banana. A total of 120 random sample planters were drawn. The results showed increasing returns to scale. The results also indicated that 91 per cent of variation in gross income was explained by independent variables. The results revealed that increase in the total expenditure up to the optimum level can even double the net income of the planters.

Singh (1975) fitted the Cobb-Douglas production functions to work out the productivity of resources in Eastern Uttar Pradesh State, India. A sample of 150 farms spread over 15 villages in Deoria district were used in this study. The results showed that the marginal value products of land, seeds, fertilizers and manure were significantly higher than its acquisition cost thereby indicating the scope to increase their utilization to realize higher returns from crop production.

Venkatesh Reddy (1982) examined the resource productivities and efficiency, for the planted and ratoon crops of Robusta and dwarfs Cavendish varieties of banana separately by using the Cobb-Douglas production function in Bangalore district. The gross return was dependent variable. The results indicated that 90 to 96 per cent of variation in gross returns was explained by independent variables.

Bal *et al* (1983) employed Cobb-Douglas production function to study productivity of various factors in crop cultivation in the central districts of Punjab at 1972-73 and 1980-81. The results showed that the elasticities of production of human labor, draught power and rental value of land had declined in 1980-81 over 1972-73 whereas it had increased in the case of irrigation. The results also indicated substitution of human labor with other factors, mainly irrigation, fertilizers and weedicides was possible.

Lyu *et al* (1984) estimated the effects of agricultural research and extension expenditures on productivity in the United States using Translog and Cobb-Douglas production functions during period 1949-81. They measured marginal returns to agricultural research and extension. The time –series and cross-sectional data for ten production regions of the United States were collected. The results showed that application of the Cobb-Douglas production function would seriously bias the marginal productivity and rates of return on investment in agricultural research and extension. The estimated marginal value product of research and extension for the United States using a translog production function was $ 8.11. The results also indicated that use of the Cobb-Douglas production function would overestimate the internal rate of return of agricultural research and extension expenditures in eight production regions.

Srikantha Murthy (1986) used Cobb-Douglas production function to analyze resource productivity in paddy and ragi crops grown under irrigated and rainfed conditions, respectively in Bangalore district. The results indicated that marginal farmers used land and nutrients in excess. In the small farmers category, farmers used relatively excess labour. Among the large farmers, labor and capital were excessively used.

Muraleedharan (1987) examined the resource use efficiency in Kerala State, India in the context of new technological change. The Cobb-Douglas production function was fitted and resource use efficiency was examined by comparing the estimated marginal value products (MVPs) of various inputs with their respective factor costs. A sample of

142 cultivators of six villages in kole lands in Trichur district was selected.The results showed constant return to scale. The levels of human labor, fertilizers and manures were higher than their optimum levels. The results also indicated that the cultivators had not been able to allocate their inputs efficiently.

Thomas and Gupta (1987) studied the economics of banana cultivation of Kottayam district of Kerala. The Cobb-Douglas production function was used. The contribution of family labour was found to be more in small sized holdings. The results also indicated increasing returns to scale.

Shrestha (1991) estimated the productivity of inputs in Nepalese agriculture during the third through the fifth development plans (1965-80) and the initial year of the sixth plan (1981). The productivities were estimated by using the Cobb-Douglas and translog production functions. The data was collected for the two agro-climatic regions of Nepal, the Hill region in the north and Terai region in the south. The results showed that most of coefficients were significant at 10 per cent in both Cobb-Douglas and translog production functions. The output elasticities with respect to land were positive and high in both regions, which shows that an increase in land will increase the agricultural output. The output elasticities with respect to labour were negative and high therefore increase of labour adds nothing to agricultural output.

Koujalagi and Kunnal (1992) examined the resource use efficiency in the cultivation of pomegranate orchards in Bijapur district of Karnataka State, India by using the Cobb-Douglas production function. The results showed that 70 per cent of the variation in gross returns was explained by the six independent variables included in the model. The regression coefficient of land, labour and manure and fertilizer was significant, but the regression coefficients of number of plants per acre and plant protection chemicals were negative and insignificant. The results also indicated that labour, irrigation and plant protection chemical were used efficiently, whereas manure and fertilizers were used inefficiently.

Mahitha and Hemachandrudu (1992) studied the resource use efficiency of factors of production on paddy farms in Andhra Pradesh State, India. They used secondary data for 15 years (1971 to 1986). The state of Andhra Pradesh was divided into three distinct agro-climatic zones. They estimated marginal value productivity using Cobb-Douglas production function. The results indicated that all the resources in the paddy cultivation in the state were used excessively, resulting in low efficiency and high cost.

Upender (1992) examined the production elasticities with respect to factor inputs, returns to scale and nature of relationship between paddy production per acre and farm size on different farm size-groups in Hasanparthy mandal of Warangal district of Andhra Pradesh State, India. A total of 72 farmers of the small, medium and large groups were selected. The Cobb-Douglas production function was fitted to the data. The results showed that the production elasticity with respect to land on small farms was the highest followed by medium and large farms. The results also indicated diminishing returns to scale in the small and medium size-groups.

Youn Kim (1992) examined existing method of estimating the translog production function and provided a general framework that allows for variable returns to scale. The model is based on the inverse input demand function and embeds a nonhomothetic production technology. He applied this framework in US manufacturing sector. The results supported the empirical relevance of the inverse demand framework that entails a nonhomothetic technology.

Panda (1996) estimated Cobb-Douglas production function for the sericulture farms in Tamil Nadu state, India. A total of 120 farmers were chosen, spread over 12 villages in the Dharmapur district in the north and Dindigul Anna district in the Central Tamil Nadu. The results indicted diminishing returns to scale in Dharmapuri district and constant returns to scale in Dindigul Anna district. The results also showed that there exists scope for increasing laying and human labour in both regions, irrigation in Dharmapuri district and Fertilizer in Dindigul Anna district for maximizing cocoon output.

Badal and Singh (2001) examined the nature of technological change in maize production through the measurement of productivity differences between high-yielding varieties and traditional varieties in the Bihar State, India. Primary data was collected from 180 farming households in 12 villages of three districts in Bihar for the agricultural year 1996-97. The Cobb-Douglas type of production function was employed to estimate the elasticities of factors of production. The production elasticities of all the inputs were relatively higher in high-yielding varieties technology as compared to traditional varieties technology.

Christy and Thirunavukkarasu (2002) analyzed the association between the socio-economic characteristics of farm women and the extent of their participation in livestock farming in Tamil Nadu, India. Linear regression model was estimated to assess the factors influencing the extent of women participation in livestock farming. Villupuram district of Tamil Nadu was selected. A sample of 120 farmers was selected from four villages. The results showed that 94.6 per cent of the variations in the average time spent by females per household for large ruminants were explained by chosen independent variables.

Dileep *et al* (2002) examined resource use efficiency of contract farms and non-contract farms in tomato of Haryana State, India. Data was collected from total sample size of 100 farmers of different size groups of Ellenabad block of Sira district during 1999-2000. They fitted Cobb-Douglas production function model and obtained allocative efficiency based on marginal value productivity (MVP). The results showed that there existed a scope to increase the production of tomato by increasing the use of critical inputs particularly fertilizer, irrigation and plant protection chemicals in the case of non-contract farms whereas the contract farmers made excessive use of plant protection chemicals.

Fraser (2002) examined the original time-series data sets used by Cobb and Douglas to establish the existence of an aggregate production function. He paid attention to the issue of whether the data provide deductive support for the 'laws of production' as claimed by Cobb and Douglas. The results showed that only the New South Wales data and to a lesser extent the New Zealand data yield results that support the assertion of Cobb and Douglas.

Gangwar (2002) formulated the Cobb-Douglas production function for different crops grown on irrigated and un-irrigated group of farms in central Uttar Pradesh, India using per hectare returns as dependent variable for the analysis. The primary data were obtained from a sample of 220 farmers, for the agricultural year of 1999-2000 and 2000-2001. The results showed that for one percent increase in expenditure on irrigation under canal irrigation, the returns per hectare from sugarcane ratoon fell by -0.185 per cent which shows over use of canal water in sugarcane ratoon.

Kumar and Sen (2002) analyzed the labor use pattern and demand function of various size-groups of family farms in Sabour block of Bhagalpur district in Bihar, India by using Cobb-Douglas production function. Four villages, two from rice-wheat cropping system area and two from maize-wheat cropping system area were chosen. Total sample constituted 60 sample farmers comprising 20 from each small, medium and large size-groups. The results showed that the percentage of irrigated area on small farms and total cropped area and labor wage on medium farms have significant positive effect on labor demand. The results also indicated that wage rate affected labor demand negatively in the kharif season in traditional crop cultivation in all size groups.

Prasad (2002) analyzed the seasonal variation in milk production in Andhra Pradesh, India by using Cobb-Douglas type of production function with dummy variable technique (incorporating seasonal dummies) for each of the three breed, i.e., local, graded and murrah buffaloes. A total sample of 240 milk producers was selected from sixteen villages in four mandals of Ranga Reddy district in Andhra Pradesh. The results showed that more yields are realized in the summer season for local and graded buffaloes while higher yields are realized in the winter and rainy seasons for murrah buffaloes. The results indicated that inter-seasonal fluctuations in milk production could be minimized by adjusting the calving dates of buffaloes.

Singh *et al* (2002) estimated technical, allocative and cost efficiencies of individual farmers and computed inter-farm and inter-regional variability in the efficiency measures to Haryana State, India by using the Data Envelope Analysis (DEA) approach. They derived the farm specific levels of cost and allocative efficiency from the cost minimization linear programming problems. A sample of 230 farmers was selected from five adjoining villages. The results showed that allocative inefficiency was a major problem as half of all farms had allocative efficiency scores of 50 or less. The villages with the most degraded land had very low allocative efficiency scores. The results also indicated about 26 per cent of farms had technical efficiency index between 81 to 100 and 6.9 per cent achieved cost efficiency score of 81 to 100 per cent.

In short, past reviews on production function analysis reveals that most of the studies used the Cobb-Douglas type of production function followed by translog production function and linear regression models. They estimated input-output relationship and worked out the elasticities of factors of production and productivity of factors of production.

2.3 Frontier production approach and technical efficiency

Farrell (1957) introduced the measure of technical efficiency that reflects actual firm performance with respect to all relevant factors of production, unlike index numbers.

He used linear programming techniques for estimating a frontier production function and for simultaneously calculating input efficiency measure for all data points in the sample.

Battese and Corra (1977) considered a statistical model for a production frontier that is consistent with the definition of a production function in the microeconomic theory. They defined maximum-likelihood estimators for the parameters of the model. The three related models were applied in the estimation of a production frontier for the pastoral zone of Eastern Australia with use of data from the Australian Grazing Industry Survey. The results indicated that the variance of asymmetric error in the model is a highly significant component.

Kontos and Young (1983) measured the degree of technical efficiency in the Peloponese, Greece by using frontier production function. The Corrected Ordinary Least Squares (COLS) was used to estimate frontier production function. The Kopp's measure of technical efficiency was used. A total sample of 83 farms was selected. The results showed that the mean level of technical efficiency was 57 per cent with almost 40 per cent of farms less than 50 per cent technical efficiency level. The results also indicated that there is considerable scope for increased efficiency of resource use.

Russel and Young (1983) examined the technical efficiency for the cross sectional data on a sample of 56 farms in North-West of England by using Kopp's and Timmer's technical efficiency measures. They estimated frontier production function. The results showed that the mean efficiency indices obtained were 0.72 and 0.73 from Kopp's and Timmer's technical efficiency measures, respectively. The results also indicated that approximately 36 per cent of the farms were at least 75 per cent efficient while 75 per cent of the farms were 64 per cent efficient.

Dawson (1985) demonstrated a methodology for calculating measures of technical efficiency over time. He estimated three measures of technical efficiency for 56 farms in the North-West of England for the four-year period 1974/5 to 1977/8. Two measures were based on econometric techniques and one using linear programming method. The results showed that there was low correlation between the different measures of technical efficiency both over time and space. This casts doubt on the usefulness of measuring efficiency using cross-section survey data.

Ekanayake and Jayasuriya (1987) employed frontier production function for estimating technical efficiency at two locations, the head and tail of major irrigation. They selected sample of 63 farmers in the head region and 61 farmers in the tail region of the canal in Sri Lanka. They estimated the Cobb-Douglas frontier production function by using corrected ordinary least squares (COLS) method. The results showed that in the head, the mean sample technical efficiency was only 53 per cent, while in the tail it was 50 per cent. The results also indicated that COLS estimates tend to over-estimate the average level of inefficiency.

Jayaram (1988) analyzed the yield gap in paddy and ragi in Mandya district using frontier production function. The results showed that technical efficiency was higher in paddy as compared to ragi. The input use efficiency was higher among large farms (83 percent), compared to small farms (70 percent) in case of paddy. In cultivation of ragi, most of the large and small farms had an input use efficiency ranging from 41 per cent to 70 per cent.

Dawson and Lingard (1989) measured farm-specific technical efficiencies of rice farms in central Luzon of the Philippines. The stochastic frontier production functions were estimated for the years 1970, 1974, 1979 and 1982. The results showed that the three years 1970, 1974 and 1979 display similar characteristics with respect to spread of technical efficiency across the samples. The results also indicated that technical inefficiency is the major reason for deviation from the frontier production function.

Weersink *et al* (1990) provided a decomposition of farm-specific measures of technical efficiency and explained the sources of variation in the efficiency values by using a deterministic non-parametric frontier technique. An overall measure of technical efficiency computed by comparing each farm's individual performance with the frontier and then disaggregating the estimated efficiency level into three components including purely technical, congestion and scale efficiency. The farm level data was used to estimate the various efficiency measures obtained from Ontario Dairy Farm. The results indicated that the majority of Ontario dairy farms in the sample were technically efficient. The major sources of inefficiency for the remaining farm are due to pure technical allocation and to non-optimal scale of production. The results also showed that herd size, milk yield had a positive influence on efficiency.

Ali and Chaudhry (1991) compared agricultural production efficiency in four irrigated cropping regions of the Punjab province, Pakistan by using probabilistic frontier production function. A sample of 226 farmers in all regions was selected. The results showed that the gross income of farmers can be increased by 13 per cent at the current levels of resource use if the production gap between the best practice and average farmers was narrowed in all cropping regions.

Dawson *et al* (1991) calculated single measures of farm-specific technical efficiency over time for rice farms in Central Luzon, the Philippines, from the residuals of a stochastic frontier production function. A sample of 22 similar farms in 1970, 1974, 1979, 1982 and 1984 were used. The results showed that there were no significant yield gaps between best and average practice farmers. The results also indicated the narrow range of efficiency between 84 and 95 per cent across the 22 farms.

Kumar and Bisalaiah (1991) studied the economic performance of contact and fellow farmers under new agricultural extension project in Karnataka state, India using the concept of technical and allocative efficiency. Data were collected from small and large contact farmers (SCF, LCF) and small and large fellow farmers (SFF, LFF). The results showed the small contact farmers (SCF) were marginally better off (92.4 per cent technical efficiency) than their fellow farmers, which was 91.8 per cent and 91.6 per cent in case of SFF and LFF respectively. LCF were slightly better off (90 per cent technical efficiency) as against 88.42 per cent and 87.95 per cent by SFF and LFF respectively.

Prasad *et al* (1991) studied technical efficiency of subsidized credit under the Integrated Rural Development Programme (IRDP) in Andhra Pradesh State, India by using the concept of frontier production function. The frontier production function was derived by Corrected Ordinary Least Squares (COLS) method. Timmer and Kopp's measures of technical efficiency were used to obtain technical efficiency. A sample of

200 beneficiaries of two blocks of Anantapur district was selected for the agricultural year 1984-85. The results showed that there was a high degree of inefficiency in credit use in both the blocks.

Jayaram *et al* (1992) employed stochastic frontier production function approach to obtain technical efficiency in rice cultivation in Karnataka state, India. They estimated frontier production function by using Corrected Ordinary Least Squares (COLS) method. They calculated technical efficiency by Timmer and Kopp's measures. A total sample of 100 farmers of Mandya district was selected from different size groups. The results clearly indicated that the farmers were allocatively inefficient although they were technically efficient. The high output efficiency coupled with the high inefficient use of resources is suggestive of improper pricing of resources.

Kautala (1993) examined production elasticity of various inputs and estimated the related parameters of technical efficiency to wheat crop grown on reclaimed soils in Haryana State, India using stochastic frontier production approach. The Cobb-Douglas type of stochastic frontier production function was specified and it was estimated by Corrected Ordinary Least Squares (COLS) method. A sample of 110 farmers was selected. The results showed that the factors, which affected output, were the land, bullock labor, fertilizer and irrigation. The results also indicated that the estimates of mean technical efficiency were 0.76, which implies that the actual output of wheat on an average was 23.64 per cent less than the frontier output.

Banik (1994) estimated technical efficiency for a sample of 99 farms in a village in Bangladesh by using frontier production function. The frontier production function was derived by Corrected Ordinary Least Squares (COLS) method. The results showed that 88 out of 99 farms had a technical efficiency of 71 per cent or above. Thirteen farms showed technical efficiency of 91 per cent to 100 per cent. The results also indicated that owner-tenant or tenant farms were technically more efficient than owner farms.

Kalirajan and Shand (1994) measured the influence of technical and allocative risks on production by using the stochastic frontier production function approach. The frontier production function was estimated by the Maximum Likelihood Estimates (MLE) method. The total sample of 64 farmers using a high-yielding variety of cotton in Tamil Nadu state, India was selected. The results showed that the farmers had not achieved their potential outputs on their frontiers. The mean economic efficiency with technical and allocative risk was 68.3 per cent. The results also indicated that an average, about 20 to 25 per cent of economic efficiency appears to have been lost by the farmers owning to their perceived technical risk and about 6 to 7 per cent to their perceived allocative risk.

Coelli (1995) reviewed the recent developments in the estimation of frontier production function and measurement of efficiency. He discussed the applicability of these methods in agricultural economics. Frontier production, cost and profit functions were discussed. The two primary methods of frontier were compared. The results showed that none of the methods of measuring efficiency relative to an estimated frontier is perfect. Those methods only provide better measures of efficiency than simple partial measures like output per unit of labor.

Coelli and Battese (1996) identified the factors, which influence the technical inefficiency of Indian farmers for the period 1975-76 to 1984-85 using stochastic frontier production function. The frontier production function was estimated by Maximum Likelihood Estimates (MLE) method. A total number of 830 farmers were selected from three villages of diverse agro-climatic regions of the semi-arid tropics of India. The results showed that the age and level of education of the farmers, farm size and the year of observation do have significant influence upon the inefficiency effects of farmers in two of the three villages considered.

Panda (1996) estimated efficiency and productivity of sericulture farms in Tamil Nadu state, India. Dharmapuri district in the north region and Dindigul Anna district in the Central Tamil Nadu were chosen. The total sample of 120 farmers was selected spread over 12 villages in the two districts. Frontier production function was derived from Cobb-Douglas production function and estimated by Corrected Ordinary Least Squares (COLS) method. Timmer's measure of technical efficiency and Kopp's measure of allocative efficiency of various resources utilized in sericulture farms were examined. The results showed that the economics of sericulture was highly profitable in both areas. The results also indicated that for improving productivity and efficiency of sericulture enterprise, mulberry cultivation and silkworm rearing technological extension support have to be strengthened.

Ayanwale *et al* (1997) assessed the resource use pattern on different farm sizes and ascertaining the level of efficiency of the resources used on different farm sizes, in Osun State, Nigeria. The 50 farms each of small (less than 10 hectares) and large size (more than 10 hectares) were selected. Both linear and Cobb-Douglas production functions were employed to each category of farm sizes. The results showed that seeds, insecticides and fertilizers were being under utilized on small farm size whereas these resources were being over-used on large sized farms.

Dhawan, R. and Gerdes, G. (1997) presented a methodology for estimating an index of technological change using farm-level data in a stochastic frontier production function model that takes into account time-varying technical inefficiency. This index is directly estimated in the context of panel data by using stochastic frontier production function approach, which controls for firm-specific and time-varying technical inefficiency. The results of applying this technique to a large panel of US firms showed a significant decline in the technological change over the 1970-1989.

Mohapatra (1998) analyzed the effect of education on worker effect in the farm production (paddy, groundnut and sugarcane) of Orissa's agriculture. Education was hypothesized to affect agricultural productivity in two ways including a choice of better inputs and output (allocative effect) and through a better utilization of existing inputs (worker effect or technical efficiency aspect). The Cobb-Douglas production function was estimated to show the effect of education on output and the MVP of education of the head of the household were calculated to show the worker effect. The result showed that education has significant effect on these two aspects.

Hazarika and Subramanian (1999) estimated technical efficiency to the tea industry in Assam state, India. A sample of 15 per cent of the total estates in the two selected districts was selected. The estates were classified into small and medium (up to 200ha) and large (above 200ha). The stochastic frontier production function of the Cobb-Douglas type of production function was specified for the study. The Maximum

Likelihood Estimates (MLE) method was used to estimate the frontier production function. The results showed that 29.41 per cent of the total large farms belonged to the most efficient category (96 to 99 per cent) whereas in the case of small and medium category, it was only 15.15 per cent. The results also indicated that by use of more of labor and fertilizer, tea production could be increased.

Dey *et al* (2000) examined the technical efficiency of tilapia growout pond operations in the Philippines. They specified a stochastic production frontier. A single-stage estimation procedure was used to examine the determinants of technical inefficiencies in terms of farm-specific characteristics. The stochastic frontier production function was estimated using the Maximum Likelihood Estimates (MLE) method. The generalized likelihood-ratio test was used in testing the significance of the model. A total sample of 128 tilapia grow out operators was selected from all over Philippines. The results showed that the mean technical efficiency of the farmers was 83 per cent. Total farm area, education and age of farmers were some of the factors affecting technical efficiency. The results also indicated that the introduction of new technology was a key to raising the productivity of tilapia farming.

Mythili and Shanmugam (2000) measured the farm level technical inefficiency to explain the difference between potential and observed yields of rice in Tamil Nadu State, India by using stochastic frontier production function approach. The frontier production function was estimated by Maximum Likelihood Estimates (MLE) method. The unbalanced panel data of 234 rice farms in Tamil Nadu was used for the period 1990-91 to 1992-93.The results showed that the technical efficiency varied widely from 46.5 per cent to 96.7 per cent across the sample farms. The mean technical efficiency was computed as 82 per cent, which indicates that on an average, the realized output can be increased by 18 per cent without any additional resources.

Sharma and Leung (2000) examined the levels and determinants of technical efficiency in carp production in India. The stochastic frontier production technique involving the model for technical inefficiency effects was applied separately to samples of semi-intensive or intensive and extensive carp producers during 1994-95.The results showed significant technical inefficiencies in carp production in India especially among extensive farms. The mean technical efficiencies for semi-intensive or intensive and extensive sample farms were estimated to be 80 and 65 percent, respectively. The study suggested that moving from extensive to semi-intensive or intensive system would result in increase in yield per hectare.

Weiming and Guang (2000) estimated frontier production functions individually for crops of rice, wheat and corn using survey data from China. They also analyzed technical efficiencies and their determinants. The results showed that the marginal productivity of labor in cereal production is quite low and should be considered as an important source for future yield growth. A major finding of this study was that China could no longer repeat it's past grain production growth, which has been driven primarily by increased chemical fertilizer usage.

Bakhshoodeh and Thomson (2001) estimated Timmer and Kopp's measures of technical efficiency in Kerman Province, Iran using a Cobb-Douglas frontier production function with a composite error term. A total sample of 164 farmers was selected. The results showed that the mean value of technical efficiency was 0.91, but one quarter of the farms were below 0.90 for the Timmer index and below 0.87 for Kopp index. The results also indicated that the level of inefficiency relates to farm size, as small and large farms were shown to be more technically efficient than medium-sized farms.

Chand *et al* (2001) examined input-output relationship and efficiency of commercial dairy herds in Bikaner city of Rajasthan state, India during the agricultural year 1996-97. They used frontier production function approach. The technical efficiency was estimated through linear programming approach. Data were collected from 100 respondents. The results showed that the technical efficiency of the herds of the average input level ranged between 91 and 93 percent. The results also indicated that concentrate and labor were more important and showed positive and significant influence on milk production.

Kumar (2001) analysed the variations in technical efficiency in the manufacturing sector of 15 major Indian states by using stochastic frontier production approach for the period 1969-95. The panel data were collected from the various issues of "Summary Results of Annual Survey of Industries: Factory Sector". The Maximum Likelihood technique was used to estimate different variants of the stochastic frontier production functions. The stochastic translog, and Cobb-Douglas frontier production functions were employed. The results showed that there were wide variations in the technical efficiency of manufacturing sectors based on stochastic translog production function. The results revealed that the Cobb-Douglas frontier production function was not appropriate for Indian manufacturing sector.

Sangho and Gwangho (2001) applied a stochastic frontier production model to Korean manufacturing industries based on data from 1980-1994 to decompose the sources of total factor productivity (TFP) growth into technical progress, changes in technical efficiency, change in allocative efficiency and scale effects. The results showed that productivity growth was driven mainly by technical progress that changes in technical efficiency had a significant positive effect, and that allocative efficiency had a negative effect. This study suggested that specific guidelines were required to promote productivity in each of the industries in the manufacturing sector.

Wilson *et al* (2001) estimated technical inefficiency in wheat yields in Eastern England using stochastic frontier production function. Variations in the technical efficiency index across production units were explained through a number of managerial and farm characteristic variables. The frontier production function was estimated using Maximum Likelihood Estimates (MLE) method. The data used were taken from the survey conducted over the years 1993-1997. The results showed that the majority of wheat farmers operated close to maximum technically feasible yield levels and there was limited potential to improve technical efficiency. The results also indicated that managers with more experience and further education were likely to be less inefficient.

Job and George (2002) estimated technical efficiency in rice production in Kerala State, India using frontier production approach. The technical efficiency in production was estimated using the stochastic frontier production function which was estimated using the Maximum Likelihood estimates (MLE) method. A sample of 180 farmers were selected from Kuttanad area of Alappuzha district for the year 1996.The results showed that the technical efficiency varied widely between 58 per cent and 99 per cent. The variation of farms yield from high feasible yield arised from differences in the use of best practices available in the area. The results also indicated that with proper allocation of the existing technology, a potential exists for improving the productivity of rice.

In short, past reviews on efficiency and frontier production approach reveals that most of the studies applied stochastic frontier production function followed by deterministic and probabilistic frontier production functions derived from Cobb-Douglas type of production function. These studies have estimated frontier production function by Corrected Ordinary Least Squares (COLS) method followed by Maximum Likelihood Estimates (MLE) and Linear Programming (LP) methods. Most of the studies have measured technical efficiency by Timmer and Kopp's measures of technical efficiency.

2.4 Cost function analysis and optimum size of farm

Binswanger (1974) estimated cost function to cross section data for the United States for the years 1949, 1954, 1959 and 1964. He employed translog cost function. The results showed that complementarity exist between the labor and fertilizer pairs, machinery and fertilizer pairs and the land and other input pair. But only the complementarity of fertilizer and labour was significant. The results also indicated that cost functions, in general, and the translog cost function, in particular, are valuable methods for estimation of production parameters.

Christensen and Greene (1976) estimated economies of scale for U.S. firms producing electric power using the translog cost function. The cross – section data for

1955 and 1970 were used. The results showed that in 1955, there were significant scale economies in nearly all firms. By 1970, the bulk of U.S. electricity generation was by firms operating in the essentially flat area of the average cost curve. The results also indicated that a small number of extremely large firms are not required for efficient production.

Baanante and Sidhu (1980) described the nature of the green revolution technology in the Indian Punjab. They estimated scale and education effects as well as own - and cross-price elasticities of demand and partial elasticities of input substitution in the production of Mexican wheat varieties (MWVs) from the farm level data during agricultural year 1970-71. They derived Translog and Cobb – Douglas cost functions and estimated by Seemingly Unrelated Regression Estimates (SURE). The results showed the effects of scale for animal power, fertilizer, irrigation, and capital equipment appeared to be important. Effects of education on factor shares across farms were significant in the case of labour, animal power, fertilizer and land. The results also indicated substitutability between capital equipment and machinery input and all other inputs except irrigation water.

Boyle (1982) estimated a complete input demand model for fertilizers involving the principal fertilizer nutrients nitrogen, phosphorus and potassium in the Republic of Ireland using a translog cost function for the period 1957/1958-1978/1979. He estimated all own - and cross - price demand elasticities and the input elasticities of substitution. The translog cost function was estimated by Seemingly Unrelated Regression Estimates (SURE). The results showed a mean value for the own-elasticities of -1.0, -0.6, and -0.5

for N, P and K respectively. The results also indicated a zero elasticity of substitution between phosphorus and potassium. The results revealed that phosphorus and potassium are substitutable for nitrogen but not for each other.

Ray (1982) provided a convenient framework for analyzing US agricultural production in a multioutput context by using the translog cost function. He utilized standard results of neoclassical duality theory to obtain measures of pair wise elasticities of substitution between inputs, price elasticities of factor demands. The data was taken from various US government publications cited for the year 1957, 1972, 1976 and 1978.The results showed a decline in the substitutability between labor and capital along with an increase in the substitutability between labor and fertilizers. The results also indicated that price elasticity of demand for all inputs increased over time.

Grisley and Gitu (1984) investigated the production structure of family owner-operated dairy farms using a translog variable cost function. Elasticities of scale, input substitution, and input own and cross-price elasticities were estimated. The total sample of 106 family owner-operated dairy farms in Pennsylvania, US was selected for the year 1981. The results also indicated that the elasticity of substitution between feeds and hired labor and the own-and cross-price elasticities were inelastic.

Arya (1984) studied relationship between size of plant and economies of scale in 12 cement industries in India using both linear and quadratic cost functions. The results showed that the quadratic term was not statistically significant. The marginal cost was constant over time and the total cost was increasing.

Champati and Patnaik (1985) estimated price of irrigation water in the Salandi ayacut irrigation project of Orissa state, India. They applied linear, quadratic and Cobb-Douglas type of cost function to calculate marginal and average costs.

Grisley and Gitu (1985) investigated the structure of production for hen and tom turkey flocks being produced under contract agreements using a translog variable cost function for the year 1980-81. The records for 165-hen and 200-tom flocks were used. The input demand elasticities and cross-price elasticities were calculated. The results showed that the input demand elasticities were inelastic with the exception of the input fuel. The results also indicated that the cross-price elasticities were in general inelastic.

Kass (1987) examined the issue of economies of scale for home health agencies. A quadratic cost function was estimated by using a 1982 national data set based on Medicare Cost Reports for 2000 home health agencies. The results showed that neither economies of scale nor scope are substantial in the provision of home health services.

Paul (1987) estimated cost functions for the mechanized and non-mechanized wheat farm groups of Ferozerpur (Punjab), Muzaffarnagar (Western UP) and Deoria (Eastern UP) by using two types of translog cost functions that capture the heterogeneity of farms. The results showed that for the mechanized farms in Ferozerpur and non-mechanized Farms in Deoria, there was no dependence of scale elasticity on the output level. The results also indicated that all the Muzaffarnagar farms and most of the Deoria Farms produced optimal outputs whereas a large proportion of farms in Ferozepur produced sub-optimal outputs.

Paul and Mehta (1991) used translog cost function to provide measures of factor demand, elasticities of substitution, bias of technical change and to test hypotheses about the structure of production technology in Indian agriculture during the period 1960-61 to 1982-83. The results showed that the agricultural technology has been biased towards the use of labor and capital, and towards the saving of fertilizer and other inputs. The results revealed that there existed strong substitution possibilities between labor and capital and between capital and fertilizer. The results also indicated that technological change has contributed significantly to the per year increase in labor and capital demand.

Ali and Parikh (1992) examined relationships among different inputs on tractorized and non-tractorized plots in the North West Frontier province of Pakistan. Data on household composition, farm production, inputs prices and costs were collected from 98 randomly selected farms for agricultural year 1987-88, covering two growing seasons. A duality approach with a translog cost function was used to estimate cost and input share. The result indicated that tractors are a substitute for human and animal labor.

Pope and Chavas (1994) characterized the cost function and investigated the consistency of expected utility maximization models with cost minimization when production is uncertain. They showed that whereas an ex-post cost function, which is dependent on actual output, couldn't expect to be consistent, there will always exist a consistent cost function. They also indicated that there is implementable approach to defining appropriate cost functions under production uncertainty.

Parikh *et al* (1995) measured farm level inefficiency using a residual approach. They imposed less structure in the cost frontier approach by using a flexible functional form. Cost inefficiency was estimated using a translog cost frontier function. Data on household composition, farm production, input prices and costs were collected from 436 farms for agricultural year 1990-91.The results showed that farmers were inefficient by Farrell's measure of cost inefficiency. The average level of inefficiency was 11.5 per cent. The results also indicated that providing rural education and extension services could reduce cost inefficiency.

Ramaswamy *et al* (1996) attempted to shed some light on the input substitution possibilities in a segment of the Indian paper industry using a variable cost function approach. They focused on firms, which use waste paper as the primary material input. The elasticities of substitution between imported and domestic waste paper and price and cross elasticities of raw materials, labor and energy were estimated. The total sample of 70 paper mills was selected. The translog cost function was employed and it was estimated by using Seemingly Unrelated Regression Estimates (SURE). The results showed that there exists a limited substitution relationship between labor, materials and energy. The results also indicated that input usages were relatively unresponsive to changes in the relative prices of inputs.

Mergos and Karagiannis (1997) provided a decomposition of productivity growth into technical change, returns to scale, and disequilibrium effects of quasi-fixed factors using data from Greek agriculture for the period from 1961 to 1993. They specified the translog variable cost function in terms of two outputs (crop and livestock products), two variable inputs (labor and intermediate inputs) and two quasi-fixed factors (land and capital). The results showed that technical change and market disequilibrium effects are the main factors affecting productivity change.

Durkin and Elliehausen (1998) estimated the cost function of the consumer finance company industry in the United States to explore the questions of existence of scale economies and elasticity of costs by loan size. The data for 51 companies that had greater than 50 per cent of their receivables in consumer credit were used. They employed the translog cost function, which was estimated by Seemingly Unrelated Regression Estimates (SURE). The results showed that significant scale economies existed in the consumer finance industry at the office but not at the firm level. The elasticity of operating costs with respect to loan size was less than unity. The results also indicated that, although larger finance companies were no more efficient than smaller finance companies, firms nevertheless could have reduced costs by consolidating business in fewer offices.

Wang (1998) examined the time variations in the elasticities of derived demand for imports and supply of exports regarding Taiwan's aggregate production during period 1961-1994. He identified the long-run relationship between production behavior and development process, and estimated price elasticities. The translog cost function was employed and it was estimated by Seemingly Unrelated Regression Estimates (SURE). The results showed that price elasticities of imported inputs and of exports increase along with the production capacity and foreign consumption, respectively. The results also indicated that the elasticity of import demand varies with income from exports and the elasticity of export supply varies with domestic production capacity.

Chan-Kang *et al* (1999) estimated an aggregate short-run food processing cost function, an input demand function and an output supply function by using restricted cost function approach for US and Canada separately. Data on food and beverage were obtained from Statistics Department of Canada and National Science Foundation of United States. The results showed that productivity growth rates of food manufacturing in Canada remained below those in the United States for the past 25 years. The results also indicated that Canada requires reducing raw food and packaging costs or need to invest more in research and development.

Salman (1999) estimated the cost function of Barley production in areas of 100-200 mm rainfall in Jordan. The economic size of Barley farms and their economic capacities were determined. The result indicated that the farm size of Barley production, which achieved economic efficiency was 32 hectares.

Garrett (2001) estimated scale economies and inefficiencies in county extension office in Kansas, United States using parametric and non-parametric techniques. Data from 95 out of 102 county extension councils were used to estimate scale economies using the normalized quadratic cost function and the translog cost function. The results showed large economies of scale in county extension councils. The results also indicted that while all counties would experience significant savings from consolidating, rural and less populated counties.

Judez *et al* (2001) analyzed the possible effects of the measures envisaged in "Agenda 2000" approved by the Berlin European Council of March 1999, on representative farms of a Spanish region specialized in arable crop production and beef and veal production. Three economic sizes were considered for each of these types of farming. They applied quadratic cost functions. The results showed that the increase in compensatory payments and premiums would not offset a possible decrease in market prices.

Namboodiri (2001) presented the results of product specific scale and scope economies of District Central Co-operative Banks by using a system of translog cost equation. He considered five outputs and two input prices. The results showed that for all banks together, there was a constant return to scale. The results also indicated that the share of operating cost in total cost as estimated by the share equation was 22 per cent for the total sample. The share of operating cost in total cost tends to rise as the size of bank increases.

Chand *et al* (2002) estimated optimum size of different categories of dairy herds in arid region of Rajasthan State, India by using average cost function. The dairy herds were categorized into small, medium and large. The data were collected for the year 1996-97. The results showed that the optimum herd size ascertained was 22, 33 and 64 milch animals for small, medium and large categories respectively. They suggested that in order to achieve the optimum herd size under the prevalent conditions of breeding, feeding and management, the number of milch animals has to be increased by 31, 17 and 7 per cent on small, medium and large categories respectively.

Segal (2002) investigated the cost structure of the life insurance industry in the United States using translog cost function. He estimated overall and product specific economies of scale for the main outputs of the life insurance industry. He presented a number of structural tests of the production technology. The total sample of 489 insurance companies was selected for the year 1995 through 1998. The results rejected the hypotheses of homothetic production function and unitary elasticity of substitution among the inputs. The results also showed that the magnitude of scale economies increases with size. The results also indicated that the industry exhibits overall and product specific economies of scale.

Greer (2003) examined the ability of rural electric distribution cooperatives in restructured electricity market in US, using 1996 data. A polynomial type of cost function in the form of quadratic cost function was estimated. The results showed that the rural electric distribution cooperatives were not operating in a cost minimizing fashion. He suggested that mergers between these firms could yield substantial savings and help ensure their survival in their present form.

In brief, past reviews on cost function analysis reveals that most of the studies used translog cost function followed by quadratic cost function, average cost function and normalized cost function. They estimated pair wise elasticities of substitution between inputs, price elasticities of factors, and optimum size of farm and productivity change through these functions.

2.5 Constraints analysis

Bandyopadhyay (1982) opined that the decrease in domestic consumption demand, cost productivity, climatic reverses, high cost of production and paucity of suitable land and capital were respectively the most important problems faced by tea producers and exporters.

Kennedy *et al* (1990) investigated production constraints of growing the three pulse crops namely black gram, red gram and bengalgram in Guntur District of Andhra Pradesh, India. Garrett's ranking technique was employed to test the severity of production constraints. The constraint ranked as of highest importance by farmers was lack of technical knowledge regarding pulses cultivation.

Mitra (1991) applied Garret's ranking technique and found that the plucking methods, low productivity, high cost on plant protection, lack of suitable lands, lack of adoption of new and improved technologies, low domestic prices and price fluctuations were the major constraints in export of Indian tea.

Rajendran and Prabahakaran (1993) identified the problems in management of milch animals in the Pappireddipatty block of Dharmapuri district of Tamil Nadu state, India using Garrett's ranking technique. The results indicated that the most important problems encountered in management of the animals were breeding problems, low milk yield, high feed requirement and costly veterinary treatment in buffaloes; breeding problems, high investment costs, frequent illness, high feed requirement, high treatment costs and low milk yield in crossbred cows; and low milk yield, breeding problems, high treatment costs, frequent illness and high feed requirement in desi cows.

Vedini and Gracy (1995) identified the major problem faced by Jasmine flower producers in Mysorė, India using ranking technique. The results showed that the non-availability of adequate financial help for cultivating the crop was a major production problem. About 85 percent of the farmers felt that commission charges were high.

Biradar and Tomer (1999) determined farmer preferences for different crops and crop varieties in Jhansi district of Uttar Pradesh state, India in the year 1995 using matrix-ranking technique. The results indicated that wheat is the most preferred crop followed by groundnut, rice, bengalgram (chickpeas), pulses and millet. Among wheat varieties Lokamanya and Kalyansona were preferred the most, and Jhungu was the most preferred groundnut variety.

Kumar *et al* (1999) identified the constraints in production of gherkin in Dindigul Mannar Thirumalai district of Kannivadi, India. The problems in gherkins production as perceived by the farmers were ranked based on the scores using Garrett's ranking technique. The results revealed that the availability of human labour, marketing facilities, and pest and diseases were the major production constraints, followed by capital and soil fertility.

Mahesh (2000) applied Garret's ranking technique to identify the various constraints faced by farmers, corporate sector units and exporters in tea production and exports in India. The results showed that lack of skilled labour, high fertilizer cost, high pesticide cost, lack of adequate credit support and price fluctuation were the main constraints faced by the farmers in production of tea, in order of importance as perceived by the farmers. In the case of corporate sector, scarcity of skilled labour, high fertilizer cost and high pesticide cost were the important constraints. In the case of tea exporters, lack of superior quality fronts in international market, lack of adequate export promotional measures, lack of thrust on strengthening competitiveness and existence of non tariff barriers are the main constraints faced by exporters in export of tea.

Rajendran and Mohanty (2003) identified and ranked the major constraints in egg production in India using Garrett's ranking technique and were in order of high cost of feed, high cost of medicine and vaccine, supply of poor quality feed and feed ingredient, non remunerative price of eggs, lack of disease control facilities and higher rate of electricity tariff.

Shirima *et al* (2003) ranked the major zoonotic diseases problems in various livestock production systems in Arusha and Iringa regions, Tanzania using matrix-ranking technique. The results showed that rabies, tuberculosis, anthrax and brucellosis ranked as the top four diseases in pastoral, agro pastoral and smallholder dairy farming systems. They suggested that Public health promotion on education might be useful in pastoral and agro pastoral communities to improve awareness of important zoonotic diseases in Tanzania.

In short, past reviews on constraint analysis reveals that most of the studies applied Garrett's ranking technique followed by matrix-ranking technique to rank constraints faced by farmers, exporters and so on.

METHODOLOGY

CHAPTER - III

METHODOLOGY

This chapter deals with the overall description of the study area, data collection, conceptual framework and analytical tools followed in the present study. This chapter is organized under three sections.

3.1. Description of the study area

3.2. Data sources and sampling design

3.3. Analytical tools and techniques

3.1. Description of the study area

3.1.1 Geographical location

Tehran province is one of 29 provinces in Iran situated between 34°52' and 36°21' North latitude and 50°10' and 53°10' East longitude with an altitude of 1173 meters above sea level and with an area of 18,909 square kilometers. Tehran province is located to the north of the central plateau of Iran and it has common borders with the Mazandaran province from north, Qom province from south, Semnan province from east and Qazvin province from west. The geographical location of the study area is given in Figure. 2.

The highest point of the province is Damavand peak at an altitude of 5,678 meters and the lowest is the plains of Varamin with 790 meters above sea level and located to the southeast of the province.

Fig. 2: Geographical Location of the Study Area

The most important rivers in this province are Jajrud, Kan, Karai, Taleqan, Qareh Chay, Haraz, Suleqan and Hableh Rood. Mountain ranges such as the Alborz span are located in the north; the Savad Kooh and Firoozkooh in the north east; Lavasanat, Qarah Daq, Shemiranat, Hassan Abad and Namak Mountains in the south; Bibi Shahrbanoo and Alqadr in the southeast and the heights of Qasr-e-Firoozeh being located to the east of the province.

Tehran province has 12 townships (Tehran, Damavand, Ray, Pakdasht, Robatkarim, Firoozkooh, Savojbolag, Shemiranat, Shahriyar, Varamin, Islamshahr and Karaj), 31 districts, 42 towns and 1988 villages out of which 651 villages are without inhabitants. Tehran is center of this province and capital of Iran (Anon. 2001_b).

3.1.2 Climate and Rainfall

The climate of Tehran province is moderate, mountainous climate in mountainous areas and semi desert climate in plains with its special specifications. Alborz Mountains, the western humid currents, and the desert in the southeast margin of the province play an effective role in climate of Tehran.

The cold season usually begins in December, but in the mountainous regions, it begins earlier. The cold season lasts 3 to 4 months. The coldest months experience as low as 1° C temperature in December-January. In mid-March, the weather grows warm. In late April, the weather begins to grow warm at a faster pace, so that in mid-May, it is rather hot. The hottest months of the year are from mid-July to mid-September when temperatures range between of 28° and 30° C. The average annual rainfall of Tehran province stands at 200 millimeters. A major part of rainfall access in winter. The rain usually begins in November and ends by mid-April.

3.1.3 Population

Tehran province is one of the smallest and most populous provinces in Iran. This province has nearly 12,023,000 inhabitants of whom about 85.46 percent reside in urban areas and the rest in the rural area (Anon. 2001_b). The census shows that about 51.5 percent of Tehran province is male. The size of household in urban and rural areas is 4.6 and 5.1 respectively. The rate of unemployment in Tehran province is about 12 percent. Tehran is the largest city and capital of Iran which hosts about 57.73 percent of total population of the province and ranks in the top 20 metropolitans of the world (Anon. 2001_b).

Agriculture occupies a special place in Iran's economy as it supplies the country's already extensive and constantly expanding food processing industry. Agricultural and animal husbandry products have always provided the major non-oil export items such as pistachio, raisins and even carpets (the wool or silk used in them).

3.1.4 Agriculture

Tehran is an industrial province that hosts a major part of the country's industries and plays a significant part in its economy. Agriculture is also one of the main occupations in suburban plains, and highlands of the province. The total cultivated land in this province is 147,895 hectares. Out of this, only 1,071 hectares is under dry farming (Anon. 2001_a). It can be seen from table 3.1 that Wheat, Barley and Alfalfa are three major annual crops in this province.

Table- 3.1: Principal annual crops in Tehran province (2000)

Crop	Area (Hectares)	Production (Tonnes)
Cereals		
Wheat	47,748	153,628
Barley	32,081	92,715
Pulses		
Bean	360	581
Pea	132	116
Vegetables		
Tomato	9,703	336,541
Potato	4,575	116,839
Onion	722	26,891
Industrial crops		
Cotton	7,199	21,326
Oil seeds	123	257
Forage crops		
Alfalfa	10,799	96,034

Source: Anon. 2001a

The total area under perrenial crops in Tehran province is 58,229 hectares.The major fruit crops of the province include apple, grape, cherry. Peach, pear, plum, black cherry and apricot are other important fruit crops of Tehran province (Anon. 2001_a).

3.2. Data source and Sampling design

The present study was carried out based on primary data. The data on Barley economics were collected in association with Tehran province Agriculture – Jihad Organization affiliated to Ministry of Agriculture – Jihad of Iran during 1999-2000. Since the study has a special focus on the Barley crop, eight townships, including Ray, Robatkarim, Firoozkooh, Savojbolag, Shahriyar, Varamin, Islamshahr and Karaj, where the barley is cultivated were purposively selected.

The sampling technique was based on two-stage random sampling method. In the first stage, 5 percent of villages with a population of less than 5000 (1105 villages) from each township were selected. Therefore total number of sample barley growing villages was 55, which covered all barley-cultivated areas in the province. In the second stage, the sampling units were selected randomly based on 20 percent of barley farm households from the list of the farmers. Thus, the total number of sample studied was 179. The sample was post-stratified into small, medium and large farmers based on the defined land size for each group. The possible error in this method was minimized by cross checking in randomly selected farms. The data were collected from the selected farmers during the months July and August 2000. The sample farmers were interviewed by district level officers of Tehran province Agriculture – Jihad Organization using a structured pre-tested questionnaire.

3.2. Analytical tools and techniques

The details of analytical tools and techniques used in this study are presented below:

3.3.1 Cost of production of Barley on different size groups of farms

The cross tables were formed to analyze the cost of barley production and profitability in different size groups of farms. The statistical measures like arithmetic mean, percentages and ratios were employed for estimating the cost and return structure and comparison of performance of different size groups of farms. The sample farms were classified into three farm size groups namely small 76 ($\leq$2 hectares), medium 46 (2.1 –10 hectares) and large 57 (> 10 hectares). The share of each farm size group to total sample farms was 42.5 percent, 25.7 percent and 31.8 percent, respectively. Since most of farmers utilized hired machinery therefore for this input only rental value was considered as variable cost. To calculate the land cost, the opportunity cost of land (rental value) was considered. The various concepts used are presented below:

3.3.1.1. Costs

The total costs were divided into two classes (i) variable cost and (ii) fixed cost. The method adopted for computing the different cost items are described here:

(i) Variable costs

(a) **Seed:** Farm produced seed has been accounted at the village prices prevalent at the time of sowing. While the purchased seeds at actual rates paid by the sample farmers.

(b) **Manure**: Farm produced manure has been accounted at the village prices prevalent at the time of sowing or at actual rates paid by the sample farmers.

(c) **Fertilizers and Plant Protection chemicals:** Costs for fertilizers and plant protection chemicals were the amounts actually paid by the sample farmers.

(d) **Labour:** Labour was charged at the prevailing wage rates paid per day (eight hours) in that locality for men.

(e) **Water charge:** Water charge has been accounted at actual rates paid by the sample farmers.

(f) **Machinery cost:** Machinery cost has been accounted at the local value of working hour of machinery for owners of machineries and the amount actually paid by the farmers without machineries.

(g) **Miscellaneous charges:** The item includes the expenses incurred by sample farmers, which cannot be included in any of the item of expenditure mentioned above. It is accounted for 5 percent of total variable costs, which is the rate that is considered by Ministry of agricultural-Jihad of Iran on annual crops.

(h) **Interest on variable cost:** It was calculated at the rate of 16 percent per annum (Bank interest rate on the agricultural loans in Iran) on the variable costs for six months.

(ii) Fixed costs

(a) Rental value of land: Rental value of land has been imputed based on the local rent prevailed in the villages for the land owner and the amount actually paid by the people who leased-in the land for cultivation.

(b) Interest on fixed cost: Interest on fixed cost has been charged at the rate of 16 percent per annum (Bank interest rate on the agricultural loans in Iran) on the fixed costs incurred.

3.3.1.2. Output and Returns

The output included both main product and by-product of the barley crop.

(a) Gross Returns: Per hectare gross returns were calculated by taking prices received by respondents at the time of sale in Rials (1 Rupee = 170 Rials). The main product was valued by taking the price prevailing in the months of July and August, during which data were collected.

The by-product of barley crop, which is used as fodder for livestock was valued at the prevailing local prices. The returns from by-product were added to returns from the main product to get gross returns.

(b) Net Return on variable cost: It was calculated by taking into account of gross returns minus total variable costs.

(c) Net Return on total cost: It was calculated by taking into account of gross returns minus total costs.

Cost ratio was worked out with reference to different costs incurred. These would indicate returns per Rupee in crop production.

(d) Returns per Rupee of variable cost: It was calculated as gross returns divided by total variable cost.

(e) Returns per Rupee of total cost: It was calculated as gross returns divided by total cost.

(f) Cost of production per kilogram: This was calculated as total cost per hectare divided by the yield (Kilogram per hectare).

3.3.2 Resource productivity and Resource use efficiency

3.3.2.1 Resource productivity

The concept of production function is basic to the development of the theory of the firm in microeconomic theory. In the classical theory, a production function is a mathematical description of the various technical production possibilities faced by a firm. The production function gives the maximum output(s) in physical terms for each level of the inputs in physical terms. It can be mathematically expressed as:

$$Y = f\,(X_1, X_2 \ldots X_m \quad X_n) \qquad \ldots\ldots\ldots \ (3.1)$$

Where Y denotes output, X_1, $X_2 \ldots X_m$ are variable inputs and X_n is fixed input and f is a function (Beattie and Taylor, 1992).

There are several types of agricultural production functions to study resource productivity. Hence it is essential to choose an appropriate form of production function taking into consideration the data to be analyzed. The resource productivity and allocative efficiency in barley cultivation were studied by fitting the Cobb-Douglas type production function to the farm level data.

Cobb-Douglas production function is known after the names of American Economists C.W.Cobb and P.H. Douglas (1928 AD). It was originally based on the assumption that output is a function of labour and capital as follows:

$$Y = AL^{\alpha}K^{\beta}, \quad \alpha + \beta = 1 \qquad \ldots\ldots\ldots (3.2)$$

Where:

Y : Quantity of output

L : Quantity of labour

K : Quantity of capital

α : Elasticity of production of labour

β : Elasticity of production of capital ($\beta = 1 - \alpha$)

Cobb-Douglas Production Function is linear homogenous function of degree one, which reflects constant returns to scale, i.e.,

$$f\,(t\times L, t\times K) = t \;\times f\,(L, K) \qquad \ldots\ldots\ldots (3.3)$$

Where t is constant, K and L are variable inputs.

In spite of some restrictive assumptions, Cobb-Douglas production function like constant returns to scale, omission of technical change and constant elasticity of production of X_i for all observations on X_i (Fraser, 2002), this function was chosen because of the advantage of this function over the other production functions, which is due to the following merits of the function.

(i) The coefficients of the variable inputs in the function are themselves the elasticities of production of those inputs.

(ii) This function allows increasing or constant or diminishing marginal productivity to each variable input at a time.

A modified Cobb-Douglas type of production function in log-linear form was fitted to the data in order to estimate the functional relationship between dependent and independent variables (elasticities of various factors of production). The coefficient of the i^{th} resource shows the resource use productivity of that input.

The form of the production function fitted for barley production in the study was as follows:

$$Y = \alpha \; X_1^{\beta 1} \; X_2^{\beta 2} \; X_3^{\beta 3} \; X_4^{\beta 4} \; X_5^{\beta 5} X_6^{\beta 6} \; e^{u} \qquad \ldots (3.4)$$

Where:

Y	=	Output (Kg/farm)
X_1	=	Labour (man-days/farm)
X_2	=	Machinery (working hours/farm)
X_3	=	Seed (Kg/farm)
X_4	=	Chemical Fertilizer (Kg/farm)
X_5	=	Manure (Kg/farm)
X_6	=	Plant protection chemicals (Kg/farm)
α	=	Intercept (constant term)
e	=	Error term
$\beta_1, \ldots, \beta_6$	=	Elasticity coefficients of respective inputs

Since all the independent variables were in quantative terms and data on quantity of water used in irrigation could not be obtained for 179 observations and the frequency of irrigation also was not a suitable variable in the production function, therefore the irrigation variable was not considered in the model.

The labour was expressed in terms of man-days of eight hours. It included both family and hired human labour utilized for performing different farm operations in the production of barley. The female day and child day labour used were converted into man-days based on the definition by Ministry of Agricultural-Jihad of Iran as follows:

One woman day = 0.75 man-day

One child day = 0.50 man-day

The manure included both farm produced and purchased manures. The agricultural machinery was measured based on working hours for both hired and owned machinery.

In this study, both dependent and independent variables in the function were measured in physical units. The advantage of this measurement is that resource productivities worked out from the function will be free from the impact of fluctuating prices. Meanwhile, due to problem of multicollinearity, the land variable was dropped from the production function. The Cobb-Douglas type of production function was converted into log-linear form and the parameters were estimated using Ordinary Least Squares (OLS) method as follows:

$$\text{Ln } Y = \text{Ln } \alpha + \beta_1 \text{ Ln } X_1 + \beta_2 \text{ Ln } X_2 + \beta_3 \text{ Ln } X_3 + \beta_4 \text{ Ln } X_4 + \beta_5 \text{ Ln } X_5 + \beta_6 \text{ Ln } X_6 + u \qquad \ldots\ \ldots\ldots\ldots\ (3.5)$$

The regression coefficients (β_i) were tested for their significance using "t" test at chosen significant level, which is given by:

$$t = \frac{\beta_i}{SE(\beta_i)} \qquad \ldots\ldots\ \ldots\ \ldots\ (3.6)$$

Where

β_i is the regression coefficient of i^{th} input

SE (β_i) is the standard error of i^{th} input

The significance of function as a whole was tested using "F" test, which is given by:

$$F = \frac{R^2 / (K-1)}{(1-R^2) / (N-K)} \qquad \text{.........} \ (3.7)$$

Where

R^2 = Coefficient of multiple determination

K = Number of parameters in the model

N = Total number of observations

Coefficient of multiple determination (R^2) is given by:

$$R^2 = \frac{RSS}{TSS} \qquad \text{............} \ (3.8)$$

Where

RSS = Regression sum of squares

TSS = Total sum of squares

In order to ascertain the goodness of fit, the adjusted coefficient of multiple determination ($\overline{R}^2$) was calculated by using the formula:

$$\overline{R}^2 = 1 - (1 - R^2) \frac{N-1}{N-K} \qquad \text{.........} \ (3.9)$$

Where

N = Total number of observations

K = Number of parameters in the model

3.3.2.2 Allocative efficiency

The objective of a farm is to maximize profit, which can be achieved by effectively coordinating the efficient utilization and a judicious mix of the resources. The degree to which this is accomplished is determined by computing the allocative efficiency. If the marginal value product of i^{th} factor is greater than marginal cost of i^{th} factor, then the farmer is said to be allocating the resources efficiently and there is further scope for application of more units of the particular input. If the marginal value product of i^{th} factor is less than marginal cost of i^{th} factor, farmers are said to be using the input excessively so that the fixed resource is no longer responsive to the variable input applied.

Allocative efficiency is determined by calculating the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC).

$$AE_{Xi} = \frac{MVP_{Xi}}{MFC_{Xi}} \qquad \text{.........} \quad (3.10)$$

Where

AE_{xi} = Allocative efficiency of i^{th} input

MVP_{Xi} = Marginal Value Product of i^{th} input

MFC_{Xi} = Marginal Factor Cost of i^{th} input

The MVP_{Xi} is the incremental change in the total output expressed in monetary terms brought out by the additional unit of X_i keeping other factors level constant. It can be computed by the product of the marginal physical product of each input and unit price of output (price / Kilogram), which is given by:

$$MVP_{Xi} = MPP_{Xi} \times P_y \qquad \ldots\ldots\ldots\ldots (3.11)$$

Where

MPP_{Xi} = Marginal Physical Product of i^{th} input

P_y = Unite price of output

The Marginal Physical Product (MPP_{Xi}) was estimated at geometric mean level of i^{th} input. The marginal physical product of i^{th} input was derived from the Cobb-Douglas production function, as:

$$MPP_{Xi} = \frac{\beta_i \times \overline{Y}}{\overline{X}_i} \qquad \ldots\ldots\ldots\ldots (3.12)$$

Where

β_i = Elasticity coefficient of the i^{th} independent variable

$\overline{Y}$ = Geometric mean of output

$\overline{X}$ = Geometric mean of i^{th} input

The Marginal Factor Cost is the unit price of input as:

$$\mathbf{MFC_{Xi} = P_{Xi}} \qquad \ldots\ldots\ldots\ldots\ldots (3.13)$$

Where

P_{Xi} = Unit price of i^{th} input

3.3.2.3 Technical efficiency

The study of efficiency, which focuses on the possibility of increasing output while conserving resource use, is very important especially in developing agricultural economies, where resources are meager and opportunities for developing and adopting better technologies have of lately started dwindling (Ali and Chaudhry, 1991).

Efficiency can be defined in terms of producing the maximum amount of output, given a set of inputs; or producing a given level of output using a minimum level of inputs; or a mixture of both. Efficient farms either use less input than others to produce a given quantity of output, or for a given set of inputs they generate a greater output (Bakhshoodeh and Thomson, 2001).

Efficiency measurement provides information, which is potentially useful in the formulation and analysis of agricultural policy. Therefore the analysis of farm technical efficiency has received considerable attention in the economics literature in recent years. In this study, the stochastic frontier production function and Timmer's measure are applied to measure technical efficiency of barley farmers, which will be explained later.

3.3.2.3.1. Frontier production function analysis

A frontier production function represents the maximum possible output for any given set of inputs setting a limit or frontier on the observed values of dependent variable. In the sense that no observed value of output is expected to lie above the production function. Any deviation of a farm from the frontier indicates the farm's inability to produce maximum output from its given sets of inputs and hence represents the degree of technical efficiency (Job and George, 2002).

A production process can be inefficient in two ways. It can be technically inefficient in the sense it fails to produce maximum output from a given bundle of inputs. On the other hand, it can be said to be allocatively inefficient in the sense that marginal value product may not be equal to the marginal factor cost, given input price. Allocative inefficiency results in utilization of inputs in the wrong proportions while technical inefficiency results in the equi-proportionate over-utilization of the inputs (Schmidth and Lovell, 1979).

In other words, a production function cannot help to assess the efficiency of a farmer in resource use whereas frontier production function helps to overcome this problem by introducing a method which permits the comparison of performance of a particular group of farmers with the most efficient farmer in that group, hence the production frontier is the locus of maximum output level for a given set of inputs. It assumed that all farmers aim at maximizing returns from Barley production by using the available farm resources in their command.

Much of the literature on efficiency is based 'directly or indirectly' on the seminal work of Farrell (1957) who argued that efficiency could only meaningfully be gauged in a relative sense, as a deviation from the best practice of a representative peer group of producers. He introduced the distinction between technical efficiency and allocative efficiency.

To capture the ability of the farmers in achieving the maximum realizable crop output with minimum level of inputs under the existing resource environment and given technologies, careful examination of farm-specific technical efficiency of the individual farmers is necessary. Technical efficiency evaluates the firm's ability to obtain the maximum possible output from a given set of resources (Panda, 1996).

The concept of the Frontier was originally developed by Farrell (1957) in the context of the measurement of technical, allocative and economic efficiencies. He introduced the frontier production function, which distinguishes the technical and allocative efficiency.

There are two types of frontier production functions, parametric and non-parametric. The parametric frontier production function has specific functional form and it has more advantage than non-parametric model because it can be described in simple mathematical form.

The parametric approach is subdivided into two main classes of approaches namely deterministic and stochastic models. The main difference between these two broad categories is that deterministic models envelope all the observations, identifying the distance between the observed production and the maximum feasible production given the quantity of input used and identifying this distance as technical inefficiency. Stochastic models instead permit one to distinguish between technical inefficiency and statistical noise (Orio, 2001). Therefore stochastic frontier production function was selected for this study.

Aigner *et al* (1977) and Meeusen and Van Den Broeck (1977) independently presented the Maximum Likelihood Estimates (MLE) to estimate a stochastic production frontier of the form:

$$Q_i = Q\,(X_{ki},\, \hat{a})\, e^{\mathring{a}}, \quad i = 1, 2 \ldots n \;; \quad k = 1,2 \ldots n \qquad \ldots\ldots \; (3.14)$$

Where

Q_i = Output of the i^{th} farm

X_{ki} = Vector of K inputs of the i^{th} farm

β = Vector of parameters

å = Farm – specific error term

This stochastic frontier is also called a 'composed error' model because the error term is composed of two independent elements:

$$å = V_i - U_i \qquad \dots\dots\dots\dots (3.15)$$

Where

U_i = Non-negative term representing technical inefficiency

V_i = Symmetric component of the error term

The symmetric component, V_i , permits random variation in output due to factors outside the control of the farm such as weather and disease. It is assumed to be independently and identically distributed as N (0, $ó_v^2$). A one-sided component ($U_i \geq 0$) reflects technical inefficiency relative to the stochastic frontier, thus $U_i = 0$ for any farm's output lying below the frontier, representing the amount by which the frontier exceeds the actual output of farm i. It is also assumed to be independently and identically distributed as N (0, $ó_u^2$). That is half-normal distribution (Dawson and Lingard, 1989).

Let $ó^2_u$ and $ó^2_v$ be the variances of technical inefficiency parameter **'U'** and statistical noise 'V' respectively then:

$$ó^2 = ó^2_v + ó^2_u \qquad \dots\dots\dots (3.16)$$

The variance ratio γ, explaining the total variation in output from the frontier level of output attributed to technical inefficiencies, can be computed as:

$$\gamma = \sigma^2_u / \sigma^2 \quad \dots\dots\dots (3.17)$$

Where

$$0 \leq \gamma \leq 1$$

Aigner *et al.* (1977) defined λ as the ratio of standard errors in stochastic to symmetric disturbances as follows:

$$\lambda = \sigma_u / \sigma_v \quad \dots\dots\dots (3.18)$$

Estimation of stochastic frontier production function by maximum likelihood method gives the value of σ^2 and γ.

The value of λ can be manually calculated by using the equations (3.16) and (3.17). From the equation (3.17), σ^2_u can be calculated as follows:

$$\sigma^2_u = \gamma \times \sigma^2 \quad \dots\dots\dots (3.19)$$

By substituting the value of σ^2_u in equation (3.16), the value of σ^2_v is computed by:

$$\sigma^2_v = \sigma^2 - \sigma^2_u \quad \dots\dots\dots (3.20)$$

Then the square root of σ^2_u and σ^2_v are substituted in equation (3.18) to obtain the value of λ. In maximum likelihood technique, the estimates of λ and σ indicate the goodness of fit.

Jondrow *et al* (1982) demonstrated that individual firm measures of technical efficiency could be calculated from the error terms (ε_i) as follows:

$$E[u_i/\varepsilon_i] = \frac{\sigma_u \ \sigma_v}{\sigma} \left(\frac{f(\varepsilon_i \lambda / \sigma)}{1 - F(\varepsilon_i \lambda / \sigma)} - \frac{\varepsilon_i \lambda}{\sigma} \right) \quad \ldots (3.21)$$

Where

ε_i = The MLE residuals

$f(\varepsilon_i \lambda / \sigma)$ = Standard normal density function

$F(\varepsilon_i \lambda / \sigma)$ = Standard normal distribution function

The technical efficiency (TE_i) can be calculated as:

$$TE_i = \exp(-E[u_i / \varepsilon_i]) \quad ; \quad i = 1, \ldots, n \qquad \ldots\ldots (3.22)$$

So that $0 \leq TE_i \leq 1 \quad ; \quad i = 1, \ldots, n$

3.3.2.3.2. Model Specification

In the present study, frontier production function was derived from Transcendental Logarithmic (Translog) production function due to its advantages over the other functional forms and was estimated by MLE method. From the estimated function, Timmer's measure of technical efficiency was examined.

Translog (Transcendental Logarithmic) production function was developed by Christensen, Jorgenson and Lau (1973). It is a generalized form of the Cobb-Douglas production function.

The translog production function is most often written in its logarithmic form as:

$$LnY = Ln\beta_0 + \sum_{i=1}^{n} \beta_i LnX_i + \frac{1}{2}\sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} LnX_i LnX_j + V_i - U_i \quad \ldots(3.23)$$

Where

Y = Output

X_i = i [th] input

X_j = j [th] input

i = 1 , 2, ..., n

j = 1 , 2, ..., n

V_i = Symmetric component of the error term

U_i = Non-negative term representing technical inefficiency

$\beta_{ij} = \beta_{ji}$, $i \leq j$ remains in the model

The specific model estimated is:

$$LnY = Ln\beta_0 + \sum_{i=1}^{6} \beta_i LnX_i + \frac{1}{2}\sum_{i=1}^{6} \sum_{j=1}^{6} \beta_{ij} LnX_i LnX_j + V_i - U_i \quad \ldots (3.24)$$

Where

Y = Output (Kg/farm)

X_1 = Land (Ha)

X_2 = Seed (Kg/farm)

X_3 = Labour (Man – days/farm)

X_4 = Machinery (Working- hours/farm)

X_5 = Chemical fertilizer (Kg/farm)

X_6 = Manure (Kg/farm)

V_i = Symmetric component of the error term

U_i = Non-negative term representing technical inefficiency

$\beta_{ij} = \beta_{ji}$

This model can be written as:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 +$$

$$\beta_6 LnX_6 + \frac{1}{2}\beta_{11}(LnX_1)^2 + \beta_{12} LnX_1 LnX_2 + \beta_{13} LnX_1 LnX_3 +$$

$$\beta_{14} LnX_1 LnX_4 + \beta_{15} LnX_1 LnX_5 + \beta_{16} LnX_1 LnX_6 + \frac{1}{2}\beta_{22}(LnX_2)^2$$

$$+ \beta_{23} LnX_2 LnX_3 + \beta_{24} LnX_2 LnX_4 + \beta_{25} LnX_2 LnX_5 +$$

$$\beta_{26} LnX_2 LnX_6 + \frac{1}{2}\beta_{33}(LnX_3)^2 + \beta_{34} LnX_3 LnX_4 + \beta_{35} LnX_3 LnX_5$$

$$+ \beta_{36} LnX_3 LnX_6 + \frac{1}{2}\beta_{44}(LnX_4)^2 + \beta_{45} LnX_4 LnX_5 +$$

$$\beta_{46} LnX_4 LnX_6 + \frac{1}{2}\beta_{55}(LnX_5)^2 + \beta_{56} LnX_5 LnX_6 + \frac{1}{2}\beta_{66}(LnX_6)^2$$

$$+ V_i - U_i \qquad \text{......... (3.25)}$$

As with most production function estimates, multicollinearity is the cause, here the existence of X_1 (area) may create same problem but it would be inappropriate to drop this variable from the equation; doing so would relegate its effects to the disturbance term, biasing the subsequent calculations of technical efficiency.

If the sole purpose of regression analysis is prediction, then multicollinearity is not a serious problem. The rationale is that the greater the fit, the better the prediction (Gujarati, 1978)

This model is estimated by MLE method. Since the individual parameters of the translog function are not readily interpretable, the output elasticities of input and returns to scale were calculated.

The output elasticity of input or factor elasticity is the percentage change in the output divided by the percentage change in the input. In other words, the partial elasticity of production with respect to a particular factor is a measure of the proportional change in output resulting from a given proportional change in that factor when the other factors are held constant (Beattle and Taylore, 1992). In mathematical notation, partial elasticities of production are defined by:

$$Ex_i = \frac{MPPx_i}{APPx_i} \qquad \text{.........} \quad (3.26)$$

Where

Ex_i = Output elasticity of i^{th} input

$MPPx_i$ = Marginal physical product of i^{th} input

$APPx_i$ = Average physical product of i^{th} input

This can be written as:

$$Ex_i = \frac{dY}{dX_i} \times \frac{X_i}{Y} \qquad \text{.........} \quad (3.27)$$

Where

X_i = Quantity of i^{th} input

Y = Quantity of output

The output elasticities of input for equation (3.25) are:

$$Ex_1 = \beta_1 + \beta_{11} LnX_1 + \beta_{12} LnX_2 + \beta_{13} LnX_3 + \beta_{14} LnX_4 + \beta_{15} LnX_5 + \beta_{16} LnX_6 \quad \ldots\ldots\ldots (3.28)$$

$$Ex_2 = \beta_2 + \beta_{12} LnX_1 + \beta_{22} LnX_2 + \beta_{23} LnX_3 + \beta_{24} LnX_4 + \beta_{25} LnX_5 + \beta_{26} LnX_6 \quad \ldots\ldots\ldots (3.29)$$

$$Ex_3 = \beta_3 + \beta_{13} LnX_1 + \beta_{23} LnX_2 + \beta_{33} LnX_3 + \beta_{34} LnX_4 + \beta_{35} LnX_5 + \beta_{36} LnX_6 \quad \ldots\ldots\ldots (3.30)$$

$$Ex_4 = \beta_4 + \beta_{14} LnX_1 + \beta_{24} LnX_2 + \beta_{34} LnX_3 + \beta_{44} LnX_4 + \beta_{45} LnX_5 + \beta_{46} LnX_6 \quad \ldots\ldots\ldots (3.31)$$

$$Ex_5 = \beta_5 + \beta_{15} LnX_1 + \beta_{25} LnX_2 + \beta_{35} LnX_3 + \beta_{45} LnX_4 + \beta_{55} LnX_5 + \beta_{56} LnX_6 \quad \ldots\ldots\ldots (3.32)$$

$$Ex_6 = \beta_6 + \beta_{16} LnX_1 + \beta_{26} LnX_2 + \beta_{36} LnX_3 + \beta_{46} LnX_4 + \beta_{56} LnX_5 + \beta_{66} LnX_6 \quad \ldots\ldots\ldots (3.33)$$

Returns to scale are technical properties of the production function. If we increase the quantity of *all* factors employed by the same (proportional) amount, output will increase. If the resulting output will increase by the same proportion, it is called 'Constant returns to scale', more than proportionally 'increasing returns to scale' and less than proportionally 'decreasing to scale'. A measure of returns to scale is given by the sum of the output elasticities of input as:

$$\text{Returns to scale} = \sum_{i=1}^{n} Ex_i \qquad \dots\dots\dots \; (3.34)$$

3.3.2.3.3. Timmer's measure of technical efficiency

Timmer (1971) imposed the Cobb-Douglas production function on the frontier and computed an output-based measure of efficiency. The Timmer's measure of technical efficiency of farm 'i' is the ratio of actual output to the potential (Frontier) output on the production function given the level of input use on farm 'i'. It is given by:

$$TE_i = \frac{Y_i}{Y_i^*} \qquad \dots\dots\dots\dots \; (3.35)$$

Where

TE_i = Technical efficiency of i^{th} farm

Y_i = Actual output on i^{th} farm

Y_i^* = Maximum output obtainable on the i^{th} farm for the given level of input

3.3.2.3.4. Estimation of potential output

The yield potential of barley is calculated based on technical efficiency-measured through Timmer's measure of technical efficiency. It is the ratio of the average actual output level to the mean technical efficiency, which is given by:

$$PY = \frac{AY}{MTE} \qquad \dots\dots\dots\dots \; (3.36)$$

Where

PY = Potential output (Kg / ha)

AY = Average actual output (Kg / ha)

MTE = Mean technical efficiency

3.3.3 Estimation of optimum size of Barley cultivation

3.3.3.1. Cost function analysis

The issue of farm size is of major and continuing interest to farm producers and policy makers. The economic understanding of farm size changes has traditionally used a long run average cost (LRAC) function framework. In this framework farm size expands when there is opportunity to gain efficiencies from size. Research into the LRAC of agriculture has, however, generally shown major cost disadvantages of small farms but little cost advantage beyond moderate sized units.

The cost function is defined as:

$$c(w, y) = \min_{x \geq o} [w \cdot x : x \in V(y)] \qquad \dots\dots\dots\dots (3.37)$$

Where

w = Vector of strictly positive input prices

$w \cdot x$ = Inner product $(\sum_i w_i x_i)$ ………… (3.38)

The cost function is the minimum cost of producing a given output level during a given time period expressed as a function of input prices and output (chambers, 1988).

In specifying a proper cost function, several properties must be ensured. First, it must be non-negative, non-decreasing, concave and linear homogeneous in input prices.

Second, it should be capable of estimation with zero values of some outputs, which means that it should allow for economies of scale and scope and sub-additivity (Greer, 2003).

The two most commonly employed in cost estimation are the translog and the polynomial, both of which are flexible enough to avoid a priori restrictions on the elasticities of substitution among the input variables. However in polynomial cost function, one variable input also can be considered as independent variable therefore the polynomial cost function was applied in present study for the purpose of the estimation of optimum size of barley farms.

A polynomial function is given by:

$$F(X) = a_n + a_{n-1} X^{n-1} + \cdots + a_1 X + a_0 \qquad \ldots\ldots\ldots\ldots (3.39)$$

Where

n = Non negative integer

The degree of the polynomial function is the highest value of n. The cost function, which is a bivariate relationship associating Area with Average total Cost (ATC) was formulated as:

$$ATC = f(X) \qquad \ldots\ldots\ldots\ldots (3.40)$$

Where

ATC = Average total Cost (Rupees / hectare)

X = Area (ha)

The polynomial cost function of degree one (linear), degree two (Quadratic), degree three (Cubic) and higher degrees were applied. First order bivariate polynomial (linear type) is defined as:

$$ATC = a_0 + a_1X \qquad \text{………… (3.41)}$$

Similarly, the quadratic and cubic polynomial cost function are given by:

$$ATC = a_0 + a_1X + a_2X^2 \qquad \text{………… (3.42)}$$

$$ATC = a_0 + a_1X + a_2X^2 + a_3 X^3 \qquad \text{………… (3.43)}$$

Variables ATC and X in these functions are same as defined in equation 3.40. The linear and quadratic polynomial cost function are estimated using Ordinary Least Squares (OLS) method and the method of fitting a linear and quadratic polynomial cost function is extended to polynomials of higher degrees.

It was found that the variance of farm size in small farms group was very low (0.432). In order to overcome this problem and to have a better fit for the sample farmers, the small and medium categories of farmers are clubbed together and a single cost function is fitted for these two groups of farmers. The separate cost function is also estimated for large farms and it is compared to aggregate barley farms. The basis for the classification was as follows.

Size group	Area (hectare)
Small and medium	≤ 10
Large	> 10

To select a particular degree of polynomial regression as the best regression model, theoretically, the subsequent two degrees of polynomial regression models should have "F" non-significant because the objective is to find the degree of polynomial cost function that provides an adequate fit. Consequently, the reduction in error sum of squares is tested by F - test as each successive term is added (Snedecor and Cochran, 1989).

For practical purposes, one can choose the model based on the quantity of Error Sum of Squares (ESS), which is given by:

$$ESS = TSS - RSS \qquad \text{............ (3.44)}$$

Where

TSS = Total sum of squares

RSS = Regression sum of squares

The researcher can decide based on the objective of research whether the ESS quantity is small or large. In other words, if reduction in Error Sum of Squares (ESS) and increase in F-value or increase in coefficient of multiple determination (R^2) in higher degree of polynomial function is found to be negligibly more than previous degree of polynomial function; because of simplicity of the model, it is better to select more simple model.

The optimum size of farm is derived from the estimated cost function by taking first derivative of ATC and equating it with zero as:

$$\frac{dATC}{dX} = 0 \qquad \text{............ (3.45)}$$

The equation 3.45 is solved to obtain the feasible solutions. The second derivative of ATC is obtained. The cost minimization condition is defined as follows:

$$\frac{d^2 ATC}{d X^2} > 0 \qquad \text{………… (3.46)}$$

Among the solutions, one is selected, which result in positive value in second derivative of ATC (cost minimization condition). This value of X (area) is optimum size of farm.

3.3.3.2. The Chow test

A Chow test is a particular test for structural change introduced. It is an econometric test to determine whether the coefficients in a regression model are the same in separate sub- samples. In other word, the Chow test is a quantative test, which is used to test the equality of two coefficients obtained from different samples. The Chow test is applied in present study to test whether there is a significant change in the structural relationships of the regression coefficient of cost function of small and medium size with large size group.

The test procedure involves the RSS (Residual Sum of Squares) of three cost functions (for small and medium size group, large size group and aggregate). The entire samples are broken into small and medium, and large sub samples. By using the RSS of these two sub samples and the entire samples, the Chow F- test is applied as follow:

$$F = \frac{\{ RSS_A - (RSS_S + RSS_L) \} / K}{(RSS_S + RSS_L) / (n_1 + n_2 - 2K)} \qquad \text{………… (3.47)}$$

Where

RSS_A = Residual sum of squares for the aggregate samples

RSS_S = Residual sum of squares for small and medium samples

RSS_L = Residual sum of squares for large samples

K = Number of parameters involved in the cost function model

n_1 = Number of observations in small and medium size group

n_2 = Number of observations in large size group

The ' F ' calculated, is compared to ' F ' table, which is given by:

$$F_{(\alpha, K, n_1 + n_2 - 2K)} \qquad \ldots\ldots\ldots\ldots (3.48)$$

Where

α = Significance level

K = Degrees of freedom for numerator

$n_1 + n_2 - 2K$ = degrees of freedom for denominator

If ' F ' calculated is higher than ' F ' table, then the null hypothesis of equity of the coefficients of cost function of two sub- samples is rejected. Therefore two sub- samples are significantly different from each other, which is due to impact of size on cost of cultivation.

3.3.4 Study the status and problems of Barley producers

Various methods, many of them based upon the normal probability curve, have been used in the scaling of constraints. A scale is a continuum or continuity along which the problems and constraints have been located in terms of difficulty or some other attributes.

The units of a scale are arbitrary and depend upon the method employed by investigator. Ideally, scale units should be equal, have the same meaning, and remain stable throughout the scale.

After scaling the constraints, the second step is scaling judgements. There are many techniques to judge the scales like " scaling of answers to a questionnaire" and " scaling ratings in terms of the normal curve" and so on. One of the most important scaling judgement techniques is Garrett's ranking technique, which is used to rank the constraints for production in this study.

3.3.4.1. Garrett's Ranking Technique

Garrett's ranking technique is basically the change orders of constraints into numerical scores. The major advantage of this technique as compared to simple frequency distribution is that here the constraints are arranged based on their importance from point of view of respondents. Hence the same number of respondents on two or more constraints may have been different ranks.

It is often desirable to transmute orders of constraints into units of amount or "scores". This can be done by means of table, if we are justified in assuming normality for the trait. Garrett's formula for converting ranks into percents was given by:

$$\text{Percent position} = 100 \times \frac{(R_{ij} - 0.50)}{N_j} \qquad \ldots\ldots\ldots\ldots (3.49)$$

Where:

R_{ij} = Rank given for i th factor (constraint) by j th individual (farmer).

N_j = Number of factors (constraints) ranked by j th individual (farmer).

It should be pointed out that a rank is an interval on a scale; 0.50 is subtracted from each R_{ij} because its midpoint best represents an interval (Garrett and Woodworth, 1965).

The percent position of each rank obtained from above formula, was converted into scores by referring to the table given by Garrett (table namely transmutation of orders of merit into units of amount or scores). Then for each factor, scores of all individuals were added and divided by the total number of respondents for that specific factor (constraint). Finally mean scores for all the factors were arranged in descending order and the ranks were given. This method is more useful in the case of those attributes, which are not easily measured by ordinary methods.

RESULTS

CHAPTER - IV

RESULTS

The important findings of the study pertaining to the predetermined objectives are presented under the following headings.

4.1 General characteristics of the respondents

4.2 Cost of production of Barley on different size groups of farms

4.3 Resource productivity and resource use efficiency in Barley production

4.4 Optimum size of Barley cultivation

4.5 Status and problems of Barley producers

4.1 General characteristics of the respondents

The general characteristics of the sample barley farmers are presented to gain an insight into the socio-economic background of respondents as below.

4.1.1 Family size

Family size in farm families is important since it has a bearing on the extent of family labour available and capacity to save and reinvest in farming. Therefore, the details on the family size of the sample respondents were worked out and presented in table 4.1. The results showed that in the case of medium category of farmers, most of the farmers (47.8 percent) had family size of more than 5 persons followed by 4-5 persons (45.7 percent) and 1-3 persons (6.5 percent), whereas in small and large categories of farmers, most of farmers belonged to family size group of 4-5 persons.

Table- 4.1: Family size of sample Barley farmers

(in numbers)

Family size (persons)	Category of farmers			
	Small (≤2 Ha)	**Medium (2.1–10 Ha)**	**Large (>10 Ha)**	**Total**
1 – 3	7 (9.2)	3 (6.5)	17 (29.8)	27 (15.1)
4 – 5	39 (51.3)	21 (45.7)	25 (43.9)	85 (47.5)
More than 5	30 (39.5)	22 (47.8)	15 (26.3)	67 (37.4)
Sample size	76 (100)	46 (100)	46 (100)	179 (100)

Note: Figures in parentheses indicate percentages to total

The results also indicated that about 30 percent of farmers in large category belonged to family size of 1-3 persons, which is much higher than small (9.2 percent) and medium (6.5 percent) family size groups. In the case of total respondents, 47.5 percent of farmers had family size of 4 –5 persons followed by more than 5 (37.4 percent) and 1 –3 persons (15.1 percent), therefore about 85 percent of barley farmers had family size of 4 or above.

4.1.2 Age distribution of sample farmers

The respondents were classified into various age groups and the results are presented in table 4.2. Among three age compositions, majority of farmers (54.75 percent) belonged to 40-60 age group. The farmers with less than 40 years, and greater than 60 years were 26.25 percent and 19 percent of total sample farmers, respectively. Among small farmers' category, 15.8 percent, 61.8 percent and 22.4 percent of farmers belonged to the less than 40, 40-60 and greater than 60 years age groups, respectively. In medium and large farmers' groups, 28.3 percent, 50 percent, 21.7 percent and 38.6 percent, 49.1 percent and 12.3 percent of farmers belonged to the same age group as mentioned above.

4.1.3 Occupation

Out of 179 respondents, 155 (86.59 percent) were mainly dependent on agriculture, while the remaining 24 (13.41 percent) had some subsidiary occupation in addition to agriculture.

4.1.4 Literacy level

The education level of the respondents influences the level of adoption of innovations. The literacy level of respondents is presented in table 4.3. This table shows that among

Table- 4.2: Age-wise distribution of barley sample farmers

(in numbers)

Particular	Below 40 years	40 –60 years	More than 60 years	Total
Small farmers (≤2 hectares)	12	47	17	76
Medium farmers (2.1 – 10 hectares)	13	23	10	46
Large farmers (> 10 hectares)	22	28	7	57
Total	47	98	34	179

Table- 4.3: Educational status of sample farmers

Education status	No. of farmers	Percentage to total
Illiterate	35	19.60
Primary Education	58	32.40
Secondary Education	49	27.33
High School	23	12.85
Diploma	10	5.59
Graduate	4	2.23
Total	179	100

heads of families of 179 sample farms, 35 (19.6 percent) were illiterate, 58 (32.4 percent) had education up to primary level, 49 (27.33 percent) had education up to secondary level, 23 (12.85 percent) up to high school level, 10 (5.59 percent) diploma and the remaining 4 (2.23 percent) were graduates.

4.1.5 Distribution of sample farms

The sample farmers were classified into three farm size groups and the results are presented in table 4.4. Among the three farm size compositions, majority (42.5 percent) of respondents belonged to small farmers category. The share of the medium and large categories of farmers to total sample farmers was found to be 25.7 percent and 31.8 percent, respectively. The average farm size of small and medium categories of farms was 1.21 and 5.87 hectares, respectively. In the case of large category of farmers, the average farm size was found to be relatively high (50.84 Ha).

The distribution of barley sample farmers by townships of Tehran province is presented in table 4.5. The highest number of samples belonged to Varamin (38 samples) followed by Ray (30 samples) and both Shahriyar and Robatkarim each one with 21 barley farmers. The share of Savejbolagh and Firoozkooh to total samples was only 8.4 percent for each one of these two townships.

4.2 Cost of production of Barley on different size groups of farms

The results on various costs of cultivation of barley per hectare are presented in table 4.6. On an average the per hectare cost incurred towards seed by small, medium and large farmer groups was Rs. 948.05, Rs. 674.25 and Rs. 543.95, respectively.

Table- 4.4: Distribution of sample farmers by farm size

Category of farmers	No. of sample farmers	Average farm size (hectare)
Small (≤2 hectare)	76 (42.5)	1.21
Medium (2.1 – 10 hectare)	46 (25.7)	5.87
Large (> 10 hectare)	57 (31.8)	50.84
All	179 (100)	18.21

Note: Figures in parentheses are percentage to the column total

Table- 4.5: Distribution of sample farmers by township

Township	No. of sample farmers	Percent to total
Ray	30	16.8
Karaj	19	10.6
Varamin	38	21.2
Savejbolagh	15	8.4
Shahriyar	21	11.7
Eslamshahr	20	11.2
Firoozkooh	15	8.4
Robatkarim	21	11.7
Total	179	100

Table- 4.6: Cost structure of barley cultivation

(Rupees per hectare)

Cost Item	Small farmers (≤2 Ha)	Medium farmers (2.1–10 Ha)	Large farmers (> 10 Ha)	Total farmers
A. Variable Costs				
Seed	948.05 (8.8)	674.25 (6.9)	543.95 (6.4)	732.54 (7.4)
Chemical fertilizer	575.57 (5.1)	422.31 (4.3)	317.27 (3.7)	442.73 (4.4)
Manure	-	63.00 (0.6)	45.37 (0.5)	36.21 (0.4)
Plant protection chemicals	8.35 (0.1)	13.43 (0.1)	14.76 (0.2)	12.70 (0.1)
Human labour	582.58 (5.2)	316.75 (3.3)	159.55 (1.9)	349.82 (3.5)
Machinery cost	2443.33 (21.6)	2196.00 (22.6)	2056.14 (24.1)	2288.69 (23.0)
Water charge	2043.44 (18.3)	1553.77 (16.0)	1674.62 (19.6)	1818.77 (18.1)
Miscellaneous charge	330.07 (3.0)	261.97 (2.7)	240.58 (2.8)	284.07 (2.9)
Interest on variable cost	528.11 (4.7)	419.16 (4.3)	384.93 (4.5)	454.52 (4.6)
Total Variable Cost	7459.50 (66.8)	5920.63 (60.9)	5437.18 (63.7)	6420.05 (64.4)
B. Fixed Costs				
Rental value of land	3214.33 (28.6)	3275.33 (33.7)	2671.97 (31.3)	3057.30 (30.7)
Interest on fixed cost	514.29 (4.6)	524.05 (5.4)	427.52 (5.0)	489.17 (4.9)
Total Fixed Cost	3728.62 (33.2)	3799.39 (39.1)	3099.48 (36.3)	3546.47 (35.6)
C. Total Cost (A+B)	11188.12 (100)	9720.02 (100)	8536.66 (100)	9966.52 (100)

Note: Figures in parentheses indicate percentages to total

The seed cost per hectare in small farmers group was found to be greater than medium and large groups. This cost for entire sample was Rs. 732.54 per hectare. The cost incurred by small farmers on chemical fertilizer per hectare was Rs. 575.57, which was more than medium (Rs. 422.31), and large farmers (Rs. 317.27). On an average, the pooled category farmers had spent Rs. 442.73 per hectare on chemical fertilizer.

The manure was utilized by the medium and large farmers in negligible amounts. Medium and large farmers incurred an expenditure of Rs. 63 and Rs. 45.37 per hectare on manure. The similar cost for entire sample was Rs. 36.21 per hectare. The cost incurred by large farmers on plant protection chemicals per hectare was Rs. 14.76, which was more than the medium (Rs.13.43), and large farmers (Rs. 8.35). On an average, the pooled sample farmers incurred Rs. 12.7 per hectare on plant protection chemicals in barley cultivation.

On an average per hectare cost incurred towards human labour by small, medium and large farmers groups was Rs. 582.58, Rs. 316.75 and Rs. 159.55, respectively. The human labour cost per hectare in small farmer category was found to be greater than medium and large groups. The average cost per hectare of human labour for total sample farms was found to be Rs. 349.82. The cost incurred by small farmers on machinery per hectare was Rs. 2443.33, which was more than medium (Rs. 2196), and large farmers (Rs. 2056.14). On an average, the pooled category of farmers spent Rs. 2288.69 per hectare on machinery.

On an average per hectare cost incurred towards water by small, medium and large farmers groups was Rs. 2043.44, Rs. 1553.77 and Rs. 1674.62, respectively.

The water cost per hectare in small farmers category was found to be greater than medium and large groups. The similar cost for entire sample was Rs. 1818.77 per hectare. The total variable cost per hectare of barley cultivation including inputs cost, miscellaneous cost and interest on variable cost for the small, medium and large farmer groups was found to be Rs. 7459.5, Rs. 5920.63, and Rs. 5437.18, respectively, which accounts 66.7, 60.9 and 63.7 percent of the total cost.

On an average the variable cost for total sample farmers was Rs. 6420.05 accounting 64.4 percent of the total cost. This shows that small farmers spent more towards variable costs. Meanwhile, the major costs in variable costs belonged to machinery and water inputs.

The total fixed cost per hectare of barley production incurred by small, medium and large farmer groups including rental value of land and interest on fixed cost was Rs.3728.62, Rs. 3799.39 and Rs. 3099.48 per hectare respectively, which constituted 33.2, 39.1 and 36.3 percent of the total cost. The similar cost for total farmers was Rs.3546.47 (35.6 percent) per hectare.

On an average the per hectare cost incurred towards land by small, medium and large farmer groups was Rs. 3214.33, Rs. 3275.33 and Rs. 2671.97, respectively which accounts for 28.6, 33.7 and 31.3 percent of the total cost. The average cost per hectare of land for total sample farms was found to be Rs.3057.3 accounting for 30.7 percent of the total cost.

The different costs of barley cultivation per hectare for total sample farmers as percentage is shown in figure-3. This figure shows that land had highest share of total cost of cultivation of barley per hectare (30.7 percent) followed by machinery (23 percent) and water (18.1 percent). The average cost of barley cultivation per hectare by township is presented in table 4.7.

The share of variable costs to the total cost among the townships under study ranged from 46.4 to 69.5 percent. Varamin Township had highest share of variable costs to total cost (69.5 percent) followed by Eslamshahr (67.9 percent) and Ray (67.5 percent). The results showed that with the exception of Firoozkooh Township, in other townships under study, land had highest share of total cost followed by machinery and water.

In the case of Firoozkooh, on an average, the cost incurred on water per hectare was very negligible (Rs. 242.25) as compared to other townships since it enjoys good surface water for irrigation, which is relatively cheap as compared to other sources of irrigation. Firoozkooh Township had highest cost incurred on land per hectare (Rs. 4550.56), which contribute 46.2 percent of total cost of barley production. The high value of land in this township is as result of availability of enough water and small land holdings in this area. Meanwhile, the rental value of land had range from Rs. 2137.25 (Savejbolagh) to Rs. 4550.56 (Firoozkooh) among townships under study.

The total cost of barley cultivation among the townships of Tehran province ranged from Rs. 7428.37 (Savejbolagh) to Rs. 11402.55 (Robatkarim). This wide difference between minimum and maximum cost of cultivation is mainly as a result of difference in rental value of land and water charge. For example in Savejbolagh Township, the average

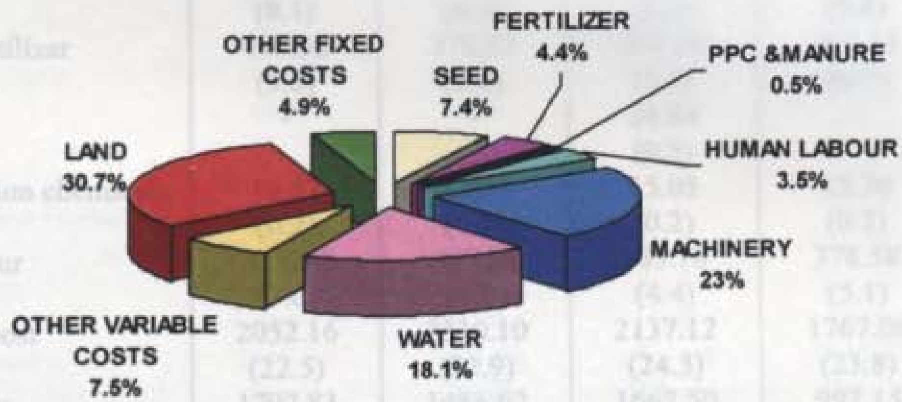

Fig. 3: Cost structure of Barley cultivation per hectare (All farms)

Table- 4.7: Cost of barley cultivation by township in Tehran province

(Rupees per hectare)

Cost Item	Ray	Karaj	Varamin	Savejbolagh
A. Variable Costs				
Seed	738.34 (8.1)	699.82 (6.9)	703.91 (8.0)	725.58 (9.8)
Chemical fertilizer	496.56 (5.5)	370.57 (3.6)	461.38 (5.3)	495.69 (6.7)
Manure	-	-	24.84 (0.3)	-
Plant protection chemicals	14.57 (0.2)	12.04 (0.1)	15.05 (0.2)	15.70 (0.2)
Human labour	325.50 (3.6)	297.31 (2.9)	383.78 (4.4)	378.58 (5.1)
Machinery cost	2052.16 (22.5)	2330.10 (22.9)	2137.12 (24.3)	1767.08 (23.8)
Water charge	1797.83 (19.8)	1486.62 (14.7)	1667.50 (19.0)	997.15 (13.4)
Miscellaneous charge	271.25 (3.0)	259.82 (2.6)	269.68 (3.1)	218.99 (2.9)
Interest on variable cost	434.00 (4.8)	415.72 (4.1)	431.49 (4.9)	350.38 (4.7)
Total Variable Cost	6130.21 (67.5)	5872.01 (57.6)	6094.74 (69.5)	4949.16 (66.6)
B. Fixed Costs				
Rental value of land	2540.70 (28.0)	3720.53 (36.6)	2305.60 (26.3)	2137.25 (28.8)
Interest on fixed cost	406.51 (4.5)	595.28 (5.8)	368.90 (4.2)	341.96 (4.6)
Total Fixed Cost	2947.21 (32.5)	4315.82 (42.4)	2674.49 (30.5)	2479.21 (33.4)
C. Total Cost (A+B)	9077.42 (100)	10187.83 (100)	8769.23 (100)	7428.37 (100)

Continued

Table-4.7 contd…

Cost Item	Shahriyar	Eslamshahr	Firoozkooh	Robatkarim
A. Variable Costs				
Seed	948.05 (8.5)	701.23 (7.5)	875.63 (8.9)	696.72 (6.1)
Chemical fertilizer	575.57 (5.1)	454.33 (4.8)	460.69 (4.7)	473.12 (4.1)
Manure	-	263.78 (2.8)	-	-
Plant protection chemicals	28.35 (0.3)	44.83 (0.5)	-	29.74 (0.3)
Human labour	562.58 (5.0)	256.96 (2.7)	684.56 (6.8)	332.42 (2.9)
Machinery cost	2443.33 (21.8)	2543.58 (27.0)	1784.69 (18.1)	1957.55 (17.1)
Water charge	2043.44 (18.3)	1392.28 (14.8)	242.25 (2.5)	2163.68 (19.0)
Miscellaneous charge	330.07 (3.0)	282.85 (3.0)	202.39 (2.1)	282.66 (2.5)
Interest on variable cost	528.11 (4.7)	452.56 (4.8)	323.83 (3.3)	452.26 (4.0)
Total Variable Cost	7459.50 (66.7)	6392.41 (67.9)	4574.04 (46.4)	6388.16 (56.0)
B. Fixed Costs				
Rental value of land	3214.33 (28.7)	2602.75 (27.7)	4550.56 (46.2)	4322.75 (37.9)
Interest on fixed cost	514.29 (4.6)	416.44 (4.4)	728.09 (7.4)	691.64 (6.1)
Total Fixed Cost	3728.62 (33.3)	3019.19 (32.1)	5278.65 (53.6)	5014.39 (44.0)
C. Total Cost (A+B)	11188.12 (100)	9411.60 (100)	9852.69 (100)	11402.55 (100)

Note: Figures in parentheses indicate percentages to total

cost incurred on land and water was Rs. 2137.25 and Rs. 997.15 per hectare, respectively whereas the similar costs for Robatkarim Township was Rs. 4322.75 and Rs. 2163.68, respectively.

The details of returns per hectare of barley cultivation by size group are presented in table 4.8. The value of main product of barley for small, medium and large farmer groups was Rs. 13,787.38, Rs.14,431.83 and Rs. 15,053.60 per hectare, respectively. On an average, the similar value for total sample farmers was found to be Rs. 14360.23.

The average gross returns per hectare of barley were highest in the case of large farmers group (Rs. 16567.75) followed by medium (Rs. 15903.70) and small farmers group (Rs. 15177.66). The average net returns over variable cost for large farmers group (Rs. 11130.57) was found to be much greater than small (Rs. 7718.16) and medium (Rs.9983.07) farmers groups. It is mainly related to two reasons, high gross returns per hectare and lower average variable cost per hectare in large farmers group. The net returns over total cost were Rs. 3989.54, Rs. 6183.68 and Rs. 8031.09 per hectare for small, medium and large farmers groups, respectively. The similar value for entire sample was Rs. 5811.44 per hectare. The net returns over total cost for large group was also greater than small and medium farmers groups with relatively higher difference as compared to net returns over variable cost. It is because of lower fixed cost in large farmers group as well. The returns per Rupee of variable cost were 2.035, 2.686 and 3.047 for small, medium and large farmers groups, respectively. The similar value for total sample farmers was 2.458. It implies that one Rupee of variable cost would give rise to a return of Rs. 2.458.

Table- 4.8: Returns in barley production

(Rupees per hectare)

Particular	Small farmers (≤2 Ha)	Medium farmers (2.1–10 Ha)	Large farmers (> 10 Ha)	Total farmers
A.Yield (Kg/Ha)	2821.61	3141.51	3667.29	3173.11
i) Main product (Rs.)	13787.38	14431.83	15053.60	14360.23
ii) By-product (Rs.)	1390.28	1471.87	1514.15	1417.73
B. Gross returns	15177.66	15903.70	16567.75	15777.96
C. Net return (Rs.)				
i) On variable cost	7718.16	9983.07	11130.57	9357.90
ii) On total cost	3989.54	6183.68	8031.09	5811.44
D. Returns per rupee of variable cost	2.035	2.686	3.047	2.458
E. Returns per rupee of total cost	1.357	1.636	1.941	1.583

The returns per Rupee of total cost were found to be 1.357, 1.636 and 1.941 for small, medium and large farmers groups, respectively. The returns per Rupee of total cost for the entire sample farmers was found to be 1.583 indicating that one rupee of total cost would give rise to a return of 1.583. Highest is, however, obtained for large farmers group.

The returns per hectare of barley cultivation by townships are presented in table 4.9. The value of main product of barley per hectare among the townships under study had range from Rs. 10506.37 (Savejbolagh) to Rs. 15703.72 (Karaj). Karaj Township had highest value of main product of barley per hectare followed by Robatkarim (Rs. 15173.93) and Varamin (Rs.14007). The results also showed that Karaj Township had highest gross returns per hectare of barley cultivation (Rs. 17898.91) followed by Robatkarim (Rs. 16615.620) and Firoozkooh (Rs. 15898.82). The net returns over total cost were found to be highest in Karaj (Rs. 7711.09) followed by Varamin (Rs.6987.25) and Eslamshahr (Rs. 6337.98).

It is interesting to note that contrary to gross returns per hectare, Robatkarim and Firoozkooh townships were not second and third places in the case of net returns over total cost, which is mainly because the total cost of cultivation of barley in these two townships were relatively high. The returns per Rupee of variable cost were highest in Firoozkooh Township (3.476). The same returns in the case of Ray (2.336) were found to be lowest among the townships under study. The returns per Rupee of total cost among the townships had range from 1.457 to 1.830. Savejbolagh Township had highest returns per Rupee of total cost followed by Varamin (1.797) and Karaj (1.757).

Table- 4.9: Costs and Returns in barley production by township (Rupees per hectare)

Particular	Ray	Karaj	Varamin	Savejbolagh	Shahriyar	Eslamshahr	Firoozkooh	Robatkarim
A.Yield								
i) Main product (Rs.)	12724.92	15703.72	14007.00	10506.37	13463.07	13610.04	13441.55	15173.93
ii) By-product (Rs.)	1596.23	2195.19	1749.49	3087.84	1474.06	2139.53	2457.27	1441.69
B. Gross returns	14321.15	17898.91	15756.49	13594.21	14937.13	15749.57	15898.82	16615.62
C. Costs (Rs.)								
i) Total variable cost	6130.21	5872.01	6094.74	4949.16	7459.50	6392.41	4574.04	6388.16
ii) Total fixed cost	2947.21	4315.82	2674.49	2479.21	3728.62	3019.19	5278.65	5014.39
iii) Total cost	9077.42	10187.83	8769.23	7428.37	11188.12	9411.60	9852.69	11402.55
D. Net return (Rs.)								
i) On variable cost	8190.94	12026.90	9661.75	8645.05	8806.92	9357.16	11324.78	10227.46
ii) On total cost	5243.73	7711.09	6987.25	6165.84	5859.71	6337.98	6046.13	5213.07
E. Returns per rupee of variable cost	2.336	3.048	2.585	2.747	2.437	2.464	3.476	2.601
F. Returns per rupee of total cost	1.578	1.757	1.797	1.830	1.646	1.673	1.614	1.457

The average costs and returns per kilogram of barley production by size groups are presented in table 4.10. The average variable cost incurred to produce one kilogram of barley was Rs. 3.66, Rs. 2.21 and Rs. 2.05 for small, medium and large farmers groups, respectively. The similar cost for total farmers was Rs. 2.70. The average total cost to produce one kilogram of barley was highest in the case of small farmers group (Rs. 5.25) followed by medium (Rs. 3.59) and large (Rs. 3.19). The same cost for entire sample farmers was (Rs. 4.09).

The gross returns per kilogram of barley production were Rs. 5.38, Rs. 5.06 and Rs. 4.52 for small, medium and large farmers groups, respectively. The lower gross returns per kilogram of barley is mainly because the large farmers sold their outputs at the minimum support price to government, which is sometimes less than its price in the market. The net returns over variable cost worked out to Rs. 1.72, Rs. 2.85 and Rs. 2.47 per kilogram of barley production for small, medium and large farmers groups, respectively. The net returns over variable cost per kilogram of output for entire sample farmers were Rs. 2.27.

It is interesting to note that the net returns over total cost per kilogram of barley, in the case of small farmers group was very low (Rs. 0.13), which was because of high total cost per kilogram of barley production in this category. The net returns over variable cost per kilogram of barley output for medium farmers group was marginally greater than large group (Rs. 1.47 Vs. Rs.1.33). The similar value for total sample farmers was found to be Rs. 0.88, which affected by more number of samples in small farmers group.

Table- 4.10: Costs and returns per kilogram of barley production

(Rupees / Kg)

Particular	Small farmers (≤2 Ha)	Medium farmers (2.1–10 Ha)	Large farmers (> 10 Ha)	All farmers
A. Costs				
i) Variable cost	3.66	2.21	2.05	2.70
ii) Fixed cost	1.59	1.38	1.14	1.39
iii) Total cost	5.25	3.59	3.19	4.09
B. Gross return	5.38	5.06	4.52	4.97
C. Net return				
i) over variable cost	1.72	2.85	2.47	2.27
ii) over total cost	0.13	1.47	1.33	0.88

The average cost of barley production per hectare by different activities for different farm size groups is presented in table 4.11. This table indicates that for all sample size groups, land cost had highest share of total cost of barley cultivation as it was 28.6, 33.7 and 31.3 percent of total cost of barley cultivation for small, medium and large farmers groups, respectively. The similar share for entire samples was 30.7 percent. After land, in the case of small farmers group, cost of vegetation stage (22.5 percent) had highest share of total cost followed by harvest (18.1 percent) and land preparation stage (17.3 percent). It is interesting to note that with increase the farm size, the share of cost of harvesting stage to total cost of barley cultivation has declined from 18.1 percent for small farmers to 6 percent for large farmers group, which is mainly because of mechanical harvesting.

In the case of medium and large farmers groups, after land cost, the cost of vegetation and land preparation stages had highest share of total cost of barley cultivation, respectively. For pooled sample farmers, land cost had highest share of total cost of barley production (30.7 percent). After land, vegetation (24.4 percent), land preparation (18.3 percent) and cultivation (14.5 percent) stages had highest share in the total cost of barley production, respectively.

The average cost of barley production per hectare by different activities for townships under study is presented in Table 4.12. This table indicates that with the exception of Ray Township, for all townships under study, land cost had highest share in the total cost of barley cultivation. The share of land cost in the total cost of barley production ranged from 30.5 percent (Varamin) to 53.6 percent (Firoozkooh). It should be noted that in Ray Township also this share was marginally less than vegetation stage (32.55% Vs. 35.1%).

Table- 4.11: Total cost of barley by different activities and farm size

(Rs / Ha)

Particular	Small farmers (≤ 2 Ha)	Medium farmers (2.1–10 Ha)	Large farmers (> 10 Ha)	All farmers
A. Production stages*				
Land preparation	1930.00 (17.3)	1847.17 (19.0)	1715.91 (20.1)	1826.29 (18.3)
Cultivation	1500.33 (13.4)	1477.44 (15.2)	1323.18 (15.5)	1445.15 (14.5)
Vegetation	2521.80 (22.5)	2274.48 (23.4)	2313.4 (27.1)	2431.83 (24.4)
Harvest	2021.69 (18.1)	845.60 (8.7)	512.20 (6.0)	1205.95 (12.1)
B. Land	3214.33 (28.6)	3275.33 (33.7)	2671.97 (31.3)	3057.30 (30.7)
Total	11188.12 (100)	9720.02 (100)	8536.66 (100)	9966.52 (100)

Note: Figures in parentheses indicate percentages to total

* 1. Land preparation includes irrigation, tillage, disking, leveling operations.

2. Cultivation includes Manuring, fertilizing, sowing operations.

3. Vegetation includes irrigation, top-dressing, spraying operations.

Table- 4.12: Total cost of barley by different activities and township

(Rs. / Ha)

Township	Land preparation	Cultivation	Vegetation	Harvest	Land	Total cost
Ray	1090.37 (12.1)	1353.16 (15.0)	3172.82 (35.1)	513.41 (5.7)	2947.21 (32.5)	9077.42 (100)
Karaj	1610.68 (15.8)	1264.11 (12.4)	2161.32 (21.2)	835.90 (8.2)	4315.82 (42.4)	10187.83 (100)
Varamin	1727.54 (19.7)	1043.54 (11.9)	2420.43 (27.6)	903.23 (10.3)	2674.49 (30.5)	8769.23 (100)
Savejbolagh	1902.32 (25.6)	1055.23 (14.2)	1025.52 (13.8)	966.09 (13.0)	2479.21 (33.4)	7428.37 (100)
Shahriyar	2203.19 (19.7)	1364.55 (12.2)	3332.55 (29.8)	559.21 (5.0)	3728.62 (33.3)	11188.12 (100)
Eslamshahr	1816.67 (19.3)	2288.22 (24.3)	1807.02 (19.2)	480.50 (5.1)	3019.19 (32.1)	9411.60 (100)
Firoozkooh	1429.33 (14.5)	877.28 (8.9)	571.76 (5.8)	1695.66 (17.2)	5278.65 (53.6)	9852.69 (100)
Robatkarim	1038.13 (9.1)	1391.91 (12.2)	3228.16 (28.3)	729.96 (6.4)	5014.39 (44.0)	11402.55 (100)

Note: Figures in parentheses indicate percentages to total

The cost of land preparation in Savejbolagh, cultivation in Eslamshahr, vegetation in Ray and harvest stage in Firoozkooh had highest share in the total cost of barley cultivation per hectare (percentage). The share of cost of vegetation stage in the total cost of production in Firoozkooh was found to be lowest among townships. It is as a result of low cost of water, which is the main cost in this stage. On the contrary, this cost was high in Ray Township therefore the cost of vegetation stage in this township had highest share to total cost of barley cultivation. The share of cost of harvesting stage in the total cost of barley production per hectare in the case of Firoozkooh Township was found to be highest among townships.

4.3 Resource productivity and Resource use efficiency in Barley production

4.3.1 Resource productivity

In this section, an attempt is made to study the productivities of resources involved in the production of barley in Tehran province. The analysis was done to determine whether the factors of production were used optimally.

A Cobb-Douglas type of production function was fitted to the data, since it provides a compromise among adequate fit to the data, computational feasibility and sufficient degree of freedom to allow for statistical testing as compared to other production functions like Translog and Transcendental type of production functions.

The results of regression coefficients in respect of the production function are given in table 4.13.

Table-4.13: Cobb- Douglas Production function estimates in barley production

Item	Regression Coefficients	Standard error	t - value
Variable			
Intercept	4.083 *	0.405	10.069
Labour (X_1)	0.063	0.075	0.843
Machinery (X_2)	0.388 *	0.086	4.537
Seed (X_3)	0.116	0.120	0.970
Chemical fertilizer (X_4)	0.402 *	0.073	5.516
Manure (X_5)	0.016 **	0.010	1.689
Plant protection chemicals (X_6)	0.025	0.027	0.928
Model summary			
R^2	0.956		
$\overline{R}^2$	0.954		
N	179		
F –statistic	619.319		
Returns to scale	1.01		

Note: * Significance at 1 percent level
** Significance at 5 percent level

The results showed that the Coefficient of multiple determination (R^2) was 0.956 indicating that the variables included in the model had explained 95.6 percent of variations in the output of barley. The adjusted coefficient of multiple determination ($\overline{R}^2$) was found to be 0.954, which is almost equal to coefficient of multiple determination indicating the goodness of fit. The observed "F" was found to be highly greater than the theoretical "F" value even at one percent level of significance, which also reveals the goodness of fit. The coefficients of machinery and chemical fertilizer input were 0.388 and 0.402, respectively and both significant at one percent probability level. The manure input was found to be significant at 5 percent probability level.

The coefficients of labour and plant protection inputs were small and insignificant, whereas the coefficient of seed was large but not significant. In addition, the intercept was significant at one percent significant level. This table also reveals that the output elasticities of all inputs were positive. The magnitude of output elasticity in the case of chemical fertilizer and machinery inputs were considerably higher than other inputs. The regression coefficients in the Cobb-Douglas production function themselves are the production elasticities, and their sum indicates the returns to scale. The estimate for returns to scale was found to be 1.01, which is not significantly different from unity, indicating constant returns to scale.

The average yield of barley per hectare in different size groups is shown in Figure-4. This figure reveals that on an average, the large category of farmers had highest yield per hectare (3667 Kg/Ha) followed by medium (3141 Kg/Ha) and small category of farmers (2822 Kg/Ha), respectively. The average yield per hectare of barley cultivation for entire sample farmers was 3173 Kg/Ha.

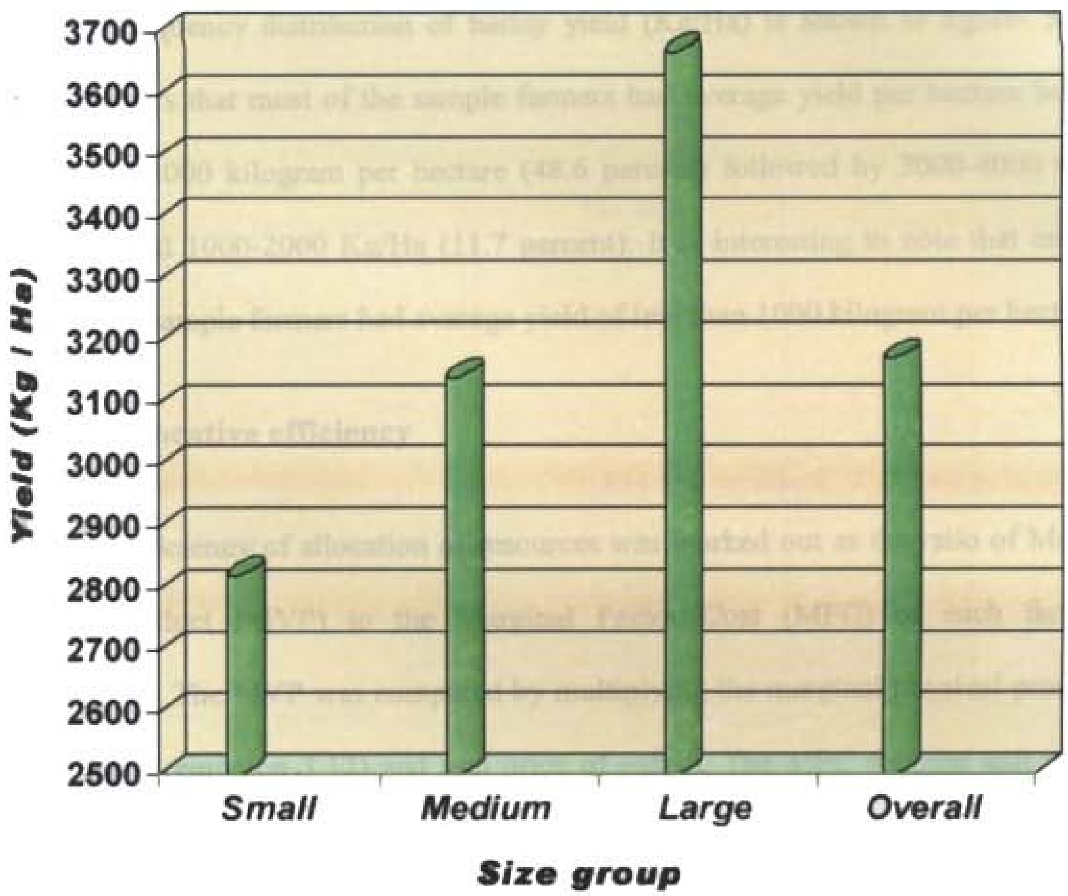

Figure. 4: Yield of Barley by size group

The different sources of irrigation in barley production for the sample farmers are presented in table 4.14. This table indicates that the major source of irrigation of barley was deep well (67.5 percent) followed by mixed sources (14.5 percent) and river (6.1 percent), respectively.

The frequency distribution of barley yield (Kg/Ha) is shown in figure- 5. This figure shows that most of the sample farmers had average yield per hectare between 2000 and 3000 kilogram per hectare (48.6 percent) followed by 3000-4000 Kg/Ha (34.1%) and 1000-2000 Kg/Ha (11.7 percent). It is interesting to note that only 1.1 percent of sample farmers had average yield of less than 1000 kilogram per hectare.

4.3.2 Allocative efficiency

The efficiency of allocation of resources was worked out as the ratio of Marginal Value Product (MVP) to the Marginal Factor Cost (MFC) of each factor of production. The MVP was computed by multiplying the marginal physical product of each input (equation 3.12) and unit price of output. The MFC was the unit price of each input.

The Geometric mean and unit price of inputs and output that was used to calculate allocative efficiency (equations 3.10, 3.12, 3.13) is given in table 4.15. The allocative efficiency of variables included in the analysis of barley production is presented in table 4.16. The results showed that the ratios of MVP to MFC for all variables were greater than unity. The ratio of MVP to MFC was highest in the case of chemical fertilizer (12.48). This ratio for plant protection chemical was found to be 4.49.

Table- 4.14: Different sources of irrigation in Barley production

Source of Irrigation	No. of sample farmers	Percent to total
Subterranean	6	3.4
Spring	6	3.4
River	11	6.1
Deep – Well	121	67.5
Semi deep Well	1	0.6
Shallow Well	5	2.8
Canal	3	1.7
Mixed irrigation sources	26	14.5
Total	179	100

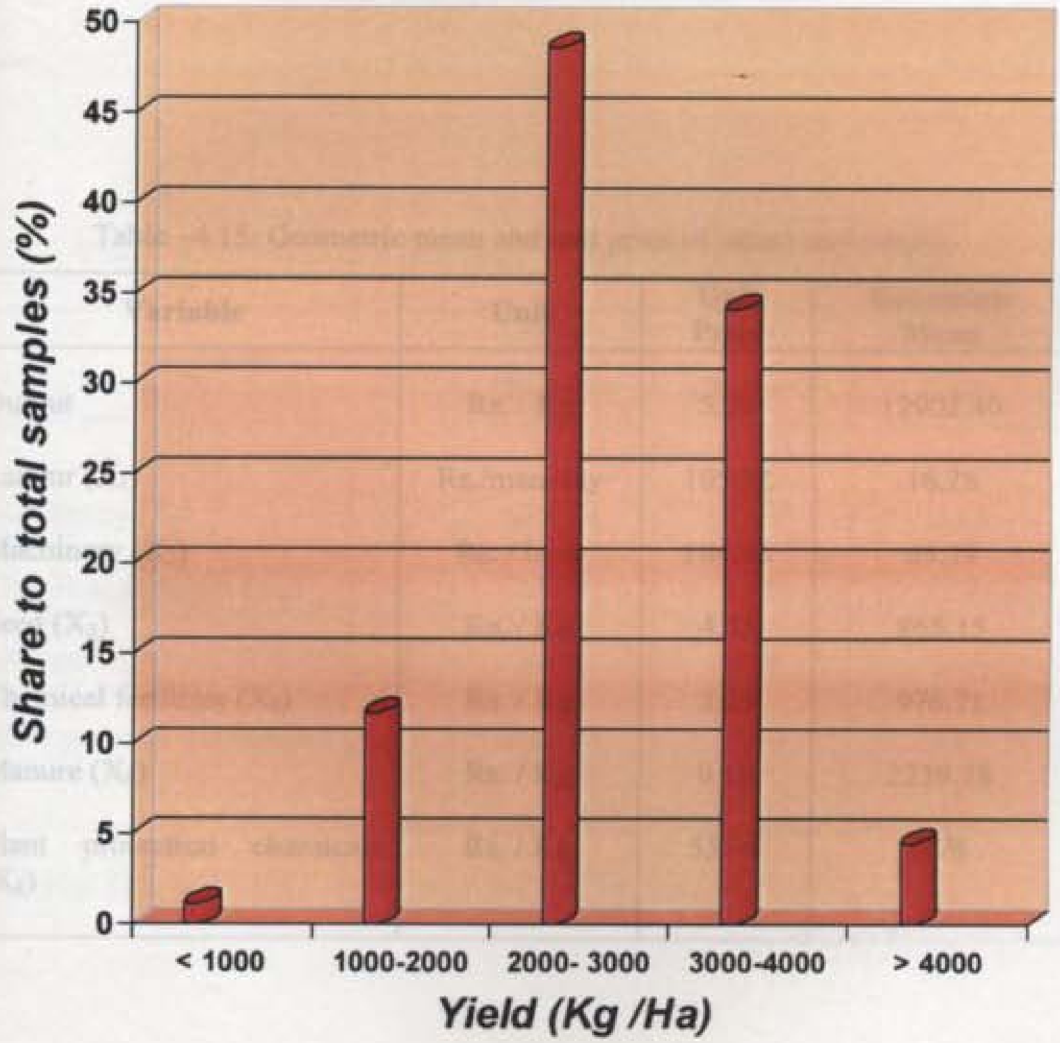

Fig. 5: Frequency distribution of Barley Yield

Table –4.15: Geometric mean and unit price of inputs and output

Variable	Unit	Unit Price	Geometric Mean
Output	Rs. / Kg	5.29	12902.40
Labour (X_1)	Rs./man-day	105.92	16.28
Machinery (X_2)	Rs. / hour	184.93	65.79
Seed (X_3)	Rs. / Kg	4.53	865.15
Chemical fertilizer (X_4)	Rs. / Kg	2.25	976.71
Manure (X_5)	Rs. / Kg	0.18	2239.78
Plant protection chemicals (X_6)	Rs. / Kg	55.94	6.76

Table –4.16: Allocative efficiency of resources in barley production

Variable	MVP (Rupees)	MFC (Rupees)	MVP/ MFC Ratio
Machinery (X_2)	402.53	184.93	2.18
Chemical fertilizer (X_4)	28.09	2.25	12.48
Manure (X_5)	0.50	0.18	2.78
Plant protection chemicals (X_6)	251.39	55.94	4.49

Note: The MVP/MFC ratios are presented for significant variables only.

4.3.3 Resource use efficiency and technical efficiency in Barley production

4.3.3.1. Frontier production function

In order to study the technical efficiency of barley producers, the translog frontier production function was employed and it is estimated by maximum likelihood estimates. This was done by regressing output of barley on inputs including land (X_1), seed (X_2), labour (X_3), machinery (X_4), chemical fertilizers (X_5) and manure (X_6).

The results of maximum likelihood estimates are presented in table 4.17. From the table, it is clear that in the case of barley farmers, the estimated λ (1.0435) and ó^2 (0.1337) were different from zero indicating goodness of fit and the correctness of the distributional assumption specified. The variance ratio (ã) was found to be 0.5211 indicating 52.11 percent of farm specific variability contributed to the variation in output, which means that the total variation in output from the frontier is attributable to technical inefficiency. It also implied that one-sided errors U_i dominate the symmetric error V_i. In other words, about 52 percent of the differences between the observed and the maximum production frontier outputs were due to differences in farmer's levels of technical efficiency and not much related to random variability.

The constant term, and the coefficients of land and machinery were found to be significant at one percent probability level. On the other hand, the coefficients of seed and fertilizer were significant at 5 percent probability level. Since the individual parameters of translog production function are not directly interpretable, therefore the output elasticities of input and returns to scale were separately calculated and results are presented in table 4.18.

Table-4.17: Maximum Likelihood Estimates of Translog frontier production

Name of Variables	Parameters	Coefficient
Constant	β_0	15.6556 * (1.5487)
Land	β_1	9.3743 * (2.5510)
Seed	β_2	- 0.5258 ** (0.2792)
Labour	β_3	-0.5425 (2.2978)
Machinery	β_4	- 0.8603 * (0.2744)
Fertilizer	β_5	- 5.5592 ** (3.2264)
Manure	β_6	- 0.7646 (0.8445)
Land × Land	β_{11}	0.6215 ** (2.9849)
Seed × Seed	β_{22}	- 0.4307 (0.4766)
Labour × Labour	β_{33}	- 0.7002 * (0.0980)
Machinery × Machinery	β_{44}	- 0.7473 * (0.1975)
Fertilizer × Fertilizer	β_{55}	- 0.2886 * (0.0414)
Manure × Manure	β_{66}	- 0.0733 (0.0558)
Land × Seed	β_{12}	0.2700 * (0.8202)
Land × Labour	β_{13}	0. 7201 * (0.2892)
Land × Machinery	β_{14}	0.4031 ** (0.2335)
Land × Fertilizer	β_{15}	- 2.0186 * (0.6881)
Land × Manure	β_{16}	- 0.1649 ** (0.0962)
Seed × Labour	β_{23}	- 0.3318 (0.4127)

Continued

Table-4.17 contd…

Name of Variables	Parameters	Coefficient
Seed × Machinery	β_{24}	- 0.4397 * (0.1298)
Seed × Fertilizer	β_{25}	0.7660 ** (0.3936)
Seed × Manure	β_{26}	0.1085 (0.2387)
Labour × Machinery	β_{34}	0.0984 (0.3021)
Labour × Fertilizer	β_{35}	0.4004 * (0.1562)
Labour × Manure	β_{36}	0.0293 (0.1776)
Machinery × Fertilizer	β_{45}	0.8848 * (0.3173)
Machinery × Manure	β_{46}	0.0093 (0.0741)
Fertilizer × Manure	β_{56}	0.1182 ** (0.0183)
Variance Parameters		
	σ^2	0.1337 * (0.0230)
	γ	0.5211 (0.1297) *
	λ	1.0435

Note: * Significance at 1 percent level
** Significance at 5 percent level
Figures in parentheses indicate standard errors

Table-4.18: Output elasticities of inputs and returns to scale

Particular	Elasticity
Output elasticities of input	
Land (X_1)	0.5605
Seed (X_2)	0.1537
Labour (X_3)	0.2213
Machinery (X_4)	0.1209
Chemical fertilizer (X_5)	0.1752
Manure (X_6)	0.0950
Returns to scale	1.3266

The output elasticities of all inputs were found to be positive, which indicates that all inputs had a positive influence on barley production. The estimated output elasticities showed that land input had a high output elasticity (0.5605) relative to other inputs, which revealed that it highly influenced the barley output, whereas, output elasticity of manure (0.095) had least effect on barley output. The return to scale, which is apparent from the sum of output elasticities of input, was found to be 1.3266. The output elasticities of input by individual firms are given in Appendix – I.

4.3.3.2. Farm specific technical efficiency

To assess the level of technical efficiency obtained by individual barley farmers, the outputs obtained and inputs used by farmers were compared with the corresponding values derived from the frontier production function. The frontier production function provided the information base for the construction of a technical efficiency index for the individual farmers. The translog frontier production function was estimated using the maximum likelihood method (table 4.17) and the farm specific technical efficiencies were estimated using Timmer's measure of technical efficiency as the ratio of actual output to the potential output (equation 3.22). The frequency distribution of technical efficiency ratings for sample farms is presented in table 4.19.

It is clear that 71.9 percent of total farmers belonged to the high efficient category (81-90 percent). It is interesting to note that only 0.6 percent of farmers belonged to most efficient category (91-99 percent). This table also shows that 25.7 percent of total barley farmers belonged to the medium efficient category (71-80 percent). These implied that most of the farmers categorized as medium and high efficient. The technical efficiency estimates by firms are given in Appendix – II.

Table-4.19: Frequency distribution of technical efficiency ratings for sample farms

Efficiency rating (Class interval %)	**Number of farmers**	**Classification**
0– 60	1 (0.6)	Poor
61 – 70	2 (1.2)	Low
71 – 80	46 (25.7)	Medium
81 – 90	129 (71.9)	High
91 – 99	1 (0.6)	Very high
Total	179 (100)	-

Note: Figures in the parentheses shows percentages to the total observations.

The frequency distribution of farm specific technical efficiency is shown in figure-6. This figure shows that about 97 percent of farms are between 70 and 90 percent technically efficient. It is interesting to note that only 1.8 percent of sample farmers are less than 70 percent, and 1.2 percent more than 90 percent technically efficient.

The mean technical efficiencies of small, medium and large farmers are presented in table 4.20.

This table reveals that the farm specific technical efficiency varied from 0.29 to 0.97 with a mean technical efficiency of 0.8241 for the whole sample farms. It is evident from the table that there were not much difference in mean technical efficiency among the three categories but the mean technical efficiency of the large farmers was marginally higher than small and medium farmer groups. On the other hand, minimum and maximum technical efficiency in medium and large categories were same and higher than small category.

The mean technical efficiencies of barley cultivators according to township are presented in table 4.21.

This table indicates that the mean technical efficiency of barley farmers among the townships of the province varied between 0.7693 and 0.8584. The highest and lowest mean technical efficiency belonged to Karaj and Firoozkooh, respectively. Five out of eight townships of the province, where the barley is cultivated, had the mean technical efficiency more than 0.80. It is evident from the table that the minimum and maximum technical efficiency belonged to Ray and Robatkarim townships, respectively.

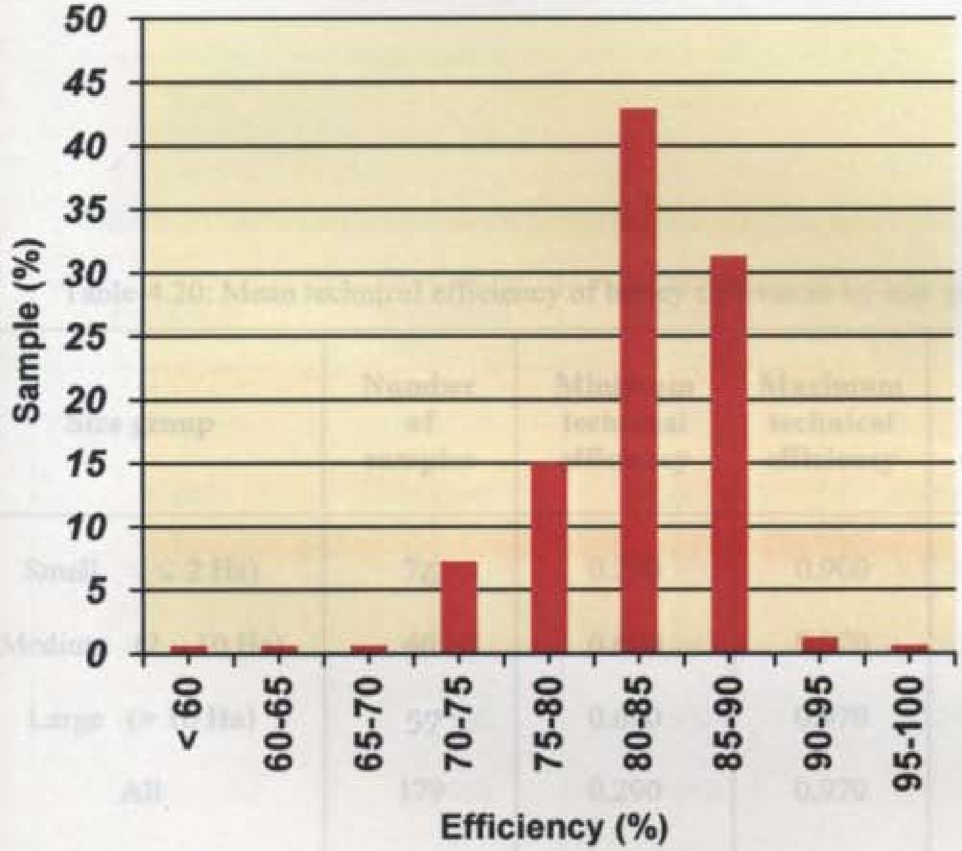

Fig. 6: Frequency distribution of technical efficiency

Table-4.20: Mean technical efficiency of barley cultivators by size group

Size group	Number of samples	Minimum technical efficiency	Maximum technical efficiency	Mean technical efficiency
Small (≤ 2 Ha)	76	0.290	0.900	0.8226
Medium (2 – 10 Ha)	46	0.690	0.970	0.8228
Large (> 10 Ha)	57	0.690	0.970	0.8318
All	179	0.290	0.970	0.8241

Table-4.21: Mean technical efficiency of barley cultivators by township

Township	Minimum technical efficiency	Maximum technical efficiency	Mean technical efficiency
Ray	0.2920	0.8880	0.7991
Karaj	0.8090	0.9020	0.8584
Varamin	0.7590	0.9020	0.8441
Savejbolagh	0.7050	0.8460	0.7701
Shahriyar	0.6260	0.8880	0.8091
Eslamshahr	0.7460	0.8530	0.8261
Firoozkooh	0.7430	0.8980	0.7693
Robatkarim	0.7360	0.9650	0.8233

4.3.3.3. Potential output of barley

The potential output of barley was calculated based on the technical efficiency measured through Timmer's measure for different size groups and to the whole sample farms by dividing average output (Kg /Ha) in each group to its corresponding mean technical efficiency. The results are presented in table 4.22. The results indicated that the large farms were having highest potential output of 4401.71 Kg /Ha of barley with the present inputs. The potential output for small and medium farms were 3429 Kg /Ha and 3501.09 Kg /Ha, respectively. On an average, the potential output of barley to the whole sample farms was 3850.39 Kg /Ha, which was higher than the present output (3173.11 Kg /Ha) by 677.28 Kg /Ha. This is higher by nearly 21 percent.

4.4. Optimum size of Barley cultivation

The different degrees of polynomial cost function, which relates average total cost on varying quantities of different inputs and the corresponding area, was estimated using equasions 3.40 to 3.43 for barley cultivation in Tehran province. The barley sample farmers were classified into three groups namely small and medium (≤ 10 Ha), large (>10 Ha) and pooled farmers groups. The different degrees of polynomial cost function were estimated for each of these groups separately by using Ordinary Least Squares (OLS) method.

As it is mentioned in chapter III, a particular degree of polynomial regression is selected as the best regression model based on Error Sum of Squares, R^2, F-value and significance level of "F". The best model is one that has least amount of 'ESS', highest 'R^2 'and 'F' values and high significance level of 'F'.

Table-4.22: Potential output level of barley production by size group

Size group	Mean output (Kg / Ha)	Mean technical efficiency	Potential output level (Kg / Ha)	Output difference (Kg / Ha)
Small (≤ 2 Ha)	2820.68	0.8226	3429.00	608.32
Medium (2 – 10 Ha)	3168.68	0.8228	3501.09	332.41
Large (> 10 Ha)	3661.34	0.8318	4401.71	740.37
All	3173.11	0.8241	3850.39	677.28

Note: Output difference is mean output minus potential output level

It should be noted that if reduction in error sum of squares (ESS) and increase in F-value or increase in Coefficient of multiple determination (R^2) in higher degree of polynomial function is found to be negligibly more than previous degree of polynomial function it is better to select more simple model; because of simplicity of the model. The selection of best degree of polynomial cost function for different size groups is presented in table 4.23.

In the case of small and medium farmers group, cubic polynomial was found to be the best fit based on the following reasons:

1- Error sum of squares shows decline till cubic form and after that it has increased.
2- F-value is highest in cubic polynomial cost function.
3- R^2 has rapidly increased till cubic model and it has been fixed or increased negligibly beyond cubic model.

In large farmers category and also entire sample farmers, based on the criteria, which are mentioned previously, the selection of the best model was between cubic and quartic polynomial cost functions. Theoretically, the quartic model should be selected but since the improvement of the model from cubic to quartic is very negligible therefore, for the reason mentioned above, for its simplicity, the cubic model was selected in both large farmers group and entire sample farmers. It should be noted that all F-values were significant at one percent level with the exception for linear model in the case of entire sample farmers, which was found to be non-significant. On the other hand, the difference between R^2 and adjusted R^2 for all the models and all farmers groups was found to be very negligible, which also indicates the goodness of the fit.

Table-4.23: Selection of best degree of polynomial cost function

Particular	No. of obs.	ESS	F-value	R^2 (%)	$\bar{R}^2$ (%)
Small & medium farmers (≤ 10 Ha)					
Linear	122	22,208,822	386.74 *	76.3	76.1
Quadratic	122	2,482,635	2188.18 *	97.4	97.3
Cubic	122	444,850	8253.02 *	99.5	99.5
Quartic	122	512,922	7152.50 *	99.5	99.4
Quintic	122	418,522	6525.23 *	99.6	99.5
Large farmers (> 10 Ha)					
Linear	57	14,513,860	152.86 *	73.5	73.1
Quadratic	57	12,959,589	87.28 *	76.4	75.5
Cubic	57	1,695,169	553.99 *	96.9	96.7
Quartic	57	1,619,998	580.51 *	97.0	96.9
Quintic	57	1,682,825	558.18 *	96.9	96.8
Overall (0.15 - 200 Ha)					
Linear	179	226,000,000	2.59	1.4	0.9
Quadratic	179	139,000,000	57.72 *	39.6	38.9
Cubic	179	45,500,676	235.80 *	80.2	79.8
Quartic	179	35,269,094	239.47 *	84.6	84.3
Quintic	179	36,491,274	229.99*	84.1	83.7

Note: ESS is Error Sum of Squares

* Significance at 1 percent level

The results of regression coefficients in respect of the cubic cost function estimates for small and medium farmers group is presented in table 4.24. The results showed that the Coefficient of multiple determination (R^2) was found to be 0.995 indicating that the variables included in the model had explained 99.5 percent of variations in the average total cost of barley cultivation per hectare. The adjusted coefficient of multiple determination ($\overline{R}^2$) was found to be 0.995, which is equal to coefficient of multiple determination indicating the goodness of fit. The observed "F" was found to be highly greater than the theoretical "F" value even at one percent level of significance, which also reveals the goodness of fit.

The coefficient of area (X) was negative and significantly different from zero, at one percent level of significance. The coefficient of quadratic term (X^2) was negative and significant at one percent level of significance. In the case of cubic term (X^3), the coefficient was found to be positive and significant at one percent level of significance. The F-value was very high and significant at one percent level of significance, which indicates goodness of fit.

It should be noted that since the purpose of estimation of cost function was estimation of optimum size of farm, therefore only one variable input (area) was considered as a function of average total cost per hectare in different degrees. Here, the estimated parameters of polynomial cost function could not be directly interpreted.

The results of estimation of cubic polynomial cost function for large farmers group is presented in table 4.25.

Table-4.24: Estimated cubic cost function for small and medium farmers group

Particular	Coefficient	Standard error	t- value
Variable			
Intercept	8580.339 *	16.344	524.981
X	- 851.147 *	17.183	- 49.534
X^2	- 154.932 *	4.456	- 34.771
X^3	7.021 *	0.302	23.249
Model summary			
R^2	0.995		
$\overline{R}^2$	0.995		
ESS	444,850		
F –statistic	8253.017 *		
N	122		
Average farm size (Ha)	2.96		
Optimum farm size (Ha)	17.08		

Note: * Significance at 1 percent level

Table-4.25: Estimated cubic cost function for large farmers group

Particular	Coefficient	Standard error	t-value
Variable			
Intercept	6288.922 *	97.708	64.364
X	- 87.541 *	5.352	- 16.356
X^2	1.295 *	0.066	19.550
X^3	- 0.004 *	0.0002	- 18.767
Model summary			
R^2	0.969		
$\overline{R}^2$	0.967		
ESS	1,695,169		
F –statistic	553.987 *		
N	57		
Average farm size (Ha)	50.84		
Optimum farm size (Ha)	41.96		

Note: * Significance at 1 percent level

This table shows very high values of R^2 (0.969) and adjusted R^2 (0.967) indicating goodness of fit. The coefficient of area (X) was negative and significantly different from zero, at one percent level of significance. The coefficient of quadratic term (X^2) was positive and significant at one percent level of significance. In the case of cubic term (X^3), the coefficient was found to be negative and significant at one percent level of significance. The F-value was found to be high and significant at one percent level of significance indicating goodness of fit.

The cubic polynomial cost function estimates for entire sample farmers is presented in table 4.26. The results showed that the Coefficient of multiple determination (R^2) was 0.802 indicating that the variables included in the model had explained 80.2 percent of variations in the average total cost of barley cultivation per hectare. The F-value was high and significant at one percent level of significance, which indicates goodness of fit. The coefficient of area (X) was negative and significantly different from zero, at one percent level of significance. The coefficient of quadratic term (X^2) was positive and significant at one percent level of significance. In the case of cubic term (X^3), the coefficient was found to be negative and significant at one percent level of significance.

The Chow test, which is a test to determine whether the coefficients in a regression model are the same in separate sub- samples or not. It was applied using equation 3.46 to test whether there is a significant change in the structural relationships of the regression coefficients of cost function of small and medium size with large size group. The F-ratio calculated in Chow test was found to be 866.193, which was highly greater than the theoretical "F" value [$F(\alpha, K, n_1 + n_2 - 2K) = F(0.01, 4, 171) = 3.32$] even at one

Table-4.26: Estimated cubic cost function for entire farmers

Particular	Coefficient	Standard error	t-value
Variable			
Intercept	7327.113 *	53.715	136.408
X	- 153.643 *	6.062	- 25.346
X^2	2.119 *	0.095	22.255
X^3	- 0.0067 *	0.0004	- 18.918
Model summary			
R^2	0.802		
$\bar{R}^2$	0.798		
ESS	45,500,676		
F –statistic	235.801 *		
N	179		
Average farm size (Ha)	18.21		
Optimum farm size (Ha)	46.43		

Note: * Significance at 1 percent level

percent level of significance, therefore the null hypothesis of the equity of the coefficients of two sub- samples is rejected. It indicates that small and medium farmers group, and large farmers group are significantly different from each other, which is due to impact of size on cost of cultivation.

In economic terminology, the "most profitable' amount can also be called the "optimum" amount (Doll and Orazem, 1978). The optimum size of farm, which is the most profitable amount of area, in the cases of small and medium, large and total farmers groups were found to be 17.08, 41.96 and 46.43 hectares, respectively. It indicates that the average total cost decreases with increase in farm size and reaches its minimum when area is 17.08, 41.96 and 46.43 hectares in small and medium, large and pooled sample farmers groups, respectively. Beyond these levels of area the average total cost increases at increasing rate.

4.5 Status and problems of Barley producers

In order to study the status and problems of barley producers, the sample farmers were asked about the various constraints faced by them in barley production. To avoid the bias in information, the pre-determined questions were not applied and they were free to list the problems, based on the priority of importance.

The Garrett's ranking technique, which is basically the change orders of constraints into numerical scores, was used to combine the ranks given by all the farmers and find out the final ranks of constraints. The results are presented in table 4.27.

Table-4.27: Constraints faced by farmers in barley production

Constraints	No. of respondents	Total score	Mean score	Rank
Lack of timely supply of fertilizers and plant protection chemicals	120	6885	57.38	I
Low minimum support price	110	6257	56.88	II
Lack of adequate credit support	100	5508	55.08	III
Non-availability of enough irrigation water	102	5244	51.41	IV
High cost of human labour	92	4395	47.77	V
High interest rate on loan	100	4360	43.60	VI
High machinery price	87	3474	39.93	VII
Lack of technical guidance	83	3166	38.14	VIII

From the table, it is obvious that lack of timely supply of fertilizers and plant protection chemicals, low minimum support price of barley and lack of adequate credit support are the important constraints faced by the barley producers in Tehran province, respectively.

Besides, non-availability of enough irrigation water, high human labour charge, high interest rates on loan, high machinery price and lack of technical guidance are the other constraints in barley production.

DISCUSSION

CHAPTER - V

DISCUSSION

In this chapter the results of the study are discussed in the backdrop of the objectives of the study and compared or contrasted with relevant literature in the field. This chapter is organized under the following heads.

5.1 General characteristics of the respondents

5.2 Cost of production of Barley on different size groups of farms

5.3 Resource productivity and resource use efficiency in Barley production

5.4 Optimum size of Barley cultivation

5.5 Status and problems of Barley producers

5.1 General characteristics of the respondents

The general characteristics of the sample barley farmers have been studied. It was found that about 85 percent of barley farmers had family size of 4 or above. In medium category of farmers, most of the farmers (47.8 percent) had family size of more than 5 persons followed by 4-5 persons (45.7 percent) and 1-3 persons (6.5 percent), whereas in small and large categories of farmers, most of farmers belonged to family size group of 4-5 persons.

About 30 percent of farmers in large category belonged to family size of 1-3 persons, which is much higher than small and medium family size groups. It is mainly because of the fact that there is almost inverse relationship between family size and income level of the family in agriculture sector.

It was found that in the case of total sample farmers, most of farmers (54.75 percent) belonged to 40-60 age group followed by less than 40 years (26.25 percent) and greater than 60 years (19 percent). It is important to note here the small farmers group was elder than medium, and large farmers groups. The results showed this fact that agriculture in Tehran province is old, which is because of that most of the young generation migrate from villages to the adjacent urban areas looking for better job opportunities. This calls for some improvement through inventions and innovation of the small agricultural implements and machinery in order to improve the labour efficiency in agricultural operation and minimization of drudgery in carrying out the agricultural operations by farmers.

For most of farmers (86.6 percent), agriculture was found to be the main source of income and the remaining 24 (13.4 percent) had some subsidiary occupation in addition to agriculture. This indicates that the economic well being of farmers depends greatly on the better performance of the agriculture. This calls for some policy measures to reduce people directly depending on agriculture for overall well being of the rural areas. As regards the educational level, among the heads of families of entire sample farms, 80.4 percent were literate, which distributed to primary level (32.4 percent), secondary (27.3 percent), high school (12.9 percent) education and remaining 7.8 percent had education level of diploma and more. Since majority of farmers were educated, there is scope for adoption of new technologies and innovation in the study area.

The total number of sample farmers was 179. The sample farmers were classified into three farm size groups namely small (≤2 Ha), medium (more than 2 and less than or equal to 10 hectares) and large (> 10 Ha). Majority of the respondents belonged to small farmers category (42.5 percent) followed by large (31.8 percent) and medium (25.7 percent). The average farm size of small and medium and large categories of farms was 1.21 and 5.87 and 50.48 hectares, respectively. The average farm size was found to be relatively high for the large farmers' category, which is mainly as the result of high effects of 11 observations with 100 hectares and above on mean. The distribution of barley sample farmers by townships of Tehran province showed that the highest number of samples belonged to Varamin (38 samples) followed by Ray (30 samples) and both Shahriyar and Robatkarim each one with 21 barley farmers. It was because of that these townships were major areas in Tehran province, in which barley was cultivated.

5.2 Cost of production of Barley on different size groups of farms

The results on various costs of cultivation of barley per hectare indicated that the seed cost per hectare in small farmers group was found to be greater than medium and large groups. It is mainly because of that the small farmers did seeding with hand, which increases the wastes.

The cost incurred by small farmers on chemical fertilizer per hectare was more than medium, and large farmers. It could be as a result of this fact the small farmers perception more utilization of fertilizer results in more output therefore they used this input technically inefficient. In addition, this category of farmers does not supplement fertilizer with manure.

Manure was utilized only by medium and large farmers in negligible amounts. The cost incurred by large farmers on plant protection chemicals per hectare was more than medium, and large farmers. The negligible cost of plant protection chemicals in barley cultivation is because; the farmers utilized it only to control weeds, which was not considerable.

The human labour cost per hectare in small farmer category was found to be lesser than medium and large groups because in large farms, most of the agricultural operations were mechanized. The cost incurred by small farmers on machinery per hectare was more than medium, and large farmers. It could be as a result of this fact that on an average, per hour cost of machinery in small farms is more than medium and large farms therefore it could not be interpreted as more utilization of machinery per hectare of barley by small farmers.

The water cost per hectare in small farmers category was found to be greater than medium and large groups mainly because of that in small farms, water management is more difficult than medium and large farms therefore in these farms; transmission losses of water were more than medium and large farms.

The total variable cost per hectare of barley cultivation including inputs cost, miscellaneous cost and interest on variable cost for the small, medium, large and total farmers groups shows that small farmers spent more on variable costs. It is because the fact that small farmers spent more for seed (because sowing is done through broadcasting), labour (non-mechanized farming) and water (waste of water in traditional irrigation system, which results in buying more units of water). In addition, the unit price of machinery in small farmers group was greater than the medium and large groups. It could be as a result of small and scatter land holdings in this group. It should be noted here the more spent on these inputs does not mean the more utilization of these inputs in technically efficient way. It could be visualized that the more spent on these inputs would not caused the improvement in the yield per hectare of barley in small farmers group as compared to medium and large groups. Because the appropriate proportion and timely use of the production inputs are more important rather than the quantity used. The small farmers also unable to carry out the agricultural operations in appropriate time because most of them are depending on others machinery mostly owned by large category of farmers. Meanwhile, the major costs in variable costs belonged to machinery and water inputs. The total cost per hectare of barley production was found to be highest in small farmers group followed by medium and large groups. So the null hypothesis of the inverse relationship between farm size and average cost of barley cultivation was accepted.

On an average the per hectare cost incurred towards land rent by the three categories of farmers indicate that the large farmers paid less than medium and small farmer for land as rental value, which is quite natural since land market like other markets follows supply and demand rules. The number of farmers seeking the small and medium agricultural land has been much more than for large land therefore the unit price of these types of land was more than large land.

Land had highest share of total cost of cultivation of barley per hectare (30.7%) followed by machinery (23 percent) and water (18.1 percent) for the total sample farms.

It reveals that these three inputs as well as yield per hectare were major factors that influenced the profitability of barley production in Tehran province.

The results on various costs of cultivation of barley per hectare by townships of the province indicated that land had highest share of total cost followed by machinery and water in townships under study with the exception of Firoozkooh Township. In the case of Firoozkooh, on an average, the cost incurred on water per hectare was very negligible as compared to other townships since it enjoys good surface water for irrigation, which is relatively cheap as compared to other sources of irrigation. On the contrary, in this township, land had highest cost incurred for barley cultivation per hectare among the townships under study, which contributed to 46.2 percent in total cost of barley production. The high value of land in this township is as result of availability of sufficient surface water and more number of small land holdings in this area.

The total cost of barley cultivation per hectare among the townships of Tehran province had a wide range. This wide difference between minimum and maximum cost of cultivation is mainly as a result of difference in rental value of land and water charge.

The average gross returns per hectare of barley were highest in the case of large farmers group followed by medium and small farmers groups. The average net returns over variable cost for large farmers group was found to be much greater than small, and medium farmers groups. It is mainly related to two reasons, high gross returns per hectare and lower average variable cost per hectare in large farmers group. The net returns over total cost for large group was also greater than small and medium farmers groups with relatively higher difference as compared to net returns over variable cost. It is because of lower fixed cost in large farmers group as well. The return per Rupee of total cost was found to be greater than one for small, medium and large farmers groups. The return per Rupee of total cost for entire sample farmers was found to be 1.583 indicating that one rupee of total cost would give rise to a return of 1.583. Highest is, however, obtained for large farmers group, which is because the higher returns and lower total cost in this group as compared to small and medium groups. The major factors of the reduction in the cost and increase in returns could be timely use of inputs due to enough finance, more efficient use of inputs, managerial skills, better irrigation system, use of better seed and other inputs, and economies of scale (which leads to reduction of the cost).

The returns per Rupee of variable cost were highest in Firoozkooh Township and the same returns in the case of Ray were found to be lowest among the townships under study. Savejbolagh Township had highest returns per Rupee of total cost followed by Varamin and Karaj.

The average total cost to produce one kilogram of barley was highest in the case of small farmers group (Rs. 5.29) followed by medium (Rs. 3.59) and large (Rs.3.19). It is mainly because of that both average variable cost and average fixed cost in this group was higher than other groups.

The lower gross returns per kilogram of barley in the case of large farmers group is mainly because the large farmers sold their outputs at the minimum support price to government, because there is no wholesale market for barley and local traders also have no capacity to buy and stock their products, therefore the large farmers have to sale barley to the government at minimum support price, which is most of the times less than the local market price. The net returns over total cost per kilogram of barley output for medium farmers group was marginally greater than large group (Rs.1.47 Vs. Rs.1.33).

The study of the average cost of barley production per hectare by different activities for different farm size groups revealed that land cost had highest share of total cost of barley cultivation for all sample farmers groups. After land, in the case of small farmers group, cost of vegetation stage had highest share of total cost (22.5 percent) followed by harvest (18.1 percent) and land preparation stage (17.3 percent). For the medium and large farmers groups, after land cost, the cost of vegetation and land preparation stages had highest share of total cost of barley cultivation, respectively whereas in the case of pooled sample farmers vegetation (24.4 percent), land preparation (18.3 percent) and cultivation (14.5 percent) stages had highest share of total cost of barley production, respectively. It is interesting to note that with increase in the farm size, the share of cost of harvesting stage to total cost of barley cultivation has declined from 18.1 percent for small farmers to 6 percent for large farmers group, which is mainly because of mechanical harvesting.

The study of average cost of barley production per hectare by different activities for townships under study showed that the cost of land preparation in Savejbolagh, cultivation in Eslamshahr, vegetation in Ray and harvest stage in Firoozkooh had highest share to total cost of barley cultivation per hectare in percentage. The share of cost of vegetation stage to total cost of production in Firoozkooh was found to be lowest among townships. It is as a result of low cost of water, which is main cost in this stage. On the contrary, this cost was high in Ray Township, therefore the cost of vegetation stage in this township had highest share to total cost of barley cultivation.

It is interesting to note that the share of cost of harvesting stage to total cost of barley production per hectare in the case of Firoozkooh Township was found to be highest among townships because this township is mountain area and most of the agricultural operations are being done by labour, which is more costly than machinery.

5.3 Resource productivity and resource use efficiency in Barley production

5.3.1 Resource productivity

In order to maximize the profits from a farm, optimum use of resources is imperative. This is examined on the basis of the productivity of resources used in production. In this section, the productivity of various resources involved in the production of barley are analyzed. The Cobb-Douglas type of production function was fitted separately for entire sample respondents. The independent variable used in the production function were Labour (X_1), Machinery (X_2), Seed (X_3), Chemical fertilizer (X_4), Manure (X_5) and Plant protection chemicals (X_6).

The results of regression coefficients in respect of the production function showed that the Coefficient of multiple determination (R^2) was 0.956 indicating that the variables included in the model had explained 95.6 percent of variations in the output of barley. The adjusted coefficient of multiple determination ($\overline{R}^2$) was found to be 0.954, which is almost equal to coefficient of multiple determination indicating the goodness of fit. The observed “F” was found to be highly greater than the theoretical “F” value even at one percent level of significance, which also reveals the goodness of fit.

The coefficients of machinery and chemical fertilizer input were 0.388 and 0.402, respectively and both significant at one percent probability level. Since the calculated returns to scale shows the constant returns to scale these coefficients implying that one percent increase in working hours of machinery or chemical fertilizer resulted in 0.388 and 0.402 percent increase in barley production, respectively. The coefficients of labour and plant protection inputs were small and insignificant, whereas the coefficient of seed was large but not significant.

The results also revealed that the output elasticities of all inputs were positive, which indicates that all inputs had a positive influence on barley production. The magnitude of output elasticity in the case of chemical fertilizer and machinery were considerably higher than other inputs indicating these two inputs have more influence on the output than other inputs. In other words, barley production was sensitive to machinery and chemical fertilizer use. Therefore these two inputs play an important role in barley production in Tehran province.

The estimate for returns to scale was found to be 1.01, which is not significantly different from unity, indicating constant returns to scale. This implies that an increase in the use of the selected variables in the model would result in same proportionate increase in total production of barley. The result is similar to reported findings of Muraleedharan (1987), Mythili and Shanmugam (2000), which indicated constant returns to scale. On the other hand, the calculated returns to scale in present study was found to be against studies of Thomas and Gupta (1987), Hazarika and Subramanian (1999), in which the results showed increasing returns to scale as well as the reported findings of Upender (1992), Namboodiri (2001), Dileep *et al.* (2002) in which the results indicated decreasing returns to scale. It is interesting to note that on an average, the large category of farmers had highest yield per hectare (3667 Kg/Ha) followed by medium (3141 Kg/Ha) and small category of farmers (2822 Kg/Ha), respectively. The higher yield per hectare of barley in the large farmers' category could be because of the timely and better use of the inputs, more efficient irrigation system, use of high yielding varieties of seed, managerial skills, access to technical guidance by the agricultural specialists and more credit support by the government.

It was found that the major source of irrigation of barley was deep well (67.5 percent) followed by mixed sources (14.5 percent) and river (6.1 percent), respectively. It is mainly because of climate of Tehran province, which is substantially semi- desert. Therefore most of the farmers have not access to the sources like river, surface Well or even semi-deep Well.

The results also showed that about 48.6 percent of barley farmers had average yield per hectare between 2000 and 3000 Kg/Ha followed by 3000-4000 Kg/Ha (34.1 percent) and 1000-2000 Kg/Ha (11.7 percent) and only 1.1 percent of sample farmers had average yield of less than 1000 kilogram per hectare. When we compare average yield per hectare of barley production in Tehran province with same value for whole country, it is revealed that the average yield of barley in this province is almost two times more than whole country's average.

5.3.2 Allocative efficiency

The efficiency of allocation of resources was studied by comparing Marginal Value Product (MVP) and Marginal Factor Cost (MFC) of each factor of production. The allocative efficiency of variables included in the analysis of barley production showed that the ratios of MVP to MFC for all variables were greater than unity indicating that the farmers have allocated all inputs efficiently and there is further scope for application of more units of these inputs. So the null hypothesis of allocating inputs efficiently by Barley farmers was accepted. In other words, it implies the under use of these resources.

The ratio of MVP to MFC was highest in the case of chemical fertilizer, which clearly shows that the chemical fertilizer productivity in the barley cultivation is high and indicates the considerable scope for the increased use of chemical fertilizer. However, the recommendation of the soil scientists should be viewed seriously for up keeping of long-term fertility of the soil.

5.3.3 Technical efficiency

5.3.3.1. Frontier production function

In order to study efficiency of barley producers, the frontier production function was employed. The translog frontier production function was estimated by Maximum Likelihood Estimates (MLE). This was done by regressing output of barley on inputs including land (X_1), seed (X_2), labour (X_3), machinery (X_4), chemical fertilizers (X_5) and manure (X_6). The results of Maximum Likelihood Estimates indicated that the estimated λ (1.0435) and σ^2 (0.1337) were different from zero indicating goodness of fit.

The variance ratio (γ) was 0.5211 indicating 52.11 percent of farm specific variability contributed to the variation in output (total variation in output from the frontier) is attributable to technical inefficiency. It also implied that one-sided errors U_i dominate the symmetric error V_i. In other words, about 52 percent of the differences between the observed and the maximum production frontier outputs were due to differences in farmer's levels of technical efficiency and not much related to random variability. These factors are under the control of the farm and the influence of which can be reduced to enhance technical efficiency of the barley producers. On the other hand, the constant term, and the coefficients of land and machinery were found to be significant at one percent probability level. On the other hand, the coefficients of seed and fertilizer were significant at 5 percent probability level.

It is interesting to note that the individual parameters of translog production function could not be directly interpreted; hence the output elasticities of input and returns to scale were separately calculated. The output elasticities of all inputs were found to be positive, which indicates that all inputs had a positive influence on barley production.

The results showed that land input had highest output elasticity (0.5605) as compared to other inputs, which revealed that it highly influenced the barley output, so further allocation of land for the barely cultivation may increase total production, however, allocation of more area towards barley cultivation depends on the profitability of the other crops, and availability of the land.

The returns to scale, which is apparent from the sum of output elasticities of input, was found to be 1.3266. It indicates that the barley cultivation in Tehran province experienced increasing returns to scale. Hence if we increase all inputs by one percent, the barley output will increase by 1.3266 percent. The result is similar to reported findings of Youn Kim (1992), which indicated increasing returns to scale.

5.3.3.2. Farm specific technical efficiencies

The translog frontier production function provided the information base for the construction of a technical efficiency index for the individual farmers. The farm specific technical efficiencies were estimated using Timmer's measure of technical efficiency as the ratio of actual output to the potential output. The frequency distribution of technical efficiency ratings for sample farms indicated that 71.9 percent of total farmers belonged to the high efficient category (81-90 percent). It is interesting to note that only 0.6 percent of farmers were belonged to most efficient category (91-99 percent). The results also showed that 25.7 percent of total barley farmers belonged to the medium efficient category (71-80 percent). The results implied that most of the farms (97.6 percent) categorized as medium and high efficient. So the null hypothesis of " The Barley farmers are technically inefficient" was rejected.

The mean technical efficiencies of small, medium and large farmers showed that the farm specific technical efficiency varied widely from 0.29 to 0.97, which is very vast range of technical efficiency. The wide range of technical efficiency was similar to the results obtained by Mythili and Shanmugam (2000) and, Job and George (2002) but contrary to results of the study by Dawson *et al* (1991), who found the narrow range of technical efficiency between 0.84 and 0.95 across the 22 farms. The vast range of technical efficiency here may be as a result of more number of observations and very high variance among the land input.

The mean technical efficiency for the whole sample farms was found to be 0.8241, which indicates that on an average the realized output could be increased by 17.6 percent without any additional resources. The mean technical efficiency was almost similar to reported findings of Mythili and Shanmugam (2000), and against the reported studies like Kontos and Young (1983), Ekanayake and Jayasuriya (1987). It is mainly because of the fact that most of the barley farmers were familiar with the production techniques and employed it into the best possible advantage. On the other hand, minimum and maximum technical efficiency in medium and large categories were same and higher than small category. The mean technical efficiencies of barley cultivators according to township indicated that it varied between 0.7693 and 0.8584. The highest and lowest mean technical efficiency belonged to Karaj and Firoozkooh, respectively. It was found that the minimum and maximum technical efficiency belonged to Ray and Robatkarim townships, respectively.

5.3.3.3. Potential output of barley

The potential output of barley was calculated based on the technical efficiency measured through Timmer's measure for different size groups and to the whole sample farms. The results indicated that the large farms were having highest potential output of 4401.71 Kg /Ha of barley with the present inputs followed by medium (3501.09 Kg /Ha) and small (3429 Kg /Ha) farms groups. On an average, the potential output of barley to the whole sample farms was 3850.39 Kg /Ha, which was higher than the present output per hectare by 677.28 kilogram per hectare. It reveals that there is scope for increase the average yield per hectare by using the best available technologies and technical guidance.

5.4 Optimum size of Barley cultivation

The issue of farm size is of major and continuing interest to farm producers. The polynomial cost function was applied in present study for the purpose of the estimation of optimum size of barley farms. The different degree of polynomial cost function, which relates average total cost to varying quantities of different inputs and the corresponding area, was estimated. The barley sample farmers were classified into three groups namely small and medium ($\leq$ 10 Ha), large ($>$ 10 Ha) and pooled farmers groups. The different degrees of polynomial cost function were estimated for each of these groups separately by using Ordinary Least Squares (OLS) method.

For all three farmers groups, the cubic polynomial cost function was found to be the best fit based on reduction in Error Sum of Squares (ESS) and increase in F-value or increase in Coefficient of multiple determination (R^2) in higher degree of polynomial function. It should be noted that in large farmers group and pooled sample farmers group, since the model was negligibly improved in Quartic polynomial model, therefore because of simplicity of the model, the cubic polynomial cost function was selected.

It should be noted that since the purpose of estimation of cost function was estimation of optimum size of farm, therefore only one variable input (area) was considered as a function of average total cost per hectare in different degrees. Here, the estimated parameters of polynomial cost function could not be directly interpreted.

The results of estimation of the cubic cost function for small and medium farmers group revealed that the calculated R^2 was 0.995 indicating that the variables included in the model had explained 95.6 percent of variations in the average total cost of barley cultivation per hectare. In other words, it indicates that area alone could explain maximum variation in average total cost in the estimated cost function. The adjusted coefficient of multiple determination ($\overline{R}^2$) was found to be 0.995, which is equal to coefficient of multiple determination indicating the goodness of fit. The observed "F" was found to be highly greater than the theoretical "F" value even at one percent level of significance, which also reveals the goodness of fit. The coefficients of area (X), quadratic term (X^2) and cubic term (X^3) had expected sign and all of them were significant at one percent level of significance.

In the case of large farmers group, the results of estimation of cubic cost function showed very high values of R^2 (0.969) and adjusted R^2 (0.967) indicating goodness of fit. These values were marginally less than same values in the case of small and medium farmers group. The coefficients of area (X) and cubic term (X^3) were negative, whereas the coefficient of quadratic term (X^2) was found to be positive and all of the coefficients were significant at one percent level of significance. The F-value was high and significant at one percent level of significance indicating goodness of fit.

The regression coefficients of cubic cost function for total sample farmers group indicated that the coefficient of linear and cubic terms were negative, whereas the coefficient of quadratic term was positive. All the coefficients were found to be significant at one percent level of significance, which indicates the goodness of fit. The

Coefficient of multiple determination (R^2) was 0.802 indicating that the variables included in the model had explained 80.2 percent of variations in the average total cost of barley cultivation per hectare. The F-value was very high and significant at one percent level of significance, indicates goodness of fit.

The Chow-test was applied to examine whether there is a significant change in the structural relationships of the regression coefficient of cost function of small and medium size with large size groups of farmers. The F-ratio calculated in Chow-test was found to be 866.193, which was greater than the theoretical "F" value even at one percent level of significance, therefore the null hypothesis of the equity of the coefficients of two sub-samples is rejected. It indicates that small and medium farmers group, and large farmers group are significantly different from each other, which is due to impact of farm size on cost of cultivation. The result is similar to reported findings of Badal and Singh (2001).

The optimum size of farm, which is the most profitable size of farm, is very important for policy makers in agriculture sector to facilitate land consolidation and agricultural cooperatives, to make farming more profitable and many other agricultural policies. The results showed that the optimum size of barley farms in the case of small and medium, large and total farms groups were 17.08, 41.96 and 46.43 hectares, respectively. It was greater than the average sample farm size in the case of small and medium farms group (2.96 Ha) and total farms group (18.21 Ha). So the null hypothesis of "The average size of Barley farms is less than optimum size" was accepted. The optimum size of farm was found to be less than the average farm size in the case of large farms group (50.84 Ha).

The study of the optimum size of farm revealed that the average total cost decreases with increase in farm size and reaches its minimum when area is 17.08, 41.96 and 46.43 hectares in small and medium, large and pooled sample farmers groups, respectively. Beyond these levels of area, the average total cost increases at increasing rate. The estimated optimum size of farms showed the fact that the most profitable farm size for all farm size groups belongs to large category of farms.

5.5 Status and problems of Barley producers

The Garrett's ranking technique, which is the change orders of constraints into numerical scores, was applied to study the status and problems of barley producers in Tehran province. The respondents were asked about the various constraints faced by them in barley production and they arranged these constraints based on their importance. The Garrett's ranking technique was used to combine the ranks given by all the farmers and find out the final ranks of constraints. The results showed that lack of timely supply of fertilizers and plant protection chemicals, low minimum support price of barley and lack of adequate credit support are the important constraints faced by the barley producers, respectively. Besides, non-availability of enough irrigation water, high human labour charge, high interest rates on loan, high machinery price and lack of technical guidance are the other constraints in barley production. So the null hypothesis of " Barley cultivation in Tehran province is subjected to production constraints" was rejected.

It is interesting to note that contrary to simple frequency distribution of constraints, here two constraints namely lack of adequate credit support and high interest rates on loan with same number of respondents have been categorized in two different ranks. This advantage helps policy makers to emphasis on most important constraints.

SUMMARY AND CONCLUSIONS

CHAPTER - VI

SUMMARY AND CONCLUSIONS

A brief review of the findings of the study along with the salient features is presented in this chapter. Based on empirical findings, conclusions are drawn and policy options are suggested.

Agriculture is an economic activity providing healthful products to its customers; farmers who manage resources wisely and have a positive influence on their communities and the environment. The agricultural sector plays a major role in Iran economy. It is the basic fulcrum for realizing food sufficiency. About 12.34 million hectares of the country's total land area is cultivated, which contributes 7.49 percent of Iran's land area of which, the total area under annual crops is 10.27 million hectares (83.23 percent) and the remaining 2.07 million hectares are under perennial crops. Wheat and Barley are two major annual crops of Iran. Other principal crops include pea, alfalfa, rice, cotton, oil seeds, lentil, potatoes, vegetables, fruits, nuts, sugarcane, sugar beets, herbs, spices, tea, and tobacco. Major agricultural exports include fresh and dried fruits, nuts, animal hides, processed foods, and spices.

Barley is the fourth largest grain crop after wheat, rice, and corn in the world. It is grown in many different countries throughout the world. After wheat, barley is the second major crop produced in Iran. It constitutes 11.66 per cent of total cultivated area in Iran. Barley in Iran is mostly utilized as animal feed (91 percent). Iran is one of the largest barley importers in the world and stands seventh out of 162 barley-importing countries in the world in the year 2000.

Tehran province is one of the smallest and most populous provinces in Iran. This province has nearly 12 million inhabitants. Agriculture is one of the main occupation and prevailing activity in suburban plains, and highlands of the province. Similar to whole country, barley is the second major crop produced in Tehran province. In Tehran province the annual crops under dry farming are very negligible (less than 0.3 percent) of arable crop area. In the case of barley, out of 28,581 hectares under barley in the year 1999, only 66 hectares (0.2 percent) was under dry farming, therefore this study is focused on only irrigated barley.

Tehran province ranks first in livestock and poultry industries among the 29 provinces of Iran. It produced 33.8, 29.7 and 11.3 percent of total milk, egg and poultry products in Iran, respectively in the year 2000. On the other hand, Tehran province has highest number of dairy cattle in Iran. Though Tehran province occupies first place in poultry and livestock production, it is unable to meet internally the barley requirement, which is a major component of livestock feed. Hence farmers make arrangement of their requirements of barley from the other provinces and imported barley, which increases the cost of livestock and poultry products.

The identification of the factors, which may improve the productivity of barley production in Tehran province, may bring down the quantity of barley imports as well as the cost of production of livestock and poultry products. This leads to improvement of the economy of this province and whole country.

In this background on the importance of Barley crop for agricultural economy of Iran particularly for animal and poultry nutrition, the present study is proposed with the following specific objectives.

1. To estimate the cost of production of Barley on different size groups of farms.
2. To study the resource productivity and resource use efficiency in Barley production.
3. To determine the optimum size of Barley cultivation.
4. To study the status and problems of Barley producers.

Two-stage random sampling method was used for the primary data collection from 179 barley farmers in Tehran province, from eight township, include Ray, Robatkarim, Firoozkooh, Savojbolag, Shahriyar, Varamin, Islamshahr and Karaj, where the barley is cultivated. The data were collected from the selected farmers during the months July and August 2000. For the purpose of comparison, barley farmers were post stratified into small category farmers (≤ 2 Ha), medium category farmers (2.1–10 Ha) and large category farmers (> 10 Ha).

Various analytical tools and techniques were used in this study for economic analysis of irrigated barley in Tehran province. The cost of production of Barley on different size groups of farms was worked out using simple cross tables and ratios approach. Resource productivity was studied using production function analysis. The resource use efficiency was estimated based on frontier production function approach using Maximum Likelihood Estimates method by Timmer's measure of technical efficiency. The optimum size of barley farm was estimated using polynomial cost function and finally the status and problems of Barley producers was studied using Garrett's ranking technique. Moreover, test statistics as students 't'-test, 'F'-test and Chow test were used to test the significance of estimates.

The major findings of the study are summarized here under:

In the case of barley farmers, about 85 percent of barley farmers had family size of 4 or above. It was found that there was almost inverse relationship between family size and size of the farm. The age distribution of sample farmers showed that most of farmers (54.75 percent) belonged to 40-60 age group followed by less than 40 years (26.25 percent) and greater than 60 years (19 percent). The small farmers group was elder than medium, and large farmers groups. For the most of farmers (86.6 percent), agriculture was found to be the main source of income and the remaining 13.4 percent had some subsidiary occupation in addition to agriculture.

Among the heads of families of entire sample farms, 80.4 percent was literate, which distributed to the primary level (32.4 percent), secondary (27.3 percent), high school (12.9 percent) and remaining 7.8 percent had education level of diploma and more. The average farm size of small and medium and large categories of farms was 1.21 and 5.87 and 50.48 hectares, respectively.

The study of various costs of cultivation of barley per hectare showed that the total variable cost per hectare was found to be highest in small farmers group followed by medium and large groups. The major costs in variable costs belonged to machinery and water inputs. The total fixed cost per hectare of barley production was found to be highest in medium farmers group followed by small and large groups. It contributed 33.2, 39.1 and 36.3 percent of total cost in the case of small, medium and large farmers group, respectively.

The total cost per hectare of barley production was found to be highest in small farmers group followed by medium and large groups. So the null hypothesis of the inverse relationship between farm size and average cost of barley cultivation was accepted.

Among the various inputs, land rent had highest share of the total cost of cultivation of barley per hectare (30.7 percent) followed by the machinery (23 percent) and water (18.1 percent) for pooled category of farmers. The total cost of barley cultivation among the townships of Tehran province had range between Rs.7428.37 (Savejbolagh) and Rs.11402.55 (Robatkarim). The average gross returns per hectare of barley were highest in the case of large farmers group followed by medium and small farmers groups.

The net returns over total cost for large group was greater than small and medium farmers groups. The returns per Rupee of total cost were found to be 1.357, 1.636 and 1.941 for small, medium and large farmers groups, respectively. The gross returns per kilogram of barley production were Rs. 5.38, Rs. 5.06 and Rs.4.52 for small, medium and large farmers groups, respectively.

The study of the average cost of barley production per hectare by different activities showed that after rental value of land the vegetation stage, land preparation stage and cultivation stage had highest share of total cost of barley production, respectively.

The study of resource productivity reveals that all the variables in the model including labour, machinery, seed, chemical fertilizer, manure and plant protection chemicals had a positive influence on barley production. Moreover, chemical fertilizer and machinery were found to be two inputs, which had more influence on the output than other inputs. The results also showed constant returns to scale indicating an increase in the use of the selected variables in the model would result in same proportionate increase in total production of barley.

The average yield per hectare of barley was highest in large farmers group followed by medium and small groups indicating scope to improve the barley yield per hectare even in current input use position. The study of the efficiency of allocation of resources revealed that the ratio of MVP to MFC for all inputs were greater than unity indicating that the farmers have allocated all inputs efficiently and there is further scope for application of more units of these inputs. So the null hypothesis of allocating inputs efficiently by Barley farmers was accepted. In other words, it implies the under use of these resources. In other words, it implies the under use of these resources. This ratio was highest in the case of chemical fertilizer, which implies that every additional rupee spent on this factor result in more returns than other inputs.

The estimated translog frontier production function indicated that all inputs had a positive influence on barley production, which confirms the results obtained in Cobb-Douglass production function. Land, which was not included in Cobb-Douglas model to avoid multicollinearity problem, had highest output elasticity as compared to other inputs, which revealed that it highly influenced the barley output.

The farm specific technical efficiencies revealed that 71.9 percent of total farmers belonged to the high efficient category (81-90 percent) and only 0.6 percent of farmers were belonged to most efficient category (91-99 percent). The results implied that most of the farms (97.6 percent) categorized as medium and high efficient. So the null hypothesis of " The Barley farmers are technically inefficient" was rejected. The mean technical efficiency for the whole sample farms was found to be 0.8241, which indicates that on an average the realized output could be increased by 17.6 percent by reorganizing the existing resources without any additional resources. The mean technical efficiency of the large farmers was marginally higher than small and medium farmers groups. The mean technical efficiencies of barley cultivators according to township indicated that it varied between 0.7693 and 0.8584. The highest and lowest mean technical efficiency belonged to Karaj and Firoozkooh, respectively. The study of potential yield of barley showed that the large farms were having highest potential output of barley with the present level of inputs followed by medium and small farms groups.

The cubic polynomial cost function was selected as the best fit for all farm size groups. The result of Chow-test implied that the null hypothesis of the equity of the coefficients of two sub- samples is rejected. It indicates that small and medium farmers group, and large farmers group are significantly different from each other, which is due to impact of farm size on cost of cultivation.

The optimum size of barley farms in the case of small and medium, large and total farms groups were 17.08, 41.96 and 46.43 hectares, respectively. It was greater the average sample farm size in the case of small and medium farms group (2.96 Ha) and total farms group (18.21 Ha). So the null hypothesis of "The average size of Barley farms is less than optimum size" was accepted. The optimum size of farm was found to be less than the average farm size in the case of the large farms group (50.84 Ha). Beyond the optimum size of the farm, the average total cost increases at the increasing rate. It should be noted that the organizing farms around the optimum size of the farm may be difficult because of the political, social and the other issues on the ground level.

The study of status and problems of barley producers showed that lack of timely supply of fertilizers and plant protection chemicals, low minimum support price of barley and lack of adequate credit support are the important constraints faced by the barley producers, respectively. So the null hypothesis of " Barley cultivation in Tehran province is subjected to production constraints" was rejected.

Policy implications

Based on the present study, the following suggestions or implications are drawn. The major policy implication is summarized below.

1- Cost of production of barley per kilogram in the case of small, and medium categories of farmers is considerably higher than large category of farmers. It is very essential for the government and other development agencies to design the programme that would bring down per unit cost of barley, so has to increase the profitability of barley cultivation among small, and medium categories of farmers.

2- Water for irrigation of barley in Tehran province is scarce and the methods of irrigation are being traditional. Government should invest in modernizing irrigation infrastructure and encourage the farmers to adopt improved irrigation techniques so that water will be used very efficiently in barley production and bring down the unit cost of water in barley production, which is found to be a major component of the cost of cultivation of barley.

3- The study of production function showed that the machinery input is the second most important input in barley production after chemical fertilizer and there is scope for the further use of this input. On the other hand, machinery cost had highest share to the total variable cost of barley cultivation among all three categories of farmers. Therefore to encourage the barley farmers to mechanize, the domestic price of agricultural machineries could be subsidized and research to invest locally suitable agricultural machinery should be initiated and imports duty on the imported machineries needs to be reduced, which results in the reduction of the rental value of machinery and increase the profitability.

4- Based on the results of the study, most of the barley farms were less than optimum size, which directly influence the farm's profitability. The government could encourage farmers to come forward in the locally suitable land consolidation programmes and agricultural cooperatives to operate around the optimum size of the farm, which is the most profitable point.

5- The lack of timely supply of fertilizer and plant protection chemicals was the most important constraints faced by barley farmers. Since the timely supply of fertilizer and plant protection chemicals are equally important as the quantity supplied, therefore timely availability and information regarding timely use of fertilizer and PP chemicals needs to be strengthened through appropriate institutional and extension measures.

6- The results showed that about 52 percent of variation in output is attributable to technical inefficiency. There is need for the detailed study on the causes of this technical inefficiency to identify the factors, which have highest share to this technical inefficiency, so that the suitable measure could be taken up to increase the efficiency of barley production.

7- The majority of barley farmers belonged to the small farmers' category and the benefit-cost ratio in this group was much smaller than the medium and large groups. In addition, for 87 percent of these farmers, agriculture is the main source of income. It should be also added that more than 90 percent of small farmers had family size of 4 persons or more. In this background, since the agricultural income is insufficient, most of the young generation migrates to urban areas, which leads to scarcity of human labour and naturally increase the labour wages. It is suggested that the government provides some subsidiary income in villages to increase the family income by providing credit facilities to establish small barley processing industries and other occupations related to agriculture in the villages.

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CHAPTER - VII

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APPENDICES

APPENDIX – I

Output elasticities of input by firm in translog frontier function

Firm	Ex_1	Ex_2	Ex_3	Ex_4	Ex_5	Ex_6
1	0.7927	0.0934	0.2315	0.0057	-0.9032	0.5442
2	2.32	-0.6683	0.5848	-0.6556	-1.2179	0.5348
3	2.7378	-0.9279	0.4568	-0.8264	-1.0634	0.5599
4	1.7067	-0.4817	0.4615	-0.3622	-1.0408	0.5957
5	1.1724	-0.3648	0.7389	-0.0491	-1.3191	0.6767
6	0.8949	-0.1351	0.9992	0.3702	-1.9813	0.6754
7	1.3889	-0.2567	-0.1594	-0.4231	-0.0543	0.5211
8	0.8928	0.0855	0.0604	0.14	-0.9468	0.5493
9	2.2737	-0.2181	-0.7131	-0.3557	-0.4512	0.3772
10	0.6942	0.1547	-0.2786	0.3112	-0.5822	0.5669
11	0.5483	0.2108	-0.1418	0.2799	-0.6286	0.5635
12	2.1022	-1.0777	0.7669	-0.0361	-1.5788	0.8422
13	0.8594	-0.8202	0.8952	-0.1024	-0.5532	0.9014
14	2.151	-0.6317	0.0318	-0.3557	-0.7849	0.582
15	6.4895	-2.1457	-1.6684	-2.1594	0.604	0.2722
16	4.0375	-1.883	0.7551	-0.9783	-1.4337	0.7363
17	4.3743	-1.5928	-0.3845	-1.1451	-0.5849	0.5285
18	1.7925	-0.6755	0.0818	0.0494	-0.8832	0.712
19	1.0497	-0.0366	-0.0457	-0.1909	-0.4083	0.5213
20	0.3783	0.2705	-0.1051	0.3448	-0.639	0.574
21	3.4505	-1.2055	0.047	-0.9092	-0.8819	0.5488
22	2.2737	-0.2181	-0.7131	-0.3557	-0.4512	0.3772
23	1.6756	-1.1319	0.715	-0.4466	-0.4268	0.8559
24	0.5531	0.6412	-0.4123	0.7487	-1.2526	0.4385
25	2.5736	-1.0885	0.2391	-0.4734	-0.8098	0.6936
26	2.5217	-0.7836	-0.2997	-0.5165	-0.3262	0.5521
27	2.3129	-0.759	-0.1634	-0.4423	-0.3857	0.5856
28	2.1752	-0.6795	-0.1743	-0.3068	-0.4732	0.5922
29	1.4689	0.032	-0.7779	0.1003	-0.4098	0.4651
30	1.5368	0.0464	-1.0002	-0.1257	-0.0732	0.4246
31	0.8368	-0.4269	0.5101	0.8055	-1.4056	0.8498
32	2.3766	-0.3551	-0.7606	-0.5352	-0.1938	0.3982
33	2.3809	-1.2322	0.2474	0.1866	-1.2912	0.8854
34	2.3545	-1.1962	-0.0093	0.06	-0.7859	0.8452
35	2.0864	0.1358	-0.8816	0.0543	-0.7915	0.2998
36	1.162	0.1033	-0.4492	0.3345	-0.9517	0.5325
37	1.7964	-0.1395	-1.3458	-0.1243	0.2192	0.4651
38	3.1195	-0.6052	-0.9266	-0.6737	-0.2902	0.3653
39	1.182	0.0894	-0.314	0.2202	-0.8691	0.5078
40	1.8098	-0.7071	-0.0861	0.031	-0.6761	0.7211
41	1.5356	-0.6208	0.0266	0.0805	-0.6521	0.7317
42	2.4178	-1.2231	0.4601	0.007	-1.4034	0.855

Firm	Ex_1	Ex_2	Ex_3	Ex_4	Ex_5	Ex_6
43	1.4498	-1.073	0.5046	-0.158	-0.3229	0.9019
44	2.6217	-0.8622	-0.5561	-0.1946	-0.4536	0.6178
45	1.9241	-0.3833	-0.4782	-0.3698	-0.2007	0.503
46	3.1973	-1.138	-0.1756	-0.5955	-0.7725	0.5986
47	1.9626	-0.1	-0.6514	-0.2193	-0.4957	0.3954
48	1.1159	-0.9475	0.5596	-0.0033	-0.3646	0.9229
49	1.5769	0.2374	-0.7616	0.4086	-1.0282	0.3973
50	2.5731	-0.9415	-0.9974	0.2095	-0.2767	0.7128
51	3.3219	-1.2229	-1.0865	-0.1677	-0.191	0.6619
52	1.9719	-0.204	-0.4454	-0.1335	-0.7612	0.4556
53	1.9591	-0.1704	-0.8229	-0.1762	-0.2733	0.4307
54	2.5122	-0.3073	-1.1408	-0.5367	0.1366	0.345
55	2.352	-0.3035	-0.694	-0.5007	-0.2794	0.379
56	2.5129	-0.9739	-0.017	-0.0284	-1.0683	0.714
57	1.8494	-0.2721	-0.5733	0.1307	-0.7117	0.5388
58	1.7416	-0.1764	-0.5	-0.0348	-0.6113	0.493
59	2.14	-0.5205	-0.8406	0.1505	-0.4681	0.6012
60	1.7603	-0.5305	-0.3228	0.1194	-0.6529	0.6656
61	1.7981	-0.1934	-0.4847	-0.0709	-0.6027	0.4839
62	0.7455	-0.1864	-0.0973	0.6292	-0.8064	0.7463
63	1.7873	-0.5833	-0.27	0.1294	-0.694	0.6855
64	1.9548	-0.343	-0.5945	-0.2073	-0.3202	0.5028
65	1.9416	-0.4506	-0.4787	-0.0481	-0.5158	0.5751
66	2.269	-0.4442	-0.3991	-0.2892	-0.6282	0.4842
67	1.6793	-0.0214	-0.7481	-0.004	-0.4159	0.4339
68	3.2087	-0.5858	-0.9821	-0.7094	-0.2604	0.3339
69	2.9163	-0.7831	-0.7973	-0.4941	-0.2887	0.5026
70	2.3473	-0.4062	-0.8593	-0.5125	0.0309	0.4207
71	2.4277	-0.4418	-0.7245	-0.2639	-0.4788	0.4634
72	2.5106	-0.6088	-0.8144	-0.445	-0.0947	0.4968
73	2.3829	-0.6708	-0.6148	-0.1494	-0.4779	0.5878
74	1.9073	-0.327	-0.5351	0.0198	-0.5953	0.5339
75	2.0389	-0.3086	-0.7585	-0.0086	-0.4476	0.4988
76	1.0385	-0.3192	-0.3615	0.6539	-0.6545	0.7556
77	1.9551	-0.6568	-0.3964	0.1251	-0.6203	0.6876
78	2.4719	-0.4212	-0.8065	-0.1581	-0.5499	0.4599
79	2.2286	-0.2727	-0.8764	-0.2943	-0.2347	0.415
80	1.573	0.0622	-0.8302	-0.2175	-0.0641	0.384
81	2.352	-0.3035	-0.694	-0.5007	-0.2794	0.379
82	2.0611	-0.8039	0.0581	0.1804	-1.1252	0.7423
83	1.9924	-0.292	-0.7439	-0.0006	-0.4718	0.5032
84	1.5855	-0.2792	-0.4374	0.1757	-0.7038	0.5961
85	1.9412	-0.5991	-0.3587	0.0402	-0.6271	0.655
86	3.0436	-0.5712	-1.0207	-0.663	-0.1916	0.3673
87	0.483	0.5602	-0.7233	0.4674	-0.4894	0.4483
88	1.5976	-0.3131	-0.5061	-0.0933	-0.2505	0.5647

Firm	Ex_1	Ex_2	Ex_3	Ex_4	Ex_5	Ex_6
89	1.824	-0.3467	-0.4008	0.0397	-0.7235	0.5652
90	1.7518	-0.1215	-0.6441	0.169	-0.7658	0.4981
91	1.634	0.0776	-0.7603	0.5742	-1.1948	0.4895
92	2.8843	-0.5377	-1.1128	-0.5338	-0.1474	0.3993
93	1.4572	0.0512	-0.6647	0.0171	-0.5142	0.4546
94	2.5508	-0.6305	-0.9614	-0.3438	-0.027	0.5095
95	1.6735	-0.3481	-0.5799	-0.083	-0.2083	0.5678
96	1.6256	0.0622	-0.9361	0.7098	-1.1013	0.5128
97	1.9021	-0.1344	-0.9133	-0.0588	-0.365	0.4491
98	2.1196	-0.4431	-0.6498	-0.3227	-0.2093	0.5057
99	0.9291	-0.0573	0.0488	0.1168	-0.7586	0.5971
100	1.2789	0.0418	-0.6222	-0.0113	-0.2745	0.4747
101	1.1312	-0.52	0.0122	0.5687	-0.9213	0.8236
102	0.3713	-0.1967	0.0324	0.9337	-0.9463	0.8559
103	1.1635	-0.4494	-0.0397	0.5869	-0.9708	0.7888
104	0.5418	-0.1705	0.0483	0.6844	-0.8961	0.7852
105	0.4423	0.2477	-0.1187	0.3198	-0.6343	0.5701
106	1.1543	-0.1278	-0.4676	0.4507	-0.7037	0.6362
107	0.773	-0.1631	-0.1086	0.6602	-0.9371	0.7428
108	0.9672	-0.3735	-0.0225	0.6866	-1.0235	0.8051
109	1.0453	-0.0112	-0.8586	0.13	0.1471	0.5487
110	1.3762	-0.8183	0.1274	0.8582	-1.3017	0.9534
111	1.2039	-0.0574	-0.6596	0.3008	-0.4266	0.5746
112	1.0988	-0.3488	0.0138	1.0288	-1.6131	0.8236
113	1.6765	-0.5175	-1.393	-0.2324	0.9069	0.6287
114	0.7878	-0.1605	0.0913	0.7293	-1.2961	0.7547
115	-0.2037	0.1478	0.0395	1.2886	-1.1791	0.8523
116	0.3574	-0.0054	-0.0261	0.8424	-0.9965	0.7671
117	1.1309	-0.361	0.0074	1.0147	-1.6085	0.8218
118	2.2528	-0.3805	-0.9143	-0.01	-0.4926	0.5045
119	0.7878	-0.1605	0.0913	0.7293	-1.2961	0.7547
120	2.2021	-0.544	-0.853	0.1233	-0.4592	0.5976
121	1.9412	-0.5991	-0.3587	0.0402	-0.6271	0.655
122	2.5954	-0.3921	-0.8458	-0.5303	-0.3015	0.3825
123	0.6436	0.4862	-0.8795	0.4894	-0.4	0.4549
124	1.0929	-0.0278	-0.0768	0.123	0.3248	0.0386
125	2.2537	-0.7971	-0.0397	0.0188	-1.0335	0.6865
126	1.1113	-0.0932	-0.3563	-0.015	-0.2871	0.5619
127	2.2012	-0.4681	-0.4247	-0.2957	-0.4796	0.5015
128	1.4928	-0.6999	0.4589	0.8765	-1.845	0.8799
129	1.2143	-0.1597	-0.1643	0.1582	-0.6427	0.5902
130	2.1225	-0.5089	-0.448	-0.3382	-0.3032	0.5268
131	-0.0988	0.6321	-0.0439	0.142	0.6981	-0.0484
132	0.3467	0.1329	0.4798	0.4142	0.1766	0.0002
133	0.5126	0.2075	0.7439	0.297	-0.2515	-0.0313
134	-0.3065	0.552	0.7221	0.733	-0.3034	0.0264

Firm	Ex_1	Ex_2	Ex_3	Ex_4	Ex_5	Ex_6
135	-0.3911	0.6212	0.7009	0.7471	-0.2878	0.0123
136	1.988	-1.0036	0.373	0.407	-1.439	0.8708
137	0.5359	0.2492	0.4583	0.1205	0.1591	-0.067
138	0.3341	0.1275	0.4653	0.4061	0.2174	0.0036
139	0.2392	0.3081	0.7928	0.4126	-0.2774	-0.0144
140	-0.1736	0.6605	-0.0291	0.1747	0.6875	-0.044
141	0.3467	0.1329	0.4798	0.4142	0.1766	0.0002
142	2.3349	-1.1352	0.3042	0.255	-1.3895	0.8505
143	0.2937	0.3411	0.5064	0.2266	0.1245	-0.0528
144	1.9883	0.0292	-2.0499	0.0171	0.5683	0.3702
145	2.1965	-0.1349	-1.4698	-0.3119	0.2878	0.361
146	1.9152	-0.2393	-1.1809	-0.5448	0.5648	0.4229
147	1.5824	-0.0704	-1.0996	-0.2118	0.2401	0.4514
148	1.9177	-0.0502	-1.6935	-0.2194	0.6523	0.3764
149	1.9645	-0.2763	-1.7863	-0.508	1.1631	0.4359
150	2.9236	-0.5469	-1.0378	-0.7334	0.0168	0.3636
151	2.0555	-0.1033	-1.2846	-0.1274	-0.1152	0.4068
152	1.9216	-0.0689	-1.4916	-0.1986	0.3132	0.3994
153	1.4898	-0.3471	-0.0316	-0.0545	-0.8514	0.6226
154	1.4539	0.3121	-1.678	0.2168	0.1426	0.3648
155	2.9269	-0.3925	-1.6846	-0.4961	0.3226	0.3259
156	2.2572	-0.1332	-1.3307	-0.0638	-0.271	0.3935
157	2.1676	-0.1971	-1.5986	-0.3531	0.4938	0.3939
158	1.6898	-0.4508	-0.2014	-0.0896	-0.6972	0.6282
159	1.7552	-0.1535	-0.9151	-0.0581	-0.1008	0.4692
160	0.9149	0.289	-1.0177	0.3222	-0.0201	0.4614
161	0.8139	0.2634	-0.6373	0.3531	-0.4538	0.5054
162	1.6356	-0.4501	-0.0625	0.6197	-1.3033	0.7047
163	1.7996	-0.61	-0.0431	0.4587	-1.2801	0.7402
164	1.9748	-0.3245	-0.529	0.0091	-0.6879	0.5241
165	1.5723	-0.0509	-0.7726	-0.025	-0.2503	0.4623
166	1.5184	-0.1869	-0.6954	0.3877	-0.59	0.5853
167	1.568	-0.6276	-0.2507	0.7464	-1.0688	0.8168
168	-0.1303	0.7165	0.0748	0.5702	0.0543	-0.0289
169	2.5377	-1.2999	-0.0735	0.6993	-1.4663	0.9464
170	2.3966	-0.8915	-0.4305	0.4735	-1.0862	0.7593
171	1.2554	0.0721	-0.9508	0.3274	-0.2701	0.5085
172	2.2058	-0.6857	-0.2578	0.3979	-1.1359	0.6824
173	1.6518	-0.5746	-0.0482	0.4959	-1.2152	0.7541
174	1.9629	-0.2567	-0.4211	0.0989	-0.9534	0.5087
175	1.2265	0.0455	-0.9239	0.2002	-0.1275	0.5095
176	1.9673	-0.5699	-0.1683	0.5362	-1.2754	0.6899
177	1.7661	-0.6075	-0.0535	0.4597	-1.2423	0.7448
178	1.9952	-0.3156	-0.5054	0.0223	-0.7541	0.5187
179	-0.0425	0.6832	0.0574	0.5317	0.0669	-0.0341

APPENDIX – II

Technical efficiency estimates by firms

Firm	TE	Firm	TE
1	0.78921839E+00	46	0.80858869E+00
2	0.80841074E+00	47	0.80660492E+00
3	0.83159306E+00	48	0.74573585E+00
4	0.84988503E+00	49	0.82955023E+00
5	0.83326889E+00	50	0.87570150E+00
6	0.79167970E+00	51	0.88086391E+00
7	0.88769716E+00	52	0.85421034E+00
8	0.82627358E+00	53	0.87325138E+00
9	0.81304713E+00	54	0.86119871E+00
10	0.87059046E+00	55	0.81159937E+00
11	0.86895485E+00	56	0.85043995E+00
12	0.74395296E+00	57	0.87510681E+00
13	0.83433009E+00	58	0.85885875E+00
14	0.78945418E+00	59	0.84536706E+00
15	0.79016269E+00	60	0.77296642E+00
16	0.88330807E+00	61	0.88690771E+00
17	0.85120839E+00	62	0.89292389E+00
18	0.76515757E+00	63	0.81997157E+00
19	0.88341218E+00	64	0.87190302E+00
20	0.86335125E+00	65	0.77972493E+00
21	0.80554749E+00	66	0.80407507E+00
22	0.81304713E+00	67	0.88142389E+00
23	0.88800959E+00	68	0.81711308E+00
24	0.86271271E+00	69	0.86292649E+00
25	0.83542687E+00	70	0.90185906E+00
26	0.88472806E+00	71	0.75911642E+00
27	0.83777137E+00	72	0.83626650E+00
28	0.88584854E+00	73	0.83139663E+00
29	0.84570172E+00	74	0.88210158E+00
30	0.86510388E+00	75	0.88429745E+00
31	0.81103137E+00	76	0.87867003E+00
32	0.88090987E+00	77	0.81632456E+00
33	0.90233189E+00	78	0.86221114E+00
34	0.86820206E+00	79	0.88159429E+00
35	0.80849161E+00	80	0.80141561E+00
36	0.86776875E+00	81	0.81159937E+00
37	0.83348262E+00	82	0.84649651E+00
38	0.85627306E+00	83	0.86073333E+00
39	0.86155562E+00	84	0.83735057E+00
40	0.89544925E+00	85	0.78015700E+00
41	0.87723845E+00	86	0.84615038E+00
42	0.72035019E+00	87	0.74633055E+00
43	0.79495739E+00	88	0.70595025E+00
44	0.77642329E+00	89	0.74982746E+00
45	0.29220174E+00	90	0.76798662E+00

Firm	TE
91	0.82559034E+00
92	0.79295924E+00
93	0.75060707E+00
94	0.75402402E+00
95	0.70471540E+00
96	0.83951942E+00
97	0.77060477E+00
98	0.72931934E+00
99	0.85290149E+00
100	0.79982837E+00
101	0.86518423E+00
102	0.84332901E+00
103	0.82013998E+00
104	0.87088980E+00
105	0.80765904E+00
106	0.69128858E+00
107	0.85406564E+00
108	0.83538415E+00
109	0.85480191E+00
110	0.76652705E+00
111	0.76058210E+00
112	0.82066013E+00
113	0.76549471E+00
114	0.80407280E+00
115	0.88764668E+00
116	0.84683086E+00
117	0.81870648E+00
118	0.62208410E+00
119	0.80407280E+00
120	0.85015484E+00
121	0.78015700E+00
122	0.82495841E+00
123	0.74136656E+00
124	0.83696445E+00
125	0.84896160E+00
126	0.81104821E+00
127	0.74571816E+00
128	0.85005414E+00
129	0.75757210E+00
130	0.77872238E+00
131	0.84170213E+00
132	0.83738055E+00
133	0.83808506E+00
134	0.81671100E+00
135	0.85342891E+00
136	0.85051006E+00
137	0.83591264E+00
138	0.83353017E+00
139	0.83784561E+00
140	0.83442744E+00

Firm	TE
141	0.83738055E+00
142	0.84812495E+00
143	0.82685086E+00
144	0.82467817E+00
145	0.83393428E+00
146	0.87465272E+00
147	0.80149562E+00
148	0.84355172E+00
149	0.86905126E+00
150	0.85825885E+00
151	0.84588469E+00
152	0.86260551E+00
153	0.89279758E+00
154	0.74340622E+00
155	0.87286777E+00
156	0.83280100E+00
157	0.89157565E+00
158	0.89765907E+00
159	0.85236050E+00
160	0.79749599E+00
161	0.85075181E+00
162	0.80417431E+00
163	0.82876769E+00
164	0.74485668E+00
165	0.82690321E+00
166	0.83669064E+00
167	0.85377057E+00
168	0.83292333E+00
169	0.81117551E+00
170	0.76642673E+00
171	0.85080913E+00
172	0.79060306E+00
173	0.83715575E+00
174	0.96527882E+00
175	0.84687938E+00
176	0.78521145E+00
177	0.83768826E+00
178	0.73595081E+00
179	0.83353544E+00

APPENDIX – III: Interview schedule for Barley farmers

AN ECONOMIC ANALYSIS OF IRRIGATED BARLEY PRODUCTION IN IRAN: A STUDY IN TEHRAN PROVINCE

Department of Agricultural Economics, University of Agricultural Sciences, G.K.V.K, Bangalore 5660065

A) General Details

1. Name of the respondent……………………………..
2. Age (year)…………..

3. Education ☐ Illiterate ☐Primary ☐Secondary ☐high school

☐ Diploma ☐Graduate

4. Sex: ☐ Male ☐ female

5. Family Size Male ……….. Female………. Children ………Total ………..

6. Number engaged on farm Male ……….. Female………. Children ………Total ………..

7. Name of the Village………… Section……….. Township…………….

8. Main sources of Irrigation: ☐Spring ☐Subterranean ☐River

☐Deep-Well ☐Semi deep well ☐ Surface well ☐artesian well

☐ Canal ☐pond/pool ☐Mixed sources

Other (please specify)…………

A) Family details

Sl. No	Age (year)	Education status*	Occupation		Non-agricultural Income	Relation with family head**
			Primary	Secondary		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						

*Illiteracy(1) Primary(2)Secondary(3) high school(4) Diploma (5)Graduate

** Son/daughter (1) wife (2) daughter/son in law (3) grandchild (4)

B) Land holding particulars

SI. No	Particulars	Irrigated land	Dry Land	Garden Land	Total
1	Owned Land (Ha)				
2	Leased in Land(Ha)				
3	Leased out Land (Ha)				
4	Land value (Rls /Ha)				
5	Rent per year (Rls /ha)				
6	Number of land fragments				

C) Wage rate of labour in different stages (Rls/Working-Day)

Type of Labour	Land preparation	Irrigation	Harvesting	Other operations
Male				
Female				
Child				

D) Details of input used and their cost in different stages of Barley production

SI.No	Particular	Amount
Land preparation stage		
1	Irrigation source**	
2	Water charge (Rls)	
3	Frequency of irrigation	
4	Hours to irrigate the crop on time for the entire area	
5	Cost of mechanized irrigation (Rls)	
6	Human labour for non-mechanized irrigation	
7	Cost of labour for non-mechanized. Irrigation (Rls)	
8	Mechanized Tillage (hr/ha)	
9	Cost of mechanized Tillage (Rls)	
10	Non-mechanized tillage (hr/ha)	
11	Kind of animal used in Non-mechanized Tillage*	
12	No of labour in Non-mechanized Tillage	
13	Labour cost in Non-mechanized Tillage (Rls)	
14	Disking (with machine)(hr/ha)	
15	Cost of disking (with machine) (Rls)	
16	Disking (without machine)(hr/ha)	

*Ox /cow (1) horse (2) Donkey (3) mule (4) others (mention it)

**Spring (1) Subterranean (2) River (3) Deep-Well (4) Semi deep well (5) Surface well (6) Artesian (7) well (8) Dam /Canal (9) pond/pool (10)

[1]Other mechanized work: streaming, Boundary and etc.

SI.No	Particular	Amount
Land preparation		
17	Labour used in mechanized disking (working-day)	
18	Labour Cost for Non-mechanized Disking (Rls)	
19	Kind of animal used in disking*	
20	No of animal used in disking	
21	Animal cost in Non-mechanized disking (Rls)	
22	Mechanized Leveling (hr)	
23	Mechanized Leveling cost (Rls)	
24	Labour used in mechanized leveling (working-day)	
25	Leveling with animal force (working-day)	
26	Kind of animal*	
27	Labour used in non-mechanized leveling (working-day)	
28	Other mechanized operations[1] (hr)	
29	Other mechanized cost (Rls)	
30	Animal used in other works in land preparing stage (working-day)	
31	Kind of animal*	
32	Animal cost in other works in land preparing stage (Rls)	

*Ox /cow (1) horse (2) Donkey (3) mule (4) others (mention it)

**Spring(1) Subterranean(2) River (3) Deep-Well (4) Semi deep well(5) Surface well(6)Artesian (7)well(8) Dam /Canal(9) pond/pool (10)

[1]Other mechanized work: streaming, Boundary and etc.

SI.No	Particular	Amount
Cultivate stage		
33	Amount of Manure (Kg)	
34	Cost of Manure (Rls)	
35	Transportation cost of manure till farm (Rls)	
36	Manuring cost by machine (Rls)	
37	Human labour to manuring (working-day)	
38	Human labour cost to manuring (Rls)	
39	Amount of Nitrogenous fertilizer (Kg)	
40	Cost of Nitrogenous fertilizer (Rls)	
41	Amount of Phosphorous fertilizer (Kg)	
42	Cost of Phosphorous fertilizer (Rls)	
43	Amount of Potash fertilizer (Kg)	
44	Cost of Potash fertilizer (Rls)	
45	Amount of other fertilizers (Kg)	
46	Cost of Other fertilizers (Rls)	
47	Transportation cost of chemical fertilizer (Rls)	
48	Fertilizing cost with machine (Rls)	
49	Labour for non-mechanized fertilizing (working-day)	
50	Labour cost for non-mechanized fertilizing (Rls)	
51	Amount of Seed (Kg)	
52	Seed cost (Rls)	
53	Winnowing cost of seed (Rls)	
54	Seed treatment cost (Rls)	
55	Transportation cost of seed to farm (Rls)	
56	Hours to seeding by machine (hr)	
57	Human labour to seeding (working-day)	
58	Seeding cost (Rls)	

SI.No	Particular	Amount
59	Hour cost of grain-drill (Rls/hr)	
60	Labour cost for seeding (Rls/Labour)	
61	Other machinery operations (hr)	
62	Other machinery costs (Rls)	
Vegetation stage		
63	Irrigation source**	
64	Frequency of irrigation	
65	Hours to irrigate the crop on time for the entire area	
66	Cost of mechanized irrigation (Rls)	
67	Human labour for non-mechanized irrigation (working-day)	
68	Cost of labour for non-mechanized. Irrigation (Rls)	
69	Amount of Nitrogenous (top-dressing) fertilizer (kg)	
70	Cost of Nitrogenous (top-dressing) fertilizer (Rls)	
71	Other top-dressing fertilizers (kg)	
72	Cost of Other top-dressing fertilizers (Rls)	
73	Transportation cost of top-dressing fertilizer to farm (Rls)	
74	Top-dressing fertilization cost with machine (Rls)	
75	Human labour for top-dressing fertilization (working-day)	
76	Human labour cost for top-dressing fertilization (Rls/)	
77	Human labour for rotary and weeding (working-day)	
78	Human labour cost for rotary and weeding (Rls/)	
79	Machinery used for Rotary and weeding (hr)	
80	Machinery cost for Rotary and weeding (Rls)	
81	Amount of Pesticide (Kg)	
82	Pesticide cost (Rls)	
83	Amount of Herbicide (Kg)	
84	Herbicide cost (Rls)	
85	Amount of Fungicide (Kg)	

**Spring (1) Subterranean(2) River (3) Deep-Well (4) Semi deep well(5) Surface well(6)Artesian (7)well(8) Dam /Canal (9) pond/pool (10)

SI.No	Particular	Amount
Vegetation stage		
86	Fungicide cost (Rls)	
87	Amount of Other toxin (Kg)	
88	Cost of other used toxin (Rls)	
89	Spraying with machine (hr)	
90	Cost of mechanized spraying (Rls)	
91	Number of Non-mechanized spraying	
92	Human labour for Non-mechanized spraying (working-day)	
93	Cost of Human labour for Non-mechanized spraying (Rls)	
94	Cost of biological control with pests (Rls)	
95	Number of thinning	
96	Human labour for thinning (working-day)	
97	Labour cost for thinning (Rls/labour)	
98	Other costs of vegetation stage either mechanized or Non-mechanized (Rls/ha)	
HARVEST STAGE		
99	Harvesting with combine/ Mover (hr)	
100	Number of harvesting	
101	Cost of mechanized harvesting (Rls)	
102	Labour for harvesting with handle mover (working-day)	
103	Labour cost for harvesting with machine (Rls)	
104	Number of labour in the case of un-mechanized harvesting (labour/ha)	
105	Labour cost for harvesting (Rls/labour)	
106	Labour to collect of the harvested crop with machine and put on special place (working-day)	
107	Labour cost with machine (Rls)	
108	Labour to collect of the harvested crop without machine and put on special place (working-day)	
109	Labour cost without machine (Rls)	

SI.No	Particular	Amount
110	Threshing with thresher (hr)	
111	Cost of threshing with thresher (Rls)	
112	Labour used for threshing (working-day)	
Number and type of animal for threshing		
113	Ox (number/day)	
114	Donkey (number/day)	
115	Number of days for threshing	
116	Human labour for Non-mechanized threshing (working-day)	
117	Cost of Non-mechanized threshing (Rls)	
118	Labour to clean and separate seed from plant (working-day)	
119	Cost of cleaning and separating seed from plant (Rls)	
120	Number of burlap	
121	Cost of each burlap (Rls)	
122	Labour to upload and download and packing (working-day)	
123	Cost of upload and download and packing (Rls)	
124	Transportation cost to storage (Rls)	
125	Transportation cost to market (Rls)	
126	Cost of other post harvest operations (Rls)	
127	Value of main product (Rls)	
128	Value of by-product (Rls)	
129	Area (ha)	
130	Total main product (Kg)	

E) What are the constraints being faced by you in barley production? (Please mention them based on their importance, respectively)

1)

2)

3)

4)

5)

6)

7)

8)

Others, if any (Specify)